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## Birth Interval Analysis in Fertility Surveys

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The World Fertility Survey is an international research programme whose purpose is to assess the current state of human fertility throughout the world. This is being done principally through promoting and supporting nationally representative, internationally comparable, and scientifically designed and conducted sample surveys of fertility behaviour in as many countries as possible.
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# Scientific Reports

## Birth Interval Analysis in Fertility Surveys

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# Contents

# Preface

This document, *Birth Interval Analysis in Fertility Surveys,* was prepared by the author on a contractual assignment with the International Statistical Institute, The Hague, for the World Fertility Survey as one of its *Scientific Reports,* a series intended to facilitate analysis of the large volume of data collected under its auspices in different countries. The methodological problems in the analyses of birth interval data are reviewed and a scheme of analysis of data on closed and open birth intervals, compiled through retrospective surveys of sample populations in the form of birth histories, has been developed. As an illustration these methods have been applied to the data on birth intervals collected in the Fiji Fertility Survey 1974.

P.M. Kulkarni and Y.S. Gopal provided continuous technical consultations and computational assistance to the author, at Bangalore, in the preparation of this article. Dr. Kulkarni assisted the computer programmer in writing the programmes for the analysis of the data and also in checking the results. He also assisted the author in going through the first draft of the report in the manuscript form. Dr. Y.S. Gopal assisted in the preparation of most of the tables by extracting relevant information from the computer outputs. In a developing country, where computer facilities are limited and programming service are not adequate, it is natural that a good deal of computations have to be made through hand calculators even in the proximity of computer centres. The assistance of Dr. Y.S. Gopal in this regard has been of substantial value in expediting the preparation of the report. The computer programmes were written by Mr A.S. Balasubramaniam of the Indian Institute of Science, Bangalore, in FORTRAN-IV language. The computer facilities of the Indian Institute of Science, Bangalore, and the Indian Institute of Technology, Madras, were used. The author wishes to express his deep gratitude and admiration to the above three persons but for whose assistance and continuous interaction the writing of the report would have been a more difficult task.

The first draft of this report was critically commented upon by Dr. (Mrs) Jane Menken of the Office of Population Research, Princeton University, USA, and Dr. Rod Little of World Fertility Survey, London. The present version incorporates most of their comments and also some of the suggestions given by the WFS technical staff, especially by Mr. V.C. Chidambaram, during meetings in London. I wish to express my gratitude to them for their valuable suggestions which contributed to a considerable improvement on the earlier version of this paper.

Bombay
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K. Srinivasan

# 1 Introduction

Birth intervals in human populations offer an interesting, fruitful and at the same time an intriguing area of scientific enquiry. Many of the retrospective surveys on fertility and family planning undertaken in the developing as well as in the developed countries in recent years have compiled information on fertility histories of the women included in the survey. These include data on the timing of various significant events in the life cycle of a woman, such as her marriages, separations, widowhood and divorce, and the dates (usually the month and calender year are recorded) of first, second, ... and the last live birth. These data permit computation and analysis of birth intervals which can be categorised into two broad types: the closed interval, which is the interval between the successive live births of a woman and the open interval, which is the interval from the date of the last live birth to the date of survey, computed for each woman. These interval data computed for each woman can be aggregated over women in terms of frequency distributions classified by a number of variables, such as distribution by birth orders; between marriage and first child, first and second child, etc., and the distribution of open intervals; by the age of the woman reckoning the intervals before or after specified ages; by duration of marriage; and by various relevant socio-economic variables, such as religion, education, and contraceptive usage. The basic information needed for the analysis of such birth interval distributions is available from many of the retrospective surveys, and it can be systematically analysed for describing the fertility dynamics of the population, for the analysis of fertility differentials, or for the estimation of certain parameters underlying the reproductive processes in the population.

In this report an attempt is made to identify the major methodological issues involved in the analysis of birth interval data compiled from retrospective surveys; to develop a framework that can be used in the analysis of interval data collected from retrospective surveys of populations; and, to provide an illustrative application, especially of the methodological issues involved through the analysis of interval data collected by the World Fertility Survey in Fiji[1]. The need for systematization in the analysis of birth interval data and the recognition of the limitations in such an analysis has been intensified during the past few years by the large number of fertility surveys conducted, under the auspices of the World Fertility Survey[2], in different countries of the world, using a standardized core set of questionnaries. It is one of the purposes of this paper to assist the researchers and analysts involved with the analysis and interpretation of birth interval data compiled from WFS type of surveys in undertaking a sequential set of analysis of such data and the cautions to be exercised in interpreting the results obtained in each stage.

The specific objectives of this report can be stated as follows:

1) To develop simple analytical methods for checking the quality of data on birth intervals reported in retrospective surveys and methods of adjustments for defective or incomplete data in such variables;
2) To identify and discuss the methodological issues involved in the analysis and interpretation of data on birth intervals, closed as well as open, compiled from retrospective surveys, especially when used as indicators of levels and changes in fertility;
3) To develop a simple framework for the analysis of data on birth intervals, closed as well as open, obtained from World Fertility Survey type enquiries; and
4) To make an illustrative application for the purposes of highlighting the issues involved in the analysis of retrospective survey data on birth intervals.

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1. Bureau of Statistics, *'Fiji Fertility Survey, 1974, Principal Report'*, Suva, Fiji, December 1976.

2. *World Fertility Survey; The First Three Years, Jan. '72-Jan. '75*, International Statistical Institute, Netherlands.

# 2 Fertility Analysis from Birth Interval Data: A Review

## 2.1. CLOSED BIRTH INTERVALS

The closed birth interval defined as the duration of time between two consecutive live births of one woman or over a group of women in a community, denoted by the letter *'T'* in this report, is an interesting area of investigation for students of different disciplines. For a woman of parity *i* at the time of the survey there will be *i-closed intervals* $(T_0, T_1, \ldots T_{i-1})$ and one open interval $(U_i)$ as depicted below.

| Marriage | First child | Second child | $(i-1)^{th}$ child | $(i)^{th}$ child | Date of Survey | |
|---|---|---|---|---|---|---|
| $T_0$ | $T_1$ | | $T_{i-1}$ | $U_i$ | | .......(1) |

The interval *'T'* can be used both as an independent variable for the purposes of explanation of the total fertility of the women, or as a dependent variable, with some restrictions, as a measure of maternal and child health or fertility. This interval is only a part or segment of the fertility experiences of the population and has to be interpreted along with certain other measures of fertility in any analysis of period or cohort fertility.

### 2.1.1. GENERAL ADVANTAGES AND LIMITATIONS

First, we will list the general advantages and limitations of using the birth interval data in a study of fertility, and second, we will try to identify and discuss the specific methodological issues arising in the use of data on birth intervals compiled from retrospective surveys for the study of levels and changes in fertility.

a) An analysis of reproductive history of birth intervals avoids the constraints produced on fertility analysis by arbitrary definitions of period of observation. The difficulties in the use of appropriate denominator as in the case of birth rate or fertiltiy rates are also circumvented.

b) It provides a simple means of studying the patterns of reproduction of only those who continue to reproduce. It does not measure changes in the parity progression or those of the age and marriage duration. By controlling for birth order, age of mother and marital duration, it can be used for studying secular changes and differentials in spacing patterns of a population. Allowance for the fact that it refers to a decreasing proportion of women at each successive birth order may be made through the use of a related fertility index *parity progression ratio,* the conditional probability of $n^{th}$ birth given that a woman has (n-1) births.

c) The closed birth interval measures the pattern of reproduction of only those who continue to reproduce. It does not measure changes in the parity progression or the probability that a woman of parity *i* will never proceed to parity $(i+1)$ in her life and hence cannot be used as a measure of total fertility. In the study of fertility, two dimensions appear important; i) how frequently a woman has children, and ii) how many women of a given birth order ever proceed to the next child. Actually these two dimensions of fertility seem to be almost independent of each other empirically, though theoretically, limited reproductive span for the woman implies that longer spacing should lead to smaller family size. A study of closed interval will be adequate only in the analysis of fertility change in the first dimension. Any conclusion regarding the fertility levels of a population, as a whole, based only on closed birth interval can, however, be totally misleading. For example, the average birth interval between two successive live births for an ever married Indian woman is about 36 months, which is very close to the average birth interval for an ever married woman in the USA, though the total fertility rate of the former country is almost twice that of the latter. This is because of the fact that while in India consistently high proportion of women are progressing to higher and higher parities, in the USA, after reaching parity two, only a very small proporition of women do proceed to the higher parities. Though the spacing patterns are not different between the two countries, the parity progression ratios, after parity two are drastically different. This is the reason why the total fertility rate and the completed family size in India are much higher than in the USA, in spite of the fact that the average intervals between successive births for women is as long in India as in the USA. The old adage 'Slow and steady wins the race' seems to be true even in the field of human fertility. This is a serious limitation in the use of closed birth interval for the analysis of fertility differentials, and its demographic value as a fertility measure. To a large extent the open birth interval denoted by *U* in this paper is a sensitive measure of the parity progression ratio which is a crucial factor in the explanation of the fertility differentials and fertility change in the second dimension of fertility mentioned above. Thus a study of the closed and open interval will together be useful in the analysis of the fertility of the population.

d) As an independent variable, the closed birth interval has been used as an explanatory or predictor variable in the analysis of fertility. The interval *T* is connected to the short term as well as to the long term indices of reproduction and replacement. The reduction in the live birth rate in the short run due to a lengthening of the inter-live-birth interval is obvious and needs no explanation. The interval is closely connected (actually it is a part) to the mean generational length of the population, i.e., the age of the mother at the birth of the median child. The mean generational length is a factor which in turn influences the intrinsic rate of growth of population. Two populations which have the same completed family size but differ in the patterns of spacing of the children over the reproductive span will be having differential intrinsic growth rate in the population. The population where the age of the mother at the birth of the median child is higher will have a lower intrinsic rate of growth of population than one wherein the children are born to mothers earlier in the reproductive period and thereby the mean generational length is lower. The effect of changes in the mean generational length of the population on the intrinsic growth rate in areas of high fertility has been very well illustrated by Coale and Tye[3] by comparing the fertility performances of Chinese and Malayan population of Singapore. Though the effect of changes in the total family size of a population has a greater impact on the intrinsic growth rate of the population, it is to be recognized that for any given family size the changes in the

3. Coale, A.J. and C.Y. Tye, 'The Significance of Age-Patterns of Fertility in High Fertility Population', *Milbank Memorial Fund Quarterly*, XXXIX, 1961

spacing patterns of children do have an influence in the rate of intrinsic growth of population. This can be brought out from the fact that the intrinsic rate of growth of the population $r$ is connected to the net reproduction rate $R_o$ and the mean generational length $M$ by the formula, which is due to Lotka[4], as

$$r = (\log_e R_o) / M \qquad (2)$$

For any given $R_o$ or in other words, the completed family size, an increase in $M$ or the closed birth interval, dampens the level of $r$.

e) Studies have been undertaken to assess the extent to which variations in closed birth intervals account for the differentials in fertility in a population, fertility being measured in terms of number of children born to women of specified age and duration of marriage. Mohapatra[5] in his detailed analysis on the relative roles of age at marriage, closed birth interval and open birth interval in explaining the fertility differentials among various groups of ever married women in the reproductive ages in Taiwan, classified according to the levels of modernization based on education, occupation, income, number of modern objects owned, etc., found that the closed birth interval explains the least proportion of the variance in the observed cumulative fertility of the women in different groups. The open birth interval was found to explain the maximum proportion of variance and the age at marriage the next best. This is consistent with the arguments given in section c) above, wherein it was pointed out that while the closed birth interval can measure fertility of only those who continue to reproduce, it is relatively insensitive to changes in parity progression ratio or the proportion of women of any given parity who proceed to the next parity and hence cannot be used by itself, as an indicator of current or total fertility.

f) The unique advantage of the closed intervals can be had in a component analysis of the interval. Broadly speaking, any interval between two consecutive live births to a woman can be considered to be made up of the following four components:

i) the period of post partum amenorrhoea following the birth of the child,
ii) the total duration of menstruating intervals between the two births,
iii) the periods of pregnancy and post termination amenorrhoea (if any) of abortions or still births intervening the two live births, and
iv) the period of pregnancy associated with the latter live birth.

The first component, the duration of post partum amenorrhoea, during which conception is generally held to be impossible due to absence of ovulation, is influenced both by the health conditions of the women as well as by the breastfeeding practices.

Consequently, the reproductive physiologist, the sociologist and the demographer have of late, become, increasingly interested in this component of the birth interval. The second component is the sum of the waiting times to conceptions that occur between the two live births. After the resumption of the menstruation following a birth, a further conception to a woman takes place only after a variable period of time, even in the case of a woman who is living in married state and in sexual union with her husband. In the susceptible state (a state in which the woman can conceive), conception can never be predicted with certainty and is determined by a host of biological and sociological factors. The fecundity of the woman (biological capacity to conceive), the frequency and timing of sexual unions, the sperm count and mobility of the sperms in the ejaculations of the husband, contraceptive practices and the health status of the couples are some of the more important of these factors. The length of the menstruous intervals are determined by the interaction of the above mentioned, and possibly by other factors. It is but natural that sociologists, demographers and others are trying to understand the patterns of distributions of these menstruating intervals and isolate the effects of various factors on this component of the birth interval. The parameter that is usually considered for characterizing the length of a menstruating interval is the fecundability or the monthly probability of conception which is generally considered invariable within specific age groups or within each birth interval for any woman. The number of menstruating intervals between any two live births depends on the number of foetal losses, which, in turn, depends on the probability that a conception will end in a live birth. The incidence of still births, spontaneous abortions, and induced abortions together determines this probability. The third component of the birth interval is a specific contribution of the foetal losses as they occur to the women between two live births. This *reproductive wastage* (still births and abortions) operates in a very direct way to postpone the interval between two consecutive live births. The gestational length of pregnancy at which these losses take place and the period of amenorrhoea following the termination of pregnancy are very important factors to be taken into account in addition to the frequency of these terminations. The feasibility of manipulating this factor in the reduction of the live birth rate in the community has been demonstrated by many countries, such as Japan and Hungary, and of late many developing countries have liberalised their laws on abortion, with a view to reducing the birth rate. The fourth component, the duration of pregnancy associated with a live birth, is the least variable part of the birth interval, though it is well-known that it is almost impossible to predict the exact time of delivery for a pregnant woman.

Analytical models could be developed for the probability distributions of the closed birth intervals by considering the interval as the sum of the four components mentioned above, assuming known functional forms for each of the component distribution and their statistical independence. The theoretical distribution thus derived can be tested, statistically, for its consistency with the observed distribution. Again assuming a model, the data on closed birth interval distribution could also be used to estimate some of the unknown parameters of the component distributions, which can never be directly estimated. For example, the fecundability or the monthly probability of conception of married women in the susceptible state can be estimated from an analysis of closed birth interval data with a knowledge of some of the other parameters of the component distribution. Similarly, an estimate of the incidence of foetal wastage in the population can also be obtained by assumption of the parameters on other components distributions. The major utility of closed birth intervals from the point of view of fertility analysis seems to lie more in the possibility of using such distributions for the estimation of fecundability and foetal wastage in population, which cannot be estimated directly from a survey type of situation. This is illustrated by an analysis of closed birth interval data in Fiji.

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4. Lotka, A., 'A Contribution to the Theory of Self-renewing Aggregates with Special Reference to Industrial Replacement', *Annals of Math. Stat.*, 10, 1939.

5. Mohapatra, P.S., *The Effect of Age at Marriage and Birth Control Practices on Fertility Differentials in Taiwan*, unpublished Ph.D. Dissertation in Sociology, University of Michigan, 1966.

### 2.1.2. ISSUES IN THE USE OF BIRTH INTERVAL DATA FROM RETROSPECTIVE SURVEYS

#### a) Biases

Use of data on birth intervals, closed or open, compiled from retrospective birth histories for the study of cohort or period fertility measures, has to be undertaken with a considerable amount of caution since these interval data from retrospective surveys have built into them a number of biases or distortions which have not so far been successfully handled. In this section we will attempt to identify the major biases and errors and indicate the direction in which they tend to affect the retrospective survey data.

Let us consider, as a standard, for comparative purposes, the distributions of closed birth intervals of a cohort of women, a birth cohort, born in the same calender year(s). Assuming that this cohort is follwed up throughout their reproductive span, we can develop the distributions of successive birth intervals, and let the concerned random variables be denoted by $T_{0c}$, $T_{1c}$, $T_{2c}$, $T_{ic}$, where $T_{ic}$ denotes the interval between *i*-th and *(i + 1)*th births to this cohort of women. Now if we take a retrospective survey of these women at an age *'a'*, which is within the reproductive span, compute the distributions of intervals from this retrospective survey data and denote the random variables by $T_{0a}$, $T_{1a}$, $T_{2a}, \ldots, T_{ia}, \ldots$, then obviously the distributions $T_{ic}$ and $T_{ia}$ are not identical and there are some serious biases introduced in $T_{ia}$. If for any woman the interval between *i*-th and *(i+1)*th birth in the survey is to be included in $T_{ia}$, then the woman has to be at least of parity *(i+1)* by age *'a'*.

If the woman is of parity *(i+1)*, then the maximum birth interval that she can have, in order to be included in $T_{ia}$, is $a-9_i$, i.e., in a case where the first *i* births occur with the minimum possible birth interval of 9 months. In this case all the intervals longer than $a-9_i$ in the original cohort distribution are excluded from the survey, and the truncated distribution will have a smaller mean and variance than the original distribution.

If the woman is of parity *(i+2)*, then the maximum that can be contributed to $T_{ia}$ by her will be $a-9\ (i+1)$, and so on for higher birth intervals.

We can easily see that when *a* is large and close to the total reproductive span this bias will be small, and similarly for any given *a* or age the bias is relatively high for higher parities than for lower parities. The general effect of this selection called *truncation effect* is to dampen the mean and variance of the birth intervals, i.e., of birth intervals computed from retrospective surveys can be expected to have a smaller mean and variance in comparison to parent cohort distributions. Higher the parity and/or lower the age, greater will be the dampening effect. Sheps and Menken[6], who first pointed to the existence of such effects and called them *truncation effects* in birth interval data compiled from surveys, have also worked out the magnitude of the bias in the mean values in a stable population situation. Venkatacharya[7] has estimated through micro-simulation studies the magnitude of such biases, in a population of women with known distributions of fecundability, post partum amenorrhoea and incidence of foetal loss. Now it can be seen from the arguments given above that the magnitude of this bias, on any closed birth interval data from retrospective surveys, will be minimum if we consider only the closed interval between the last and last but one live births. For any given age *a*, the truncation bias in $T_{ia}$ is minimum, if we consider only the data from the last and last but one live birth, since by excluding the women of parity *(i+2)* and over, who are likely to have higher fertility and hence shorter birth intervals, the negative bias in the closed birth interval of a retrospective survey is reduced. On the other hand, because we restrict our analyses to women of parity (i+1) at the time of the survey, we can be introducing a positive bias. Thus, we have the relations:

$$E(T_{ia}) < E(T_{ic})$$
$$E(T_{ia}) < E(T_{ia'})$$

where the operator $E$ stands for expected values, $T_{ia'}$ is the interval between *i*-th and *(i + 1)*th births for women of exact parity *(i + 1)* and age *a* at the time of the survey.

In this context it appears useful to briefly define the terms 'truncation', 'censoring' and 'selection' as used in statistics. By the term *truncation* we mean that in any distribution function *F(x)* of a positive random variable *x*, we consider only values below a level *k*, say, and consider the relative probability of occurrence of events within *k*. In this case the density function of the truncated variable g(y) is given by

$$g(y) = \frac{1}{F(k)}\, f(y) \qquad o < y < k$$
$$= 0 \qquad y \geqslant k$$

*g(y)* is said to be a truncated distribution of *x*, with truncation at *k*.

By *selection* we mean that we choose a subset of values which satisfy some other specific criteria, say, the closed intervals within an age *a*, or specifically, say, the interval between last child and the last but one child.

By *censoring* we mean we have by necessity to include a number of incomplete intervals in our analyses, the experience of each woman being truncated at different points of time. For example, data on the length of post partum amenorrhoea completed for the women after the last live birth are considered to be a censored set of data. In this case, some women would have resumed menstruation after last live birth and some may be with different periods of amenorrhoea and continuing in the state of amenorrhoea at the time of the survey. The problem of censoring is usually handled through life table analysis, wherein we put together completed and incomplete data into developing a life table function *q(n)*, in the above case denoting the probability that the woman in the state of amenorrhoea at the beginning of *x* months after delivery, will resume menstruation during the month *n*.

The concepts of *truncation, censoring,* and *selection* have been used interchangeably in demographic analysis. Actually, the problem of bias in birth intervals compiled from retrospective data is essentially a statistical problem of *censoring, combined with selection,* but the term *truncation effect* has been given to it by demographers, and for the sake of continuity and understanding we will use the same terminology. While analysis using life table techniques successfully tackles the problem of *censoring,* it does not solve the problem of *truncation* and *selection.*

Now we have to recognize the fact that in any retrospective survey, say, of ever married women below the age of 50, as in the case of Fiji Fertility Survey, the data are compiled from many birth cohorts, a synthetic cohort, i.e.,

6. Sheps, H.C. and J.A. Menken, 'On Closed and Open Birth Intervals in a Stable Population', paper presented to Segunda Conferencia, Regional de Población, sponsored by the ISSUP, Mexico City, August 1970.
7. Venkatacharya, K., *'Some Recent Findings on Open Birth Intervals'*, Artha Vijana (India), Vol.II, No.3, Sept. 1959.

for different values of $a$. If the parent cohort of birth interval distributions $T_{ic}$ change with cohort $c$, as is likely to happen in any society where fertility is changing, then we are faced with two types of problem: 1) the *truncation* effect due to $a$ and 2) the proportion of women in different ages $a$. Due to a variety of reasons, such as changes in mortality and nuptiality, the second factor may change with time, and if we consider the birth interval data from retrospective surveys, it seems absolutely essential that we should control for age and parity.

**b) Response errors**

Since an accurate assessment of the interval between two births needs correct information on the timing of the occurrence of two births, or the marriage and the first birth in the case of the first interval for each woman, the response errors in birth interval data are likely to be more than the errors in the timing of the events considered separately. However, it is also likely that women may remember more accurately the interval between two births than the dates when each of the two births occurred in the calender time. A systematic shift in the reporting of births by a fixed period of time, say, one year, will not affect the closed birth intervals. Thus, when data on intervals are collected by compiling specific information on the dates of occurrences of each of the events, such as marriage and births, one may get different types of errors in the interval data rather than when the data are compiled first on the date of occurrence of the marriage, and subsequently the intervals between successive births are obtained and used to ascertain the dates of occurrence of the subsequent events. It is also possible to obtain data by going backward in time, commencing from the last live birth. One cannot be sure beforehand as to which method of collection of data will lead to better results in terms of reduction in errors. In most of the fertility surveys, data are compiled usually from each woman on the time of occurrences of each of the vital events prospectively commencing from the date of marriage of the couple, and the interval data are subsequently checked for their consistency in terms of feasibility (a birth interval cannot be shorter than 9 months) and possibility of recall lapse giving rise to unduly long birth intervals. Such a procedure has been adopted in most of the retrospective surveys, especially the surveys carried out under the auspices of the World Fertility Survey. Potter[8] has made a detailed analysis of the distribution of births in different time intervals prior to the survey data, on the data collected from the Fiji Fertility Survey and for any given duration of marriage, observed a U-shaped pattern wherein births appear to be relatively more in times nearer the survey data and also nearer the marriage date than would be expected. He has attributed this phenomenon in part to selective recall lapse and in part to the forward type of questioning adopted in the surveys. One simple way of checking the quality of interval data is to estimate the extent of digit preference that is observed in the distribution of intervals. For example, it has been found that in most of the developing countries the distribution of closed birth intervals cluster round multiples of twelve or six months, because there is a tendency on the part of the respondents to report the interval between successive births in multiples of whole or half year. If the intervals are reported without any such digit preferences (of twelve or six months) it can be expected that when the intervals are divided by 12 and classified by the residue, the distribution obtained will conform closely to a uniform distribution with a probability of 1/12 at each of the digits 0, 1, 2 . . . 11. A simple digit preference quotient can be computed on the basis of the observed minus the expected values and used for checking the quality of data.

In many situations, the data on birth intervals are simply not available, since information on the month of the birth of the child, or the marriage of the woman, and in some situations even the year of the occurrence of the events is not known. In such cases, imputations of the month and/or year of the occurrence of the events are made according to some criteria. One simple method of imputing the timing of the birth of a child, where the year of birth is given, is to assume that the child was born on the first of July of that year, namely, the middle of the year. Various other procedures for the imputation of the time of occurrence of the events, including a choice of a random month within that year, have been developed, but it has been found that this simple procedure of imputing the time of occurrence of the child at the middle of the calendar year has considerable practical advantages and provides a fairly good statistical stability. However, when imputation is made for two successive births making a birth interval, there will be a digit preference for such intervals, increasing the digit preference quotient. The proportion of intervals for which an imputation has been made (for either of the two births) can in itself be used as an index of the quality of data. The extent of digit preference that existed among all the intervals, including the imputed intervals as well as among those intervals excluding the imputed ones, should be considered separately for judging the quality of interval data.

The interval between the marriage and the first child is in a sense unique among the set of birth intervals. This interval can be expected to be shorter than other intervals, in view of the fact that the component of post partum amenorrhoea which is present in the subsequent birth intervals is absent in this first interval. This interval can, however, be expected to be longer than nine months in countries where there are no pre-marital relations. On the other hand, in societies where pre-marital pregnancies do occur with certain acceptable frequency, it can be expected that this interval will be less than nine months, and in a few situations, negative as well, with the marriage occurring after the birth of the first child. The extent to which the first birth interval assumes negative or positive values of less than 7 months (allowing for premature births) can be taken to be an index of laxity in matters relating to premarital sex relations in the population. In case one knows *a priori* that such laxity on premarital sex is not allowed by the culture, such information will reflect the poor quality of data. Thus, with regard to assessment of response errors in the quality of birth interval data, three types of analysis will be useful, viz., i) the proportion of birth intervals for which imputation of data have been made either at the field level or at the level of analysis, ii) the extent of digit preferences in the interval distribution, both including as well as excluding the imputed data; and iii) proportion of negative or positive intervals less than 8 months in the computations of first birth interval. This is illustrated from the birth interval data for Fiji.

2.1.3. TYPES OF CLOSED INTERVALS

From the data collected through retrospective surveys, different kinds of closed birth intervals can be obtained

8. Potter, J.E., 'Methods of Detecting Errors in WFS Data: An Application to the Fiji Fertility Survey', Invited paper presented to the Mexico Conference of the International Union for the Scientific Study of Population, August 1977.

through various ascertainment plans. In recent years some research has been done on the usefulness of these different types of closed intervals as measures of fertility. In deciding the usefulness of a particular kind of interval as a measure of fertility, two criteria have been employed, viz., its sensitivity and its robustness. The criterion of sensitivity of a fertility indicator, such as the birth interval, attempts to measure the extent to which there is a change in the fertility indicator in as short a time as possible, as a consequence of a change in the basic fertility parameters, such as fecundability, foetal wastage, and post partum amenorrhoea or the age specific marital fertility rate. The earlier in time, a particular fertility indicator, such as closed interval obtained by a particular ascertainment plan, can pick up and reflect changes in the fertility parameters, the more sensitive the fertility indicator is supposed to be. The second criterion of robustness reflects the extent to which changes in the fertility indicator are caused by factors other than fertility parameters. The lesser the indicator is influenced by non-fertility factors, the more robust it is supposed to be. For example, while the crude birth rate can be considered to be highly sensitive of the fertility levels and changes in a population, it is not robust since changes can be caused in the same index by changes in the age-sex-marital status composition of the population. Indicators which are at the same time sensitive and robust are preferable to those which have only one of the two characteristics. It is worthwhile examining whether closed and open birth intervals can serve as sensitive as well as robust indicators of fertility levels and changes in a population.

Among the closed birth intervals from retrospective surveys, four types of intervals seem to have been indicated and used in the literature. The sensitivity and robustness of each type of interval has been examined by Sehgal[9], and the following findings are based on his doctoral dissertation. Sehgal has based his analysis of sensitivity and robustness on data on birth intervals obtained through computer simulations, and comparing the closed and open birth intervals obtained through different ascertainment plans under different fertility assumptions. He studied how changes in fertility input parameters have affected the birth intervals.

**i) All Closed Birth Intervals (ACBI)**

Here, all the closed birth intervals obtained from a retrospective survey are included in the analysis which is made by birth order and current age of the woman. A woman of parity-*i* will contribute *i-closed* intervals. Simulation studies have revealed that this type of closed birth intervals is not sensitive to fertility changes, and any change in fertility does not affect the mean intervals computed in this manner until about 15 years after the change has taken place in fertility. This indicator, therefore, cannot be used as a sensitive index of fertility but can only be taken as indicative of the past fertility levels of the population or as the average of the fertility during the past fifteen years.

**ii) Last Closed Interval (LCI)**

Here, the interval between the last and last but one live birth of each woman is included in the analysis. Every woman who has given birth to at least one child will contribute to one closed interval under this scheme. The women can be classified by parity and age at the time of survey or at the beginning of the interval, and used in analysis. The computer simulation studies have, surprisingly, indicated that this interval can be considered as a sensitive index of fertility and at the same time is also robust when the analysis is made by parity. This interval can be used in measuring the current changes in fertility if repeat surveys are conducted in the population and the data on last closed intervals are analysed. Further, if the analysis is restricted to the last closed intervals straddling the date of commencement of the family planning programme, the effect of the programme gets reflected in such intervals. One advantage of restricting the analysis to the last closed interval is that the data on this interval can be expected to be more reliable than earlier closed intervals, since it requires recall of information, on the part of the respondent, only on the most recent two vital events before the survey date.

**iii) Straddling Intervals (SI)**

An interval is considered to be straddling at a particular age or at a particular time point if one birth occurs before that age or particular time point and the next birth occurs later. The straddling intervals are considered to be reflective of the fertility situation at a particular point of time or age around which the straddling occurs. Simulation studies have indicated that this type of interval is quite sensitive to changes in fertility and also fairly robust to changes in non-fertility factors. If the straddling point is chosen as the year in which the family planning programme is commenced or initiated, successive sets of intervals will reflect changes in fertility attributable to the programme.

**iv) Prospective Birth Intervals (PBI)**

In this method of ascertainment, only the closed intervals wherein the earlier birth occurs at a particular age interval and the next birth occurring at any time in future are included in the analysis. In some situations the closed intervals which occur after a particular age are also included in this category. For example, the prospective interval at age 30 includes the intervals wherein both the births occur after the age 30. In such analysis, with increasing age, the truncation bias increases. These intervals can also be analysed by parity. Computer simulation studies have indicated that this type of ascertainment introduces a serious truncation bias in these intervals, and as such they can be considered neither sensitive nor robust, especially at older ages. Table 1 provides a summary of the results obtained from the computer simulation study of Sehgal[10] on the effects of decrease in mortality and the effect of decrease in fertility on various types of birth intervals from the criteria of sensitivity and robustness. From this table it can be seen that among the closed intervals only the straddling interval and the last closed interval can be considered to be sensitive as well as robust. But compared to even these two types of intervals, the study revealed that the open birth interval analysed by the age of mother at the time of the survey was highly sensitive to current fertility levels and changes, remaining at the same time robust to changes in other non-fertility parameters of the population.

Historically, analysis of closed birth interval data has been confined to mainly the first set of intervals, namely, all closed birth intervals. In some selected studies, such as standard fertility surveys conducted in India[11], analysis was confined to the last closed birth intervals (LCI). As mentioned earlier, the ACBI's are subjected to serious

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9. Sehgal, J.M., 'Indices of Fertility Derived from Data on the Length of Birth Intervals, Using Different Ascertainment Plans', Department of Biostatics, University of North Carolina, Chapel Hill; *Institute of Statistics Mimeo Series,* No.768, Sept. 1971.

10. Ibid.

11. Central Family Planning Institute, *'Standard Fertility Survey Manual of Operations', New Delhi, 1965.*

**Table 1.** Sensitivity and Robustness of Different Types of Birth Intervals Based on a Computer Simulation*

| Kind of Birth Interval | Effect of Decrease in Mortality | Effect of Decrease in Fertility on Birth Interval | Robustness |
|---|---|---|---|
| Open Birth Intervals, by Age of Mother at Survey | No Change | Proportional Increase | Yes |
| All Open Intervals | " | Slight Increase | No |
| Straddling Intervals | " | Proportional Increase | Yes |
| All Previous Closed Intervals, by Total Number of Intervals at Survey Date (ACBI) | " | Proportional Increase in Last Few Intervals | Yes |
| All Closed Birth Intervals | " | No Change | Yes |
| Last Closed Interval by Age of Mother Measured at (LBI)<br>i) Beginning of Interval<br>ii) End of Interval<br>iii) Survey Date | " | Proportional Increase in Earlier Age Groups, Smaller Increase as Age of Woman Increases | Yes |

* Adapted from Table 5.1., page 107, of the doctoral dissertation 'Indices of Fertility Derived From Data on the Lengths of Birth Intervals, Using Different Ascertainment Plans' by Sehgal, J.M., presented to the Department of Statistics, University of North Carolina, Chapel Hill, U.S.A. *Institute of Statistics, Mimeo Series, No. 768.*

truncation biases because of the limited span of reproduction and the different ages at which the women are observed at the time of the survey and because of this bias the mean values of closed birth intervals are found to decrease with parity in spite of the fact that the fecundability of women is found to decrease with age. Thus, projecting the observations made from all closed birth intervals to distribution of birth intervals for all women completing the reproduction has to be done with great deal of caution, since the former distributions may not represent the completed cohort pattern. However, as mentioned earlier, the last closed intervals are subjected to another type of compensating bias in the opposite direction. Since women of parity $i$ contribute only one birth interval $i-1$ to $i$, in this scheme, the women of parities $i+1$ and above who are exected to have shorter birth intervals between $i-1$ to $i$ are excluded from the analysis. This gives a positive bias to the closed birth intervals in contrast to the negative bias caused by the truncation effect. Probably this is one of the reasons why the computer simulation studies have revealed that LCI is a more sensitive and a robust index of fertility than the ACBI. Birth interval data from Fiji Fertility Survey have been illustratively used to compare the means and variances of different types of birth intervals classified by parity and different socioeconomic groups to analyse the nature of differences among different types of intervals.

## 2.2. OPEN BIRTH INTERVAL

The open birth interval is extremely simple in its concept and it is easily measurable since the only point of time needed as information is the date of birth of the last child. In countries where it is difficult to obtain reliable information on the time, points of occurrence of vital events, such as births, deaths, marriages, because of illiteracy, inadequate social and cultural motivation to remember such details, and errors due to recall lapse, the open birth intervals are relatively easier to measure and are likely to be more reliable. Unfortunately, of the two types of intervals, the closed and the open, the former seems to have drawn greater attention of demographers and statisticians both for analytical investigations as well as for analysis of empirical data. Studies in the field of open birth intervals seem to be more recent, but the momentum of interest in the interval seems to be increasing in the past few years in the light of some findings and observations that this interval is an important factor to be reckoned with in differential fertility, and under certain circumstances can be used as a simple sensitive index useful in the measurement of short-run changes in fertility in developing countries[12].

Though the study of open birth intervals in human populations appears to be of relatively recent origin, studies on intervals of time similar in concept were carried out in medical and industrial fields much earlier. For example, conceptually, the distribution of open birth interval is similar to the age distribution of population in which the interval is measured from the birth of an item or person instead of from the birth of the last child, the duration of sickness of people in a cross sectional survey, the distribution of the hospital days of the inpatients of a hospital, or the duration of use of the different industrial products in any cross sectional survey. Statistical studies of the above variables in industry or in medical practice were done to a limited extent in the thirties[13]. However, application of these analytical techniques to the open birth interval in the human population does not seem to have been made till recently.

In fertility the open birth interval appears to have been

12. Srinivasan, K., 'A Set of Analytical Models for the Study of Open Birth Intervals', *Demography,* Vol. 5, No. 2, 1968
13. Lotka, A., 'A Contribution to the Theory of Selfrenewing Aggregates with Special Reference to Industrial Replacement', *Annals of Math. Stat., 10, 1939.*

used for the first time in the analysis of survey data as an independent variable in the form of either an explanatory variable or a predictor variable in the study of fertility. It has been used in the analyses of fertility data collected through sample surveys in Taiwan and Korea. In Taiwan, the open birth interval has been used extensively in the analyses of fertility differentials that were existing in Taichung city before the launching of the intensive action programme in 1963. In judging the fertility differentials of contraceptive users and non-users on the basis of a pre-programme survey data, it was found that the differences can be attributed mainly to the open birth intervals[14]. Any woman who had ever used a birth control method had an open birth interval substantially longer than a woman of same age who had never used a birth control method. This was mainly because of the fact that most couples who ever used contraception had used it in the open interval, and that too fairly effectively.

As indicated earlier, Mohapatra's analyses of the relative roles of age at marriage, inter live birth intervals and the open birth intervals in explaining the fertility differentials that existed between different groups in Taiwan, revealed that of these three factors, the open birth interval was the most important factor in determining the fertility differentials[15]. Analyses of the fertility of the couples classified on the basis of the extent of their modernization with regard to factors such as education, occupation, income, and number of modern objects owned, revealed a remarkable association between the extent of modernization and mean open birth intervals and the mean open birth interval as a proportion of the duration of marriage. More modern couples in Taiwan seem to have lowered their fertility mainly by increasing their open birth interval and only to a very limited extent by increasing the age at marriage or the spacing between births.

In Korea it has been used as a predictor variable for determining the type of women who are more likely to accept a family planning method when exposed to a family planning programme. On the basis of a computer analysis of the programme data on twenty-two variables collected for a sample of women in Koyang and the rates of acceptance of any family planning method among them during the subsequent two-year period while exposed to an intensive family planning programme, it was found that the open birth interval was the optimum predictor among all the twenty-two variables[16]. Women whose last live birth had occurred less than 30 months prior to the baseline survey showed 57 per cent acceptance in the following two-year period, while those with longer open birth interval showed only 9 per cent acceptance.

The open birth interval has also been used to a limited extent in analyses of the effectiveness of family planning methods in the Koyang study, under the assumption that if a family planning programme is effective it should sooner or later reflect a longer average open birth interval for a group of women subjected to the programme. A comparison of the average open intervals at the end of the programme between the experimental (Koyang) and control area (Kimpo) revealed a two-to-four months longer open birth interval in Koyang than in Kimpo[17].

Probably based on these empirical observations, the Committee on Comparative Studies of Fertility and Family Planning of the International Union for the Scientific Study of Population has stressed the importance of the open birth interval by including it as a variable in the *core list*[18]. In commenting on the importance of this variable in fertility analyses, the committee has stated "Social differentials in fertility are only attributible either to social differentials in the age at marriage or in the open birth interval rather than to differentials in the interbirth intervals.... In less developed countries, a frequency distribution on the length of the open birth interval taken periodically as a time series may be a useful index of the adoption of contraceptive practices. If there is a spread of such practices there should be a lengthening of the open birth interval." This recommendation seems to have been based on the findings of analyses of Taiwan and Korean data which used open birth interval essentially as an independent variable either for explanation of the observed differentials or for prediction of future programme acceptance by couples and to a limited extent as an index to assess the extent of adoption of contraceptive practices.

Research on the specific utility of this interval as an index of fertility *per se*, that is a dependant variable rather than an independent variable or as a covariable with other indices of fertility, appears to have been done on analytical grounds independent of the above findings. Srinivasan[19] proposed that the mean open interval, computed by parity, can be considered as a sensitive index of fertility, especially for the measurement of fertility change in developing countries, if the distributions of open birth intervals by parity are obtained at successive points of time through independent sample surveys of women in the reproductive ages in the population. He based his conclusion both on analytical grounds as well as on analyses of empirical data. As briefly mentioned in Section II (A), fertility has to be studied in two dimensions; firstly, how women space their children, and, secondly, how many women of a given parity proceed to the next parity ever in their reproduction life. While closed birth intervals can be considered to be reflective of the first dimension, they are relatively insensitive to changes in the second dimension. The parity progression ratios are the specific indicators of fertility in the second dimension.

Fertility differentials between countries and among different socio-economic groups within the country are largely attributable to differences in limiting patterns. Srinivasan analytically proved[20] that the open birth intervals are direct statistical functions of the parity progression ratios and that these ratios can be estimated from data on the mean and variance of the open birth intervals with a knowledge of a few other parameters of the population. He also empirically demonstrated[21] through the analysis of data on birth intervals collected in a retro-

14. Freedman, R. and J.Y. Takeshita, *Family Planning in Taiwan*, Princeton University Press, Princeton, 1969.
15. Mohapatra, P.S., *The Effect of Age at Marriage and Birth Control Practices on Fertility Differentials in Taiwan*, unpublished Ph.D. Dissertation in Sociology, University of Michigan, 1966.
16. Ross, J. and S. Bang, 'Predicting the Adoption of Family Planning', *Studies in Family Planning*, No.9, Population Council, New York, January 1966.
17. Bang, S., *'A Comparative Study of the Effectiveness of a Family Planning Programme in Korea'*, unpublished doctoral dissertation, School of Public Health, University of Michigan, 1968.
18. United Nations, *Variables and Questionnaire for Comparative Fertility Surveys*, prepared by the Committee on Comparative Studies of Fertility and Fertility Planning of the International Union for the Scientific Study of Population in collaboration with the United Nations Secretariat, New York, United Nations, 1970 (ST/SOA, Ser. A/45).
19. Srinivasan, K., 'The Open Birth Interval as an Index of Fertility', *Journal of Family Welfare (India)*, Vol.XIII, Dec. 1966.
20. Srinivasan, K., 'A Set of Analytical Models for the Study of Open Birth Intervals', *Demography*, Vol.5, No.2, 1968.
21. Srinivasan, K., 'Findings & Implications of a Correlation Analysis of the Closed and Open Birth Intervals', *Demography*, Vol.7, No.4, Nov. 1970.

spective survey in India that the correlation of the open birth interval with parity controlling for age of the mother is quite high in absolute value and that mean open birth interval by parity can be considered equivalent to the conventional fertility index of average number of children ever born to women by age. However, it has been observed that it is more sensitive to recent changes in fertility. When current marital fertility decreases, the mean open birth interval by age increases and the proportionate increase in the mean open interval by age is almost equal to the proportionate decrease in marital fertility in the age group. The parity progression ratios from one parity to the next, based on the distribution of the open birth intervals, last closed interval, and the ages of the mother at the birth of the last child at the time of the survey, were also estimated.

In a recent analysis of data on birth intervals in 1970, collected from 1/1000 Public Use Sample of the U.S. Population, Hastings and Robinson[22] replicated and expanded on Srinivasan's findings that even in a developed country the open birth interval is a sensitive index of cumulative marital fertility, when marital duration and parity are controlled. It was found from the analysis that even on the basis of a micro level correlation analysis (based on data for each woman) of open interval and parity or open interval and children ever born divided by marital duration, there is a consistently high negative correlation in each age group (over 0.6 in absolute magnitude in many age groups) indicating that the mean open interval by age groups can be used as a sensitive index of fertility. The correlation coefficients can be expected to be much higher if the analysis is based at a macro level (groups) than at the micro level.

Thus, it appears that there are sound analytical reasons backed by empirical evidence from developed and developing countries for relating mean open interval computed for each age group, through regressional or functional forms, to age specific marital fertility rate and to mean number of children ever born by marital duration. Since there are many random factors (such as mortality) other than fertility and duration of marriage that determine the duration of open birth interval, and these are population specific, it seems prudent to use population specific regression equations relating open birth intervals and fertility and use such regressions to measure changes in fertility in the same populations over time rather than measuring fertility differences across population groups using data on open birth intervals. Also, in conjunction with data on closed open birth intervals and age at the birth of the last child before the survey date, the open birth interval data can be used for the estimation of parity progression ratios. Further, in combination with data on closed intervals the open birth intervals can be used in developing life tables of women of any parity surviving in the same parity status at various time intervals after the birth of a child. These three uses of data on open birth intervals are illustrated from the Fiji Fertility Survey.

22. Hastings, D.W. and W.W. Robinson, 'Open and Closed Birth Intervals for Once-married Spouse–Present White-Women', *Demography*, Vol.12, No.3, Aug. 1975.

# 3 Methods of Analysis of Birth Interval Data with Illustrative Applications from Fiji Survey

In this section an attempt is made to provide an illustrative set of analyses with the birth interval data compiled from the Fiji Fertility Survey in 1974. The objective is more to illustrate the methodology of analysis and highlight the issues involved than to provide substantive findings on Fiji. Such an analysis can proceed in distinct logical stages, with the following specific objectives:

a) Checking the quality of data through an analysis of extent of imputations of intervals and digit preference quotients.

b) Estimation of means and variances of closed and open intervals, classified by a number of socio-economic and demographic factors including age, marital duration and parity. Closed intervals can be computed using different ascertainment plans as discussed earlier.

c) Correlation and regression analysis of closed and open intervals with other indices of fertility in order to check on the nature of interrelationships.

d) Estimation of fecundability from the use of appropriate probability models for closed intervals and parity progression ratios from the open birth intervals.

Before proceeding with such an analysis it seems worthwhile to describe briefly the Fiji Fertility Survey conducted in 1974.

## 3.1. BACKGROUND OF FIJI FERTILITY SURVEY

Fiji is one of the smallest archipelagian nations of the world, made up of 300 and odd islands scattered across 425,000 sq. kms of the Pacific Ocean, with a total population of 550,000 in 1973. The land mass and the population of the country are concentrated in two principal islands containing 87 per cent of the land area and accommodating over 90 per cent of the population. About one-third of the population live in areas classified as urban or peri-urban. Suva, the capital city with a population of about 75,000, is by far the largest urban centre.

The population of Fiji though small, is characterized by ethnic and religious diversity. It is composed of two major ethnic groups: Fijians and Indians. The Fijians with a total population of 242,000 constitute 44 per cent of the total population and are the local indigeneous people. Indians were introduced to Fiji as indentured labourers between 1879 and 1916, when the extensive cultivation of sugar cane crop in the island demanded more labour than what the native population could supply. The Indian population has grown since then, mostly because of a high rate of natural growth, and the recent numbers indicate that they are about 281,000 constituting about 51 per cent of the total population. By religious denomination, most of the Fijians are Christians of some order, mainly Methodists and Catholic, while the Indians are mostly Hindus or Muslims, though a sizeable proportion of Indians are also Christians. The birth rate in Fiji has recorded a dramatic decline in the 1950's and 1960's, with the crude birth rate having declined from 40 per thousand population in the 1950's to 28 per thousand in 1973. The general fertility rate for the Indians during this period has almost halved, while the Fijian fertility rate has recorded a slower decline from a more modest level in the 1950's. It is felt that the family planning programme initiated in the country on a national scale in 1962, by the medical department, has contributed significantly to this rapid decline in fertility.

The Fiji Fertility Survey (FFS) was undertaken in early 1974 as a national endeavour, with financial assistance from the International Statistical Institute for a demographic analysis of the population, especially of the interrelationships of socio-economic factors on fertility, and for an assessment of the family planning programme. The FFS was viewed by the International Statistical Institute as its pilot project to test its machinery for the WFS world-wide programme of surveys, viz. the core questionnaire, the sampling, organization, analysis of data, and role of WFS itself. The survey was carried out by the Bureau of Statistics, Government of Fiji, with the technical and financial assistance of the World Fertility Survey. The World Fertility Survey which was just beginning its global operation in 1973 as an international programme of research into human fertility behaviour, utilized the opportunity of the survey in Fiji for pre-testing its survey methodology, including the administration of core questionnaire developed earlier for international application. The Fiji survey was carried out on a random sample of 5,000 households, representing 95 per cent of the population. The selected households were visited in early 1974 by 70 specially trained female interviewers working under the close guidance of the 20 supervisors and 4 permanent staff of the Bureau of Statistics. The questionnaires administered to the selected households consisted of two parts: part-1, a household schedule was administered to any adult member of the household, preferably the head of the household, mainly to obtain particulars on the names of all persons who stayed in the house the night previous to the day of the enquiry, including usual members of the household and temporary visitors and the usual members of the household who were temporarily absent. For each member, particulars of his or her relationship with the household, resident status, sex, age, marital status, and race were selected. For every female in the household, aged 15 years and over, additional information was collected on the number of children born, number living, and particulars of her most recent live birth. The information collected in the household schedule was useful for studying the demograhic profile of the population, fertility and mortality levels in general terms, and also for identifying the women to whom the main fertility questionnaire would be administered.

The fertility questionnaire was administered to all ever married women 15 to 49 years of age, with the definition of the term *ever married* including women who had experienced *de facto* unions as well as those in legally sactioned marriages. The fertility questionnaire consisted of 7 sections:

1. Respondents Background
2. Maternity History
3. Contraceptive Use
4. Fertility Planning
5. Work History
6. Current Husband's Background
7. Marriage History.

The particulars collected in Section 2 contain data on the time of occurrence (month and year) of the various live births that occurred to the woman, from her marriage to the date of the survey. They also include information on the number of foetal wastages that occurred in the first birth interval, in the open interval, and in the entire reproductive history of the woman. Particulars of the duration of the breastfeeding and duration of post-partum sexual abstinence were collected only with reference to the last child. Since at the time of the survey many women were continuing to breastfeed the child and were still in the period of post partum sexual abstinence, this procedure could provide only incomplete and truncated histories of these two variables. This posed a problem in the analysis of the distribution of these two variables, and life table techniques had to be adopted in order to get the parameters of the distributions of post partum amenorrhoea and post partum sexual abstinence.

Section 3 included particulars on the contraceptive use in each of the birth intervals. Information on the method adopted and the duration of use was also available. Section 7 provides information on the marriage histories of the women, including whether the woman was married more than once before the survey, whether currently married at the time of the survey, and whether there was any marriage during each birth interval.

Various analyses based on the data collected in this survey have been carried out and published by different analysts. A major report presenting the important substantive findings was published in 1976 by the Fiji Bureau of Statistics under the title *Fiji Fertility Survey, 1974: Principal Report.* The data, especially from the maternity and marriage histories, permit a detailed analysis of the distributions and differentials of different types of birth intervals in the Fijian population and also assist in checking the quality of the data collected in the survey. In such an analysis the four specific objectives listed earlier could be followed one by one. The data on the time of occurrence of each of the vital events together with the background characteristics of the woman and of her husband and her contraceptive and marriage history were stored on tape for analysis through electronic computers. The analyses and the findings are described in the following pages.

## 3.2. CHECKING THE QUALITY OF DATA ON CLOSED AND OPEN INTERVALS

### 3.2.1. EXTENT OF IMPUTATION OF TIME OF OCCURRENCE OF EVENTS

Past experience with the analysis of fertility survey data in developing countries indicates that in many cases women are not able or not willing to report the month and/or year of occurrence of various vital events in their lives, and investigators enter the best estimates in most such situations. In a few other situations, the relevant columns are left blank in the schedules, and imputation is done at the time of coding or at the time of analysis in the computer. The proportion of events or birth intervals for which imputation has been made in any of these stages, is an index of the quality of the data. Table 2 provides the imputations made in the Fiji data at the time of the computer analysis.

**Table 2.** Extent of Missing Values on the Time of Occurrence of Different Types of Vital Events

| | Events | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Births | | | | | |
| Item | Births of Women | First Marriage | First | Second | Third | Fourth | Fifth | Sixth and above |
| Total | 4,928 | 4,928 | 4,368 | 3,695 | 2,983 | 2,311 | 1,769 | 3,530 |
| Year of Occurrence Not Known | 181 | – | – | – | – | – | – | – |
| Month of Occurrence Not Known | 1,184 | 661 | 435 | 371 | 250 | 265 | 182 | 215 |
| Percentage Of Missing Information | 27.70 | 13.41 | 9.96 | 10.04 | 8.38 | 11.47 | 10.29 | 6.09 |

In Fiji, the survey was conducted on a total of 4,928 ever married women in the age group 15-49. Information on the year of birth was missing for 181 women (3.7 per cent) and data on month of birth were missing for 1,184 women (24.0 per cent). On the month and year of occurrence of the first marriages of these women and births of successive children to them, information is available for all on the year; and for 6 to 13 per cent of the events the month is not known. Probably, in the case of marriages and of births of children, the imputation of the year of occurrence had already been made at the time of coding the data. Table 2 also presents the extent of missing information on the time of occurrence of various events. The percentage of events for which the month of occurrence is not known, is found to be substantially high, especially with regard to the birth of the women. For other types of events, such as their marriages and births of children, the extent of month-unreported category is not high. In further analysis, for events for which the information on just the month of occurrence was missing, imputation was made by assuming that the events occurred in the middle of the year. While imputing, it was made sure that any interlive birth interval turning out to be less than 9 months was corrected to 9 months.

### 3.2.2. INTERVALS TO BE INCLUDED IN THE ANALYSIS AND EXTENT OF IMPUTATIONS IN THEM

The decision to include or exclude a birth interval from the analysis poses a number of difficult problems, analytic as well as empirical. Particularly, the analysis of a closed birth interval (excepting from marriage to the first child) in which a widowhood, and/or divorce, separation, and/or a remarriage occurs, followed by a live birth, poses serious difficulties. In this case, any analysis has to make, in the first instance, adjustments for the extent of non-exposure to the risk of conception because of a widowhood, divorce, or separation, and because of changes in fecundability likely to be caused by a subsequent marriage or stable union. It is also necessary to exclude intervals that are negative and of less than 8 months in the case of the first one and intervals of less than 8 months in the case of subsequent intervals. In theory, analysis of all the intervals would be smoother if only the intervals of women currently married, married only once, and below the age of 45 were included. But this procedure is likely to cut down the sample size of the intervals to a considerable extent in a society, such as Fiji, where there is a high prevalence of the remarriage of widows and divorcees. Hence it is advantageous, from the point of view of increasing the sample size, to consider all eligible intervals for all women reported ever married and in the reproductive ages at the time of the survey. The type of interval to be included or excluded also depends on the nature of analysis.

Table 3 presents figures on the number of birth intervals, closed and open, classified by birth order, where data are available from the survey, and the number that has been included for analysis in this report. The number considered for analysis has varied with the type of analysis. For the first set of analysis on quality, data with regard to the extent of imputation of intervals and of digit preference quotients and levels and differentials for birth intervals, as presented in parts B and C of this section, the first closed birth intervals which are negative or are of less than 8 months and all the subsequent birth intervals in which widowhood and/or a marriage has taken place have been excluded. As long as there is no marriage within a closed interval, such intervals of women married more than once were also included in the analysis to increase the sample size. On the other hand, with regard to the open birth intervals, only women currently married, once married, and below 45 years of age (and for whom age data were not available) have been considered for analysis. Since age of the mother did not specifically enter into the analysis in this set of tabulations, the category *age not known* was also included in the analysis. Regarding correlation and regression analysis, an estimate of fecundability in the closed and

**Table 3.** Number of Birth Intervals for Which Data Are Available and Number Considered for Analysis, by Type and by Birth Order

| | Type of Interval | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All Closed Birth Intervals (ACBI) | | | Last Closed Birth Intervals (LBI) | | | Open Birth Intervals (OBI) | | |
| Birth Order of Interval | Total | Considered for Analysis I[a] | Considered for Analysis II[b] | Total | Considered for Analysis I[a] | Considered* for Analysis II[b] | Total | Considered for Analysis I[c] | Considered* for Analysis II[d] |
| 0 - 1 | 4,368 | 3,728 | 2,972 | 673 | 548 | 490 | 560 | 466 | 461 |
| 1 - 2 | 3,695 | 3,558 | 2,790 | 712 | 671 | 574 | 673 | 555 | 548 |
| 2 - 3 | 2,983 | 2,911 | 2,224 | 672 | 652 | 549 | 712 | 589 | 576 |
| 3 - 4 | 2,311 | 2,271 | 1,682 | 542 | 531 | 451 | 672 | 568 | 551 |
| 4 - 5 | 1,769 | 1,748 | 1,236 | 496 | 490 | 391 | 542 | 472 | 452 |
| 5 & above | 3,530 | 3,485 | 2,115 | 1,273 | 1,261 | 849 | 1,749 | 1,329 | 1,240 |
| Total | 18,656 | 17,701 | 13,019 | 4,368 | 4,153 | 3,304 | 4,928 | 3,979 | 3,828 |

a. For analysis I, closed intervals within which a marriage took place, or intervals which are negative or less than 8 months, are excluded. In particular, twins are considered as single births, with birth order of succeeding births reduced by one.

b. For analysis II, in addition to those excluded for analysis I, closed intervals to women married more than once, not currently married, over 45 years of age, or age not known have been excluded.

c. For analysis I, open birth intervals to women not currently married, married more than once, or age above 45 years have been excluded (age unknown category has, however, been considered).

d. For analysis II, in addition to those excluded for analysis I of open birth intervals, intervals for women with age not known have been excluded.

* 1) Theoretically for any parity $i$, the number of open birth intervals (OBI), $U_i$ should be equal to the number of last closed birth intervals (LBI), $T_{i-1}$. In this case there are some differences because in the case of last closed interval negative and below 8 values have been excluded, while the subsequent open interval has been included.

2) Similarly the number of ACBI, 0 - 1 should be equal to sum of last closed intervals (LBI), $T_i$ equal to 1 and above, and for 1 - 2 equal to the number of last closed intervals 2 and above and etc. In this case there are minor differences since for a woman with parity $i$, with one closed interval -ve or less than 8 months, only that interval has been excluded in the analysis but other intervals have been considered.

open intervals, only closed intervals of 8 months or more and all non-negative open intervals of women currently married, once married, and below 45 years of age (and age known) have been considered for analysis.

From Table 3 we find that while information was available for 18,656 closed intervals (ACBI) from the survey, on the above considerations 17,701 intervals were considered for the first set of analyses and 13,019 intervals for the second set, viz., correlation and regression analysis and estimation of fecundability and parity progression ratios. Similarly, with regard to last birth intervals, of 4,368 intervals, 4,153 and 3,304 have been included for the two types of analysis, and with regard to open birth intervals, of 4,928, 3,979 and 3,128 have been considered for the two types of analysis. The breakdown of these intervals is given in the table.

In the first interval 0-1, it was found that of a total 4,368 intervals, 640 (14.7 per cent) had negative or less than 8 months value. This can be considered to be indicative of the extent of pre-marital conception prevailing in the population.

Table 4 presents data on the extent of imputation (for month-missing birth intervals) for different types of intervals classified by birth order, excluding the inadmissible ones for the first set of analyses described above.

**Table 4.** Number and Percentage of Imputed Birth Intervals (Month of Marriage or Births Imputed)

| | Type of Interval | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All Closed Birth Intervals (ACBI) | | | Last Closed Birth Interval (LBI) | | | Open Birth Interval (OBI) | | |
| Birth Order of Intervals | Total | Imputed | Percent | Total | Imputed | Percent | Total | Imputed | Percent |
| 0 - 1* | 3,728 | 874 | 23.44 | 548 | 63 | 11.50 | 466 | 16 | 3.43 |
| 1 - 2 | 3,558 | 618 | 17.37 | 671 | 37 | 5.51 | 555 | 10 | 1.80 |
| 2 - 3 | 2,911 | 556 | 19.10 | 652 | 52 | 7.98 | 589 | 9 | 1.52 |
| 3 - 4 | 2,271 | 500 | 22.02 | 531 | 48 | 9.04 | 568 | 10 | 1.76 |
| 4 - 5 | 1,748 | 441 | 25.23 | 490 | 79 | 16.12 | 472 | 18 | 3.81 |
| 5 & above | 3,485 | 909 | 26.08 | 1,261 | 236 | 18.72 | 1,329 | 61 | 4.59 |
| Total | 17,701 | 3,898 | 22.02 | 4,153 | 515 | 12.40 | 3,979 | 124 | 3.12 |

* 0 - 1 indicates the interval from date of marriage to the date of birth of the first child in the case of closed interval, and from date of marriage to date of survey in the case of open interval of women of parity zero.

From this table it can be seen that the extent of imputation is higher for all closed birth intervals (22.02 per cent); next high for last closed birth interval (12.40 per cent) and the least for open birth interval (3.12 per cent). This indicates that the extent of completeness of reporting of information on the date of occurrence of the last birth is more complete than the earlier birth. This is a very characteristic condition in a developing country. This indicates that on grounds of completeness of information observed in a survey, the open birth interval can be considered to be most reliable among different types of birth intervals. Among the closed birth interval the last birth interval is more reliable than the earlier intervals. Looking at the extent of imputation by birth order it is seen that the percentages imputed among the birth intervals follows a U-shape curve, with the percentages quite high in the first interval and lower in the second, third and fourth intervals and increasing again with higher parities. This indicates that the dates of occurrence of marriage and the first child are likely to be reported with large incompleteness than births of order 2, 3, and 4, and again the incompleteness of reporting increases with children of parity 5 and above. The maximum completeness in the reporting of data seems to occur in birth intervals 1-2, 2-3 and 3-4. Comparison of tables 2 and 4 reveals that the percentage imputation of intervals is substantially higher than the percentage imputation of the events making up the intervals.

3.2.3. DIGIT PREFERENCES

It is a common knowledge that data on birth intervals compiled from developing countries are subject to serious digit preferences, with women reporting the intervals in multiples of one year or half a year. In such cases, if the reported intervals are divided by 12 or 6 and classified by their residues, 1, 2, .... 11, 12 in the first case, and 1, 2, .... 5, 6 in the second case, there will be undue clustering of frequencies at 12 and 6 in the first case and at 6 in the second case. If there are no digit preferences, we can expect, in fairly large samples, the frequencies to be uniformly distributed with 1/12 in each cell in the first case, and 1/6 in the second case. Even in slightly skewed distributions, such as in the birth interval distributions, it can be shown that the distribution of residues will be more or less uniform. We can measure the departure from uniformity as follows.

In the first case if the observed frequencies or the number of intervals with the residue number 1, 2, .... 12 are denoted by $f_1, f_2 \ldots f_{12}$ and the total is denoted by $f$, then under the null hypothesis that there are no digit preferences, the quotient

$$q_1 = \sum_{i=1}^{12} \frac{(|12f_i - f|)}{f} \qquad \ldots\ldots\ldots.(3)$$

should be approximately zero. If all of them get concentrated in one residual digit, one of the $f_i$ will equal '$f$' and the remaining $f_i$'s will be zero making the $q_1$ value equal to 22. Thus the minimum $q_1$ value will be zero and the maximum will be 22. If we take $Q_1 = q_1/22$, then $Q_1$ can be considered to be digit preference quotient taking values 0 to 1, the value 0 being taken when there is absolutely no digit preference and the value 1 taken when all the birth intervals are in multiples of 12 months. Thus the value of $Q_1$ indicates the extent of digit preference in 0 to 1 scale.

Similarly we can compute another digit preference quotient on the basis of six-monthly preferences instead of twelve monthly preferences based on $Q_2 = q_2/10$.

$$\text{where } q_2 = \frac{\sum_{i=1}^{6} (|6 f_i - f|)}{f} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where $f_i$ is the frequency of intervals which leave a residue of $i$ when divided by 6, and $f$ is the total number of intervals. $Q_2$ takes the value 0 to 1.

The values of $Q_1$ and $Q_2$ can be computed developing simple computer programmes and will be useful in making comparative assessment of the quality of different sets of interval data. These have been computed for Fiji Fertility Survey data on birth intervals compiled through different ascertainment plans. Table 5 presents the summary values of $Q_1$ and $Q_2$ for different types of intervals in the Fiji Fertility Survey.

**Table 5.** Digit Preference Quotients, $Q_1$ (12 Monthly) and $Q_2$ (6 Monthly) for Different Types of Birth Intervals in Fiji Data Including and Excluding Imputed Values

| | $DPQ_1$ | | $DPQ_2$ | |
|---|---|---|---|---|
| Type of Interval | All Intervals | Excluding Imputed Intervals | All Intervals | Excluding Imputed Intervals |
| ACBI | 0.12 (17701) | 0.07 (13803) | 0.09 (17701) | 0.02 (13803) |
| LBI | 0.08 ( 4153) | 0.06 ( 3638) | 0.05 ( 4153) | 0.05 ( 3638) |
| OBI | 0.08 ( 3979) | 0.03 ( 3855) | 0.03 ( 3979) | 0.02 ( 3855) |
| Straddling at Age 20 | 0.11 ( 2492) | 0.05 ( 2015) | 0.09 ( 2492) | 0.03 ( 2015) |
| 25 | 0.09 ( 2299) | 0.05 ( 1896) | 0.07 ( 2299) | 0.04 ( 1896) |
| 30 | 0.10 ( 1348) | 0.07 ( 1119) | 0.08 ( 1348) | 0.03 ( 1119) |
| 35 | 0.09 ( 568) | 0.05 ( 473) | 0.07 ( 568) | 0.02 ( 473) |
| Prospective at age 20 | 0.10 (11039) | 0.06 ( 8984) | 0.07 (11039) | 0.02 ( 8984) |
| 25 | 0.10 ( 5166) | 0.05 ( 4163) | 0.08 ( 5166) | 0.02 ( 4163) |
| 30 | 0.08 ( 1883) | 0.05 ( 1506) | 0.07 ( 1883) | 0.02 ( 1506) |
| 35 | 0.09 ( 431) | 0.07 ( 343) | 0.07 ( 431) | 0.06 ( 343) |

Note: Figures in brackets indicate the number of intervals in which the Digit Preference Quotients have been computed.

Table 5 shows that the extent of digit preference, in both the $Q_1$ and $Q_2$ situations, is least among open birth intervals, higher among last birth intervals, and highest among all closed birth intervals. Including and excluding imputed intervals $DPQ_1$ values for open birth intervals are found to be 8 and 3 per cent, respectively; for last birth interval, 8 per cent and 6 per cent; and for all closed birth intervals, 12 percent and 7 per cent. $DPQ_2$ values for the three types of intervals are found to be 3 per cent and 2 per cent for open interval; 5 per cent and 5 per cent for last birth interval; and 9 per cent and 2 per cent for all closed birth intervals. The low values for these quotients, especially when we consider only the non-imputed intervals, are really striking. These are indicative of high quality data for a developing country, and is indeed a compliment to the care and efficiency with which the survey has been conducted. The $DPQ_1$ and $DPQ_2$ values for straddling intervals computed at ages 20, 25, 30 and 35 are also small, and there is no significant difference between all intervals and those excluding the imputed intervals. Similarly, the digit preference quotients of prospective birth intervals computed at the same ages – 20, 25, 30, and 35 – are also found to be small. Tables 2.1. to 2.6 in Appendix II provide the $DPQ_1$ and $DPQ_2$ values separately for different birth orders and for women classified by educational status, religious status, and contraceptive use. It is to be pointed out here that the DPQ values are highly sensitive to sample size, and quotients computed on frequencies of less than 60 for $DPQ_1$ and 30 for $DPQ_2$ (average frequency less than 5 for each digit) cannot be considered reliable. Since most of the straddling and prospective intervals 0-1 and 1-2 especially at ages 30 and 35 are less than these minimum frequencies, their DPQ values should not be considered reliable. Comparing the $DPQ_1$ and $DPQ_2$ values over different birth orders of the retrospective intervals, (ACBI, LBI and OBI) it is seen that for these three types of intervals the DPQ values are the highest for the first interval 0-1. This phenomenon is noticed whether we consider all intervals, or just those excluding the imputed intervals. This is again an indication of the fact that the data from marriage to the first child is not only susceptible to errors of omission on the timing of occurrence of marriage or the birth of the first child, but also on increased digit preferences with regard to interval. Such a pattern of digit preferences over birth orders is not observed in the case of straddling or prospective intervals.

Comparison of the $DPQ_1$ and $DPQ_2$ values between Tables 2.1 and 2.2 in Appendix II indicates that the $DPQ_1$

values are generally higher than $DPQ_2$ values, indicating an increased digit preference in multiples of 12 months rather than of 6 months. In this context it is worthwhile pointing out that theoretically there is no reason to assume that $DPQ_1$ values should be higher than $DPQ_2$ values, though the latter is based on 6 digits compared to the former based on 12 digits. The difference in the quotients based on all the intervals and those excluding imputed intervals indicate that when the month of an event is imputed it is likely to give rise to a digit preference in the interval.

Tables 2.3 and 2.4 in Appendix II provide data on the $DPQ_1$ and $DPQ_2$ values, respectively, of all closed birth intervals (ACBI), last birth interval (LBI), and open birth interval (OBI) for the women classified by three different socio-economic variables, namely, their educational status, religion, and contraceptive practice. These values are based on all admissible interval data including the imputed values. From these two tables, it is seen that generally those women with no education or unrecognised education have a higher digit preference quotient, indicating a stronger digit preference than those with some type of education. Among those with no education, who form a sizeable proportion of the sample, the ACBI has the highest $DPQ_1$ values (20 per cent) and the LBI the least (10 per cent); among these women with primary education which forms two third of the sample, the ACBI and OBI have the same $DPQ_1$ level (10 per cent) while the LBI has a lower value of 7 per cent. Since the frequencies of unrecognised and college education especially for LBI and OBI, are rather small, their DPQ values cannot be considered as reliable as those for the above two groups, that is, for no education and for primary education. The analysis by religion indicates that the Hindus and Muslims have higher $DPQ_1$ and $DPQ_2$ values compared to the other religious groups (Christians) in terms of all closed birth intervals (ACBI) and LBI. On the other hand, with regard to open birth interval (OBI), there does not seem to be any serious religious differential, and the Hindus have the least value (4.1 per cent on $DPQ_1$) compared to others. A special analysis was made for Hindus with no education with the objective of comparing the quality of interval data and also the levels and differentials of birth intervals with similar groups in India. For this group the $DPQ_1$ value jumped up to 19 per cent indicating that there is an interaction of religion and education with regard to quality of OBI. On the other hand, the increments on DPQ values based on ACBI and LBI between all Hindus and Hindus with no education were not substantial. The analysis by contraceptive practice was confined to three groups of women: those who never used any contraceptive in any birth interval; those who used contraceptive method subsequent to the interval under analysis; and those who used contraceptive during or earlier to the interval under analysis. Table 2.3. indicates that with regard to closed birth interval, ACBI and LBI, the DPQ values were the least in the third category and higher in the other two categories, and there is practically no difference among the three categories with regard to the open birth interval (about 5 per cent). This indicates that contraceptive users are likely to provide more reliable data on closed birth intervals while such a differential does not seem to exist in the case of the open birth intervals. Comparison of the findings between Table 2.3 and 2.4 indicates that for all groups the $DPQ_1$ values are higher than $DPQ_2$ values implying a higher preference to digits which are multiples of 12 than for multiples of 6.

Tables 2.5 and 2.6 in Appendix II display the digit preference quotients for straddling and prospective intervals for women classified by the three variables, education, religion and contraceptive usage. Table 2.5 presents the $DPQ_1$ values and Table 2.6 the $DPQ_2$ values. With regard to education considering the two large groups, namely, those with no education and those with primary education, it is found that at all ages 20, 25, 30, and 35 the DPQ values of the latter group are almost half those of the former group in straddling as well as in prospective intervals. There does not appear to be any strong age differential in the DPQ values of these intervals. With regard to religion, considering the two largest groups, the Methodists and Hindus, the DPQ value of the straddling and prospective intervals at all ages is higher for the latter than for the former, and the Hindus with no education have still higher values. There does not appear to be age differential in these values. With regard to contraceptive usage the contraceptive users have lower DPQ values than the never users at all ages. As in the case of earlier analysis the $DPQ_1$ values for all the groups (with sizeable frequencies) are higher than $DPQ_2$ values.

A general conclusion that could be drawn from the analysis of Table 5 and Tables 2.1 to 2.6 in Appendix II is that the general quality of data on birth intervals in the Fiji survey seems to be quite good for a developing country with the digit preference quotient based on data excluding any imputed value for closed birth intervals, about 7 per cent and for open birth intervals, about 3 per cent. The analysis including imputed intervals reveals preference quotients of about 10 per cent and 8 per cent for closed and open birth intervals. It will be intereresting to compare these quotients with similar values computed from fertility survey data from other developing countries in order to get a comparative picture of the quality of data. Though there are differentials observed in the digit preference quotients of women classified by education, religion, and contraceptive usage, they do not appear serious enough to warrant a separate analysis for these groups. The quality of data for all the groups can be considered to be fairly good.

### 3.2.4. GROUPING OF INTERVAL DATA

The class intervals to be selected for grouping of the birth interval data, are to be based on the extent of digit preferences that exist in the ungrouped distribution and are essentially done to reduce the biases and to facilitate further analysis of data. In Fiji we found that the extent of digit preferences are extremely small and the selection of class intervals may not really matter that much. In other developing countries this may not be the situation and selection of class intervals with their mid values at the preferred digits might help to reduce the error.

For Fiji, two class interval schemes were tried, with the grouping schemes chosen such that multiples of 6 or 12 will come near the middle of the class interval. Table 6 presents the distributions for retrospective intervals (ACBI, LBI, and OBI) according to the two schemes.

The distribution for retrospective intervals in Table 6 have been given under two grouping schemes with the birth intervals classified in 0-2, 3-8, 9-14 .... 117+ in the first scheme and 0-3, 4-9, 10-15 .... 118+ in the second scheme. For a comparative profile of the grouped and ungrouped data, the single month frequency distribution for the last birth interval of women of parity three for Hindus with no education is shown in Table 7. Table 6 also provides the mean and variance of the grouped distributions and, as well, the ungrouped distribution for purposes of comparison.

**Table 6.** Grouped Distribution of Retrospective Birth Intervals (ACBI, LBI, and OBI, Under Two Grouping Schemes)

| Grouping Schemes (Class Interval in Months) | | Type of Intervals | | | | | |
|---|---|---|---|---|---|---|---|
| | | ACBI (Frequencies) | | LBI (Frequencies) | | OBI (Frequencies) | |
| I | II | I | II | I | II | I | II |
| 0-2 | 0-3 | 0 | 0 | 0 | 0 | 204 | 277 |
| 3-8 | 4-9 | 120 | 824 | 15 | 97 | 504 | 493 |
| 9-14 | 10-15 | 3,943 | 3,759 | 642 | 647 | 480 | 479 |
| 15-20 | 16-21 | 3,086 | 3,132 | 597 | 616 | 364 | 352 |
| 21-26 | 22-27 | 3,912 | 3,796 | 720 | 707 | 332 | 307 |
| 27-32 | 28-33 | 2,188 | 1,981 | 544 | 514 | 213 | 219 |
| 33-38 | 34-39 | 1,510 | 1,426 | 397 | 385 | 196 | 193 |
| 39-44 | 40-45 | 802 | 742 | 290 | 275 | 164 | 166 |
| 45-50 | 46-51 | 639 | 605 | 237 | 221 | 149 | 124 |
| 51-56 | 52-57 | 355 | 329 | 141 | 134 | 118 | 128 |
| 57-62 | 58-63 | 284 | 277 | 114 | 116 | 103 | 100 |
| 63-68 | 64-69 | 180 | 165 | 90 | 85 | 90 | 96 |
| 69-74 | 70-75 | 168 | 171 | 79 | 80 | 91 | 81 |
| 75-80 | 76-81 | 100 | 95 | 60 | 55 | 76 | 73 |
| 81-86 | 82-87 | 81 | 74 | 39 | 39 | 71 | 72 |
| 87-92 | 88-93 | 65 | 69 | 34 | 37 | 75 | 75 |
| 93-98 | 94-99 | 57 | 50 | 34 | 29 | 67 | 74 |
| 99-104 | 100-105 | 33 | 31 | 23 | 21 | 73 | 69 |
| 105-110 | 106-111 | 25 | 27 | 11 | 10 | 66 | 62 |
| 111-116 | 112-117 | 25 | 23 | 13 | 14 | 70 | 73 |
| 117+ | 118+ | 128 | 125 | 73 | 71 | 473 | 466 |
| | Total | 17,701 | 17,701 | 4,153 | 4,153 | 3,979 | 3,979 |
| $\overline{X}$ Grouped | | 27.31 | 27.30 | 34.20 | 34.31 | 44.88 | 46.12 |
| S.D. Grouped | | 17.94 | 18.11 | 23.02 | 23.13 | 39.79 | 39.25 |
| $\overline{X}$ Ungrouped | | 27.46 | | 34.75 | | 50.43 | |
| S.D. Ungrouped | | 19.11 | | 25.50 | | 53.94 | |

**Table 7.** Distribution of Single Months of All Closed Birth Intervals (ACBI) of Birth Order 2-3 for Hindus with No Education

| | In Months | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| In Years | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | All |
| 0 | – | – | – | – | – | – | – | – | 3 | 21 | 13 | 7 | 44 |
| 1 | 55 | 9 | 15 | 10 | 20 | 17 | 16 | 16 | 10 | 19 | 16 | 13 | 216 |
| 2 | 47 | 12 | 6 | 14 | 15 | 17 | 5 | 8 | 7 | 5 | 4 | 7 | 147 |
| 3 | 23 | 6 | 8 | – | 5 | 4 | 2 | 2 | 3 | 2 | 1 | 1 | 57 |
| 4 | 6 | 1 | 2 | 3 | 1 | – | 2 | 3 | 3 | 1 | 1 | – | 23 |
| 5 | 3 | – | 1 | 2 | – | – | 1 | 1 | 1 | 2 | – | 1 | 12 |
| 6 | 5 | 1 | 1 | – | 1 | 1 | – | 1 | – | – | 1 | 1 | 12 |
| 7 | 2 | – | – | 1 | 1 | – | – | – | – | – | – | – | 4 |
| 8 | 2 | – | – | – | – | – | – | – | – | – | – | – | 2 |
| 9 | – | – | – | – | – | – | 1 | 1 | – | 1 | 1 | – | 4 |
| 10 | 1 | 6 | – | – | – | – | – | – | – | – | – | – | 7 |
| All | 144 | 35 | 33 | 30 | 43 | 39 | 27 | 32 | 27 | 51 | 37 | 30 | 528 |

N = 528, $\bar{X}$ = 28.37, S.D. = 20.70.

From Table 6 it can be seen that the mean and variance of the two grouped schemes for retrospective closed birth intervals (ACBI and LBI) agree quite closely with the ungrouped mean and variance. In the case of all closed birth intervals the mean values on the basis of ungrouped data is 27.46 while on the basis of group-1 scheme it is 27.31, and on group-2 scheme, it is 27.30 and for last birth interval the ungrouped mean is 34.75 compared to 34.20 in group-1 scheme and 34.31 in group-2 scheme. The variances between grouped and ungrouped data also agree closely. On the other hand, in the case of the open birth interval there is a substantial departure between the grouped and ungrouped means. The mean values of ungrouped data for open birth interval is 50.43 compared to 44.88 in group-1 scheme and 46.12 in group-2 scheme. This is because of the fact that a sizeable proportion of the frequencies in the case of OBI are lumped together in 117+ or 118+ category and in the grouped interval distrubution the means for last interval is assumed to be 120 and 121 respectively for the two schemes. The open birth interval seem to have a very high variance with the maximum values extending to almost 360 months which will arise in the case of a married woman aged 45 with no child and married at age 15 and as such an appropriate grouping scheme would be with a 12 month class interval, such as 0-9, 10-21, 22-23, 34-45 ....

For further analysis of levels and differentials in different types of intervals the data on birth intervals including the imputed values have been restricted to women who are currently married, once married, and below 45 years of age. While the estimates of the closed intervals (ACBI, LBI, straddling, and prospective given in the next section are based on grouped data (scheme 1), the estimates based on ungrouped data have been used in the case of the open birth interval.

## 3.3. ANALYSIS OF LEVELS AND DIFFERENTIALS

### 3.3.1. STUDY OF MEANS AND DISPERSIONS

One of the basic and useful set of tabulations in any birth interval analysis is the provision of mean, variance and higher moments (if needed) of different types of birth intervals classified by birth order and age and/or duration of marriage of the women. Such tabulation will serve as a useful baseline data for study of changes in these values at later time points in the same population and also for comparison of levels of birth intervals in different population groups.

**Table 8.** Comparison of Mean Values of Birth Intervals of Different Types in Fiji, India, and U.S.A.

| | Type of Interval | | | | | | |
|---|---|---|---|---|---|---|---|
| | ACBI | | LBI | | OBI | | |
| Order of Birth Interval | Fiji (1974) | U.S.A. (1970) | Fiji (1974) | India (1965) | Fiji (1974) | U.S.A. (1970) | India (1965) |
| 0-1 | 23.1 | 35.0 | 25.1 | 34.5 | 49.9 | 82.0 | 41.1 |
| 1-2 | 27.3 | 38.3 | 32.7 | 35.5 | 42.5 | 83.3 | 40.1 |
| 2-3 | 28.2 | 42.9 | 36.4 | 37.5 | 41.5 | 76.4 | 44.1 |
| 3-4 | 28.8 | 40.2 | 36.1 | 37.7 | 47.4 | 69.2 | 47.3 |
| 4-5 | 29.1 | 37.3 | 37.6 | 40.5 | 54.2 | 64.1 | 39.0 |
| 5 & above | 29.2 | 34.7 | 35.7 | 36.8 | 57.8 | 52.0 | 46.3 |
| Combined | 27.3 | 35.9 | 34.2 | 36.9 | 50.4 | 64.3* | 43.3* |
| General Marital Fertility Rate** | | | | | | 119.7 | 221.0 |

* Mean values of open birth intervals were computed excluding women of parity zero.

** Based on currently married women 15-44 years of age.

Note: The birth intervals among the three countries are not strictly comparable since there were differences in the categories of women included in the analysis. In Fiji women once married, currently married, and below 45; in U.S.A. once married, currently married, spouse present, with at least one live birth and all children living with parents at home (at the time of survey) which gives greater weight to younger women; and in India, women currently married, below 45, and with at least one live birth, were included.

For example, Table 8 provides the mean values of closed and open birth intervals for Fiji, India and U.S.A. for comparative purposes: ACBI for Fiji and U.S.A., LBI for Fiji and India, and the open birth interval (OBI) for Fiji, U.S.A. and India, for comparative assessment of magnitudes. The data for U.S.A. is taken from the one in a thousand Public Use Sample of U.S. Census (1970) and analysed by Hastings and Robinson, referred to earlier, and the data for India are taken from a sample survey of South Indian rural population conducted by Srinivasan in 1965. The table clearly reveals that on all the intervals and in all birth orders (except over 6 for open interval) the U.S.A. women have longer intervals than women studied in Fiji or India. This is clearly indicative of the low fertility in U.S.A. contributed both by spacing and limitation practices.

The differentials are found to be more, more than 70 per cent higher for U.S.A. women compared to Fiji or India, in the case of open birth interval than the differences in closed birth intervals, indicating that fertility reduction in U.S.A. is essentially attributable to limitation than to spacing.

Comparison of intervals between Fijian and Indian women reveals that while in closed intervals, Fijian women have shorter intervals than Indian women, on open intervals they have longer mean values. This indicates, though by no means a conclusive proof, that the lower fertility among Fijian women compared to Indian women, is largely attributable to their better limitation practice than due to better spacing between children.

The mean, variance, and, if necessary, other moments of the birth interval distribution can be computed for women in different socio-economic strata, classified by such factors as educational status of the woman, religion, race, etc., and used in differential analysis. These statistics can be computed for different types of closed birth intervals. However, as discussed in Section II, since the Last Birth Interval (LBI) and Straddling Birth Interval (SBI) can be considered the more sensitive and robust indicators of fertility among the closed intervals, it will be particularly meaningful to compare the various statistics of these two types of intervals among different socio-economic groups. Especially of value will be the analysis of last closed birth intervals straddling the time point of initiation of family planning programme and comparison made of such statistics among the different socio-economic groups in order to determine the differential impact of family planning programme.

For any retrospective interval, other than the straddling interval, it is necessary to study them in relation to age and/or duration of marriage in order to avoid the pitfalls introduced by truncation biases.

**Table 9.** Frequencies, Means and Standard Deviations of Retrospective Birth Intervals, by Type and by Birth Order

| Birth Order of Interval | Parameters | Type of Interval | | |
|---|---|---|---|---|
| | | ACBI* | LBI* | OBI** |
| 0-1 | Frequency | 3,728 | 548 | 466 |
| | Mean | 23.06 | 25.12 | 49.98 |
| | Standard Deviation | 18.70 | 21.19 | 70.89 |
| 1-2 | Frequency | 3,558 | 671 | 555 |
| | Mean | 27.31 | 32.68 | 42.50 |
| | Standard Deviation | 17.10 | 22.14 | 57.76 |
| 2-3 | Frequency | 2,911 | 652 | 589 |
| | Mean | 28.23 | 36.44 | 41.49 |
| | Standard Deviation | 17.87 | 25.46 | 48.10 |
| 3-4 | Frequency | 2,271 | 531 | 568 |
| | Mean | 28.80 | 36.13 | 47.40 |
| | Standard Deviation | 17.53 | 22.95 | 53.03 |
| 4-5 | Frequency | 1,748 | 490 | 472 |
| | Mean | 29.08 | 37.58 | 54.15 |
| | Standard Deviation | 18.20 | 24.18 | 52.51 |
| 5 & above | Frequency | 3,485 | 1,261 | 1,329 |
| | Mean | 29.22 | 35.68 | 57.84 |
| | Standard Deviation | 17.41 | 21.45 | 47.53 |
| Combined | Frequency | 17,701 | 4,153 | 3,979 |
| | Mean | 27.31 | 34.20 | 50.43 |
| | Standard Deviation | 17.94 | 23.02 | 53.94 |

* Means and standard deviation of closed birth interval are based on grouped data (Scheme I).

** Means and standard deviation of open birth interval (OBI) are based on ungrouped data.

Tables 9 and 10 provide data on the mean and variance of different types of birth intervals for Fiji, classified by birth order. Computations are based on grouped data for closed intervals and on ungrouped data for open intervals. It is interesting to see from Table 9 that the mean of all retrospective closed intervals (ACBI) is 27.3 months and of the last closed interval (LBI) is 34.20, indicating a strong *truncation bias,* in any retrospective intervals, discussed in the earlier sections. The bias seems to persist for all birth orders.

Analysis over different birth orders indicates that for all closed birth intervals (ACBI) there is a systematic but small increase in the mean values of the successive birth intervals, the interval from marriage to first child being 23.1 months and the intervals after the 5th child being 29.2 months. Regarding the last birth interval (LBI), such a systematic increasing trend is not discerned; the intervals after the second child, namely 2-3, 3-4, 4-5, etc., are found to be almost of the same order (about 33 to 36 months), and only the first interval (0-1) is found to be substantially lower than other intervals, at a level of 25.1 months. The first interval can be expected to be lower than the others because of the absence of period of post partum amenorrhoea which is present in the subsequent intervals.

**Table 10.** Frequencies, Means and Standard Deviation of Straddling and Prospective Birth Intervals by Type and by Birth Order*

| Order of Birth Interval | Parameters | Straddling at Ages | | | | Prospective at Ages | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 20 | 25 | 30 | 35 | 20 | 25 | 30 | 35 |
| | Frequency | 749 | 153 | 22 | 3 | 933 | 122 | 21 | 3 |
| 0-1 | Mean | 35.31 | 49.26 | 64.41 | 43.50 | 19.40 | 19.17 | 17.50 | 19.50 |
| | Std. Deviation | 28.14 | 37.19 | 43.57 | 24.25 | 13.91 | 14.68 | 14.57 | 6.93 |
| | Frequency | 924 | 393 | 69 | 10 | 1,565 | 275 | 50 | 7 |
| 1-2 | Mean | 32.53 | 42.71 | 49.93 | 65.70 | 28.45 | 31.99 | 37.42 | 39.79 |
| | Std. Deviation | 19.87 | 25.25 | 30.16 | 37.93 | 17.76 | 21.63 | 27.76 | 36.61 |
| | Frequency | 530 | 543 | 137 | 21 | 1,920 | 477 | 73 | 8 |
| 2-3 | Mean | 32.81 | 38.30 | 49.95 | 59.50 | 28.63 | 31.42 | 30.49 | 35.50 |
| | Std. Deviation | 20.68 | 21.31 | 29.77 | 37.23 | 17.59 | 20.74 | 20.08 | 28.69 |
| | Frequency | 202 | 538 | 193 | 42 | 1,851 | 698 | 126 | 15 |
| 3-4 | Mean | 30.72 | 37.86 | 45.32 | 44.07 | 29.22 | 30.27 | 29.40 | 27.90 |
| | Std. Deviation | 22.07 | 21.91 | 25.17 | 23.60 | 17.12 | 17.43 | 15.79 | 22.16 |
| | Frequency | 68 | 374 | 285 | 51 | 1,557 | 882 | 199 | 30 |
| 4-5 | Mean | 30.21 | 34.78 | 41.61 | 49.97 | 29.31 | 30.27 | 30.74 | 33.70 |
| | Std. Deviation | 17.97 | 21.87 | 23.90 | 24.66 | 18.25 | 18.15 | 17.49 | 18.18 |
| | Frequency | 19 | 298 | 642 | 441 | 3,213 | 2,712 | 1,414 | 368 |
| 5 & above | Mean | 37.08 | 33.45 | 36.95 | 41.12 | 29.36 | 29.75 | 30.26 | 30.25 |
| | Std. Deviation | 27.77 | 19.94 | 20.36 | 21.75 | 17.18 | 17.15 | 17.02 | 14.90 |
| | Frequency | 2,492 | 2,299 | 1,348 | 568 | 11,039 | 5,166 | 1,883 | 431 |
| Combined | Mean | 33.25 | 38.48 | 41.57 | 43.27 | 28.23 | 29.93 | 30.31 | 30.59 |
| | Std. Deviation | 23.04 | 23.77 | 24.58 | 23.70 | 17.44 | 18.01 | 17.52 | 16.24 |

* Means and Standard Deviation are based on grouped data (Group I Scheme).

With regard to open birth interval (OBI), there is a significant increasing trend in the successive birth orders excepting the first two intervals. While the effects of age tend to increase the open birth interval, the effects of parity seem to reduce this interval and consequently the interaction of age and parity tends to reduce the differentials which would have been observed otherwise. By studying the differentials of the open interval by parity within an age-group, or by age within a parity, the effects of thsese two factors can be measured.

Table 10 provides the mean values and standard deviation of the straddling and prospective intervals at ages 20, 25, 30, and 35 for different birth orders. From the table it is seen that the straddling intervals record a consistent increase with the age of the women, implying reduced fertility with the increasing age. The mean values of the straddling intervals at age 20 is found to be 33.3 months, and at age 35 found to be 43.3 months. Comparing the mean value of the straddling birth intervals over different birth orders, it is found that at ages 20 and 35 there are no systematic changes in the mean values in different birth orders which is indicative of the age effect on fertility dominating the parity effect. On the other hand, around ages 20 and 35, there is a systematic decrease in the mean values of the birth intervals with the increase in the birth order indicating that there is an interaction of parity and age in determining the fertility around these ages.

If we study the data on prospective interval given in the same table we find that there is an increasing trend in the mean values of the intervals with increasing age but the increase is found to be very small, compared to the increase observed in the straddling intervals. At age 20, the mean values of the prospective interval is found to be 28.2 months, while at age 35, it is found to be 30.6 months. Studying the mean values of the interval over different birth orders no significant trends could be observed excepting the first intervals are significantly shorter than other intervals at every age.

In order to illustrate the point that the nature of differentials exhibited among different socio-economic groups will vary with the type of intervals used and that sometimes deceptive conclusions could be drawn regarding the fertility differentials among different groups if appropriate controls by age and marital duration are not made, Tables 11, 12, and 13 provide the mean values of ACBI, and LBI, for birth interval 3 to 4, OBI for parity 3 women, and the straddling intervals at age 25 for the birth order 3 to 4. In these three tables, the three types of intervals (mean values) are given for women classified by educational status, religion, and contraceptive usage, respectively.

**Table 11.** Mean Values of Closed and Open Birth Intervals, Between 3rd and 4th Child, for Women Classified by Educational Status.

| | Type of interval | | | |
|---|---|---|---|---|
| Educational Status | ACBI 3-4 | LBI 3-4 | OBI 3- | Straddling at age 25 3-4 |
| No Education | 27.5 (591) | 32.9 (98) | 56.8 (73) | 43.0 (106) |
| Unrecognised | 25.8 (24) | – | 84.3 (3) | 41.5 (4) |
| Primary | 29.4 (1569) | 37.0 (398) | 40.9 (408) | 36.7 (403) |
| Secondary | 27.2 (62) | 32.8 (29) | 33.0 (78) | 31.6 (17) |
| College | 31.2 (25) | 45.5 (6) | 43.8 (6) | 39.3 (8) |
| All | 28.8 (2271) | 36.1 (531) | 47.4 (568) | 37.9 (538) |

Figures in brackets indicate the number of observations on which the mean values are based.

**Table 12.** Mean Values of Closed and Open Birth Intervals, Between 3rd and 4th Child, for Women Classified by Religion

| | Type of Interval | | | |
|---|---|---|---|---|
| Religion | ACBI 3-4 | LBI 3-4 | OBI 3- | Straddling at age 25 3-4 |
| Catholic | 28.2 (184) | 36.9 (34) | 37.7 (41) | 31.6 (46) |
| Methodist | 30.0 (734) | 36.9 (161) | 35.2 (178) | 34.0 (194) |
| Christian (All Other Sects) | 30.3 (80) | 39.8 (21) | 52.3 (29) | 32.9 (28) |
| Hindu | 28.1 (1053) | 35.8 (273) | 55.9 (273) | 41.8 (231) |
| Islam | 27.7 (198) | 33.9 (40) | 51.1 (43) | 45.7 (37) |
| Others | 21.9 (22) | 17.5 (2) | 34.8 (4) | 32.5 (2) |
| All | 28.8 (2271) | 36.1 (531) | 47.4 (568) | 37.9 (538) |

Figures in brackets indicate the number of observations on which the mean values are based.

**Table 13.** Mean Values of Closed and Open Birth Intervals, Between 3rd and 4th Child for Women Classified by Contraceptive Usage in the Intervals.

| | Type of Interval | | | |
|---|---|---|---|---|
| Contraceptive usage | ACBI 3-4 | LBI 3-4 | OBI 3- | Straddling at age 25 3-4 |
| Never Used Contraception | 30.2 (471) | 34.9 (125) | 59.0 (127) | 39.8 (105) |
| Contraceptive Used After the Interval | 27.1 (1513) | 34.7 (230) | 57.7 (227) | 35.6 (342) |
| Contraceptive Used During or Before the Interval | 35.5 (287) | 38.9 (176) | 29.7 (214) | 44.0 (91) |
| All | 28.8 (2271) | 36.1 (531) | 41.4 (568) | 37.9 (538) |

Figures in brackets indicate the number of observations on which the mean values are based.

For example, from Table 11 comparing the closed birth intervals of women with *primary education* and women with *no education* it is found that while the ACBI and LBI reveal a moderate increase in the mean values (from 27.5 to 29.4 in the case of ACBI, and from 32.9 to 37.0 in the case of LBI), the straddling interval at age 25 which is in a way controlled for age reveals a substantial decline from 43.0 to 36.7 between the two educational groups. Similarly the OBI (open births interval) reveals a substantial decline from 56.8 to 40.9. If we base our conclusion on the first two intervals we will conclude that the fertility of women with some education is slightly lower than those with *no education,* and opposite conclusions will be drawn if we use the straddling interval and the open birth interval. This discrepancy could have arisen due to the fact that we have not controlled for age or duration of marriage in the case of ACBI, LBI, and OBI. If women with higher education are younger or more recently married than women with *no education,* as is likely to be the case in a developing society, then they are likely to have shorter birth intervals between any two parities and they may limit fertility by adopting limitation methods which is likely to be reflected in an elongated open interval, as has happened in this case. Analysis, controlling age or duration of marriage within each birth order, is likely to reveal the dynamics at work of closed birth intervals more clearly. However, even assuming that women with *primary education* are likely to be slightly younger and likely to have shorter marital duration, the fact that the mean open interval for women with *no education* and with three children is as high as 56.8 months indicates considerable prevalence of contraceptive practice, traditional or otherwise, among them.

Similarly, from Table 12, comparing the mean values of Methodists and Hindus, we find that if we base our comparison on ACBI and LBI, there are essentially no fertility differentials, the latter being slightly more fertile than the former. On the other hand, if we base our comparison on straddling interval and open birth interval the Hindus have a significantly larger interval than the Methodists, implying a correspondingly lower fertility. Again standardisation with regard to age and duration of marriage for ACBI and

LBI may throw additional light on the matter.

Similar puzzling conclusions arise out of Table 13 wherein women who have ever used contraception are having shorter open birth intervals than the women who have never used contraception. If women who have ever used contraception are likely to be younger and have shorter marital duration than women who have never used contraception, then control by age and duration of marriage can eliminate these paradoxical and uncomfortable differentials. However, the fact that the OBI among women of parity 3, who have never used any modern contraception is as high as 59.0 months, is suggestive of other forces at work (probably traditional checks) in regulating fertility. In all the above three tables, since we are studying only closed birth intervals 3 to 4 and open interval of parity 3, controls have been automatically exercised on birth order.

### 3.3.2. LIFE TABLE ANALYSIS OF PROBABILITIES OF PROGRESSION TO THE NEXT CHILD

As has been indicated in Section II, the closed intervals describe the pattern of reproduction of only those who have continued to reproduce, and in a truncated set of observations, a good number of women might not have the time needed to close their interval and might remain in the open interval category. Women with slightly lower fecundability, including those who are sterile, are likely to remain in the open interval category and hence if a fertility analysis of a population is made just on the basis of closed intervals, it may not reflect the fertility conditions of the population. Ryder[23,24] has repeatedly pointed out the need for combining the data from closed and open intervals into a common life table analysis. This can be done fairly easily, nowadays, with the facilities of a high-speed computer. Data on open interval $U_i$, obtained from women of parity $i$, are combined with the data on the closed interval $T_i$ to prepare a life table. The $T_i$ values can be obtained in two different methods; in the first method it is observed from women of parity $i + 1$ only as the last closed interval (LBI), and in the second method, from women of parity $(i + 1)$ and above as all closed intervals $i$ to $i + 1$, (ACBI). The data are tabulated according to the ordinal month of the interval and the status of the women at the end of the interval as closed or open. If the number of completed months of a birth interval is $x$, then the ordinal month is taken as $x + 1$. If $C_x$ denotes the number of closed intervals with ordinal month $x$ and $O_x$, the number of open intervals with the same ordinal month $x$ and

$$\text{if } N_x = C_x + O_x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

then $q_x$, the probability of an interval getting closed between months $x$ and $x + 1$ or during the month $x$ is given by

$$q_x = \frac{C_x}{\sum_{y=x}^{w} N_y - \frac{O_x}{2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where '$w$' is the upper limit of the intervals for which data have been observed.

If $p_x$ denotes $1 - q_x$, we have $l_x$ the probability of a woman continuing in the same parity $(i)$ without giving birth to the next parity at month $x$ after the birth of the $i$th child, is given by

$$l_x = p_0 p_1 \ldots p_{x-1} p_x \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Such life table probabilities can form the basis for the study of changes in the fertility over time in the same population and comparison of different populations at the same time. These life tables have to be worked out for each parity separately.

As indicated above they can be computed in two different ways using two kinds of closed intervals; all closed intervals of $i$ to $i + 1$, contributed by women of parity $(i + 1)$ and above, and the last closed interval, $i$ to $i + 1$, contributed by women of parity $(i + 1)$ at the time of the survey. The life table probabilities computed on the basis of the two sets of data can be expected to be different because firstly, the number of closed intervals included in the first data set will be higher than in the second set, and secondly, the distribution of the closed intervals in the two sets may be different. While in the first case every woman of parity $(i + 1)$ and above can contribute one closed interval to the data set, in the second case only women of parity $(i + 1)$ contributes one closed interval to the data set. Thus, while the first set can give the probabilities of progression at various intervals from any given parity to the next parity, without controlling the parity distribution of women in the population, the second set provides such probabilities per woman in the population, controlling for parity distribution. The second set of probabilities should therefore be construed as indicative of the current or recent fertility conditions than the first set. It can be expected that the first set will yield lower mean values than the second set.

These life tables functions can be used to estimate mean, variance etc., and these parameters can be expected to be different from the mean, variance, etc., of the ordinary birth interval distribution. The reciprocal of the mean values based on the life table calculated on the second set per woman controlling for parity, for each parity can be expected to correspond closely to the parity specific fertility rates in the population. The computation of such rates is one of the very useful and valuable functions of the birth interval analysis.

Tables 14 and 15 provide the life table values computed from Fiji data.

23. Ryder, N.B., 'A Critique of the Rational Fertility Study', *Demography*, Vol.10, No.4, Nov. 1973.
24. Ryder, N.B., *'Fertility Measurement Through Cross-Sectional Surveys', Social Forces*, Vol. 54, No. 1, Sep. 1975.

**Table 14.** Life Table Probabilities of Continuance in the Same Parity Status $(l_{ix})$* (Based on ACBI and OBI)

| Ordinal Month $(x)$ | Parity $i$: 1 | 2 | 3 | 4 | 5 | 6+ | Combined |
|---|---|---|---|---|---|---|---|
| 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 6 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 12 | 0.6892 | 0.8897 | 0.8997 | 0.9011 | 0.9054 | 0.9071 | 0.8595 |
| 18 | 0.4732 | 0.7088 | 0.7429 | 0.7687 | 0.7758 | 0.7983 | 0.7032 |
| 24 | 0.3223 | 0.4818 | 0.5222 | 0.5621 | 0.5694 | 0.6093 | 0.5051 |
| 30 | 0.2345 | 0.3230 | 0.3660 | 0.4014 | 0.4203 | 0.4759 | 0.3668 |
| 36 | 0.1844 | 0.2345 | 0.2592 | 0.2975 | 0.3145 | 0.3789 | 0.2772 |
| 42 | 0.1503 | 0.1722 | 0.1963 | 0.2411 | 0.2610 | 0.3233 | 0.2234 |
| 48 | 0.1243 | 0.1337 | 0.1568 | 0.1884 | 0.2219 | 0.2762 | 0.1832 |
| 54 | 0.1053 | 0.1085 | 0.1389 | 0.1526 | 0.1947 | 0.2472 | 0.1579 |
| 60 | 0.0878 | 0.0879 | 0.1165 | 0.1367 | 0.1693 | 0.2263 | 0.1375 |
| 66 | 0.0778 | 0.0771 | 0.1008 | 0.1239 | 0.1507 | 0.2124 | 0.1242 |
| 72 | 0.0716 | 0.0667 | 0.0865 | 0.1091 | 0.1375 | 0.1974 | 0.1120 |
| 78 | 0.0658 | 0.0594 | 0.0805 | 0.1005 | 0.1316 | 0.1843 | 0.1038 |
| 84 | 0.0592 | 0.0535 | 0.0708 | 0.0925 | 0.1234 | 0.1776 | 0.0963 |
| 90 | 0.0552 | 0.0474 | 0.0648 | 0.0892 | 0.1186 | 0.1716 | 0.0909 |
| 96 | 0.0493 | 0.0446 | 0.0584 | 0.0871 | 0.1116 | 0.1635 | 0.0852 |
| 102 | 0.0475 | 0.0416 | 0.0556 | 0.0825 | 0.1059 | 0.1599 | 0.0818 |
| 108 | 0.0449 | 0.0403 | 0.0538 | 0.0816 | 0.1017 | 0.1540 | 0.0789 |
| 114 | 0.0415 | 0.0389 | 0.0524 | 0.0772 | 0.1017 | 0.1521 | 0.0764 |
| 120 | 0.0399 | 0.0370 | 0.0490 | 0.0743 | 0.0952 | 0.1486 | 0.0729 |
| Mean** $(\bar{T}_i)$ | 26.42 | 30.77 | 33.28 | 36.18 | 38.78 | 44.34 | 34.80 |

* $(l_{ix})$ = probability of continuance in parity $i$ at month $x$ after the birth of $i$-th child based on All Closed Birth Intervals (ACBI) and Open Birth Interval (OBI).

** Mean

$$(\bar{T}_i) = 3(l_{i,0} + l_{i,120}) + 6(l_{i,6} + l_{i,12} + \ldots + l_{i,114})$$

**Table 15.** Life Table Probabilities of Continuance in the Same Parity Status $(l'_{ix})$* (Based on LBI and OBI)

| Ordinal Month $(x)$ | Parity (i) 1 | 2 | 3 | 4 | 5 | 6+ | Combined |
|---|---|---|---|---|---|---|---|
| 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 6 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 12 | 0.7903 | 0.9452 | 0.9594 | 0.9646 | 0.9620 | 0.9661 | 0.9409 |
| 18 | 0.6441 | 0.8313 | 0.8612 | 0.8857 | 0.8822 | 0.8986 | 0.8499 |
| 24 | 0.5364 | 0.6891 | 0.7287 | 0.7770 | 0.7851 | 0.7964 | 0.7368 |
| 30 | 0.4640 | 0.5723 | 0.6364 | 0.6803 | 0.6916 | 0.7002 | 0.6414 |
| 36 | 0.4115 | 0.4916 | 0.5432 | 0.5900 | 0.6147 | 0.6212 | 0.5621 |
| 42 | 0.3783 | 0.4113 | 0.4753 | 0.5300 | 0.5582 | 0.5676 | 0.5040 |
| 48 | 0.3518 | 0.3423 | 0.4277 | 0.4695 | 0.5012 | 0.5165 | 0.4519 |
| 54 | 0.3348 | 0.3137 | 0.4030 | 0.4193 | 0.4593 | 0.4802 | 0.4181 |
| 60 | 0.3134 | 0.2867 | 0.3633 | 0.3929 | 0.4213 | 0.4545 | 0.3892 |
| 66 | 0.2991 | 0.2663 | 0.3265 | 0.3688 | 0.3907 | 0.4354 | 0.3660 |
| 72 | 0.2905 | 0.2556 | 0.3003 | 0.3373 | 0.3666 | 0.4117 | 0.3446 |
| 78 | 0.2746 | 0.2387 | 0.2886 | 0.3246 | 0.3559 | 0.3912 | 0.3286 |
| 84 | 0.2675 | 0.2268 | 0.2640 | 0.3086 | 0.3406 | 0.3775 | 0.3139 |
| 90 | 0.2625 | 0.2118 | 0.2512 | 0.2988 | 0.3290 | 0.3653 | 0.3024 |
| 96 | 0.2524 | 0.2073 | 0.2332 | 0.2961 | 0.3162 | 0.3506 | 0.2910 |
| 102 | 0.2467 | 0.1977 | 0.2234 | 0.2846 | 0.3023 | 0.3438 | 0.2819 |
| 108 | 0.2439 | 0.1926 | 0.2182 | 0.2846 | 0.2897 | 0.3349 | 0.2755 |
| 114 | 0.2378 | 0.1847 | 0.2122 | 0.2777 | 0.2897 | 0.3335 | 0.2710 |
| 120 | 0.2378 | 0.1847 | 0.1970 | 0.2777 | 0.2740 | 0.3257 | 0.2644 |
| Mean** $(\bar{T}_i)$ | 49.29 | 50.74 | 55.89 | 60.78 | 62.96 | 66.10 | 59.41 |

* $(l_{ix})$ = probability of continuance in parity $i$ at month $x$ after the birth of $i$-th child; based on Last Closed Birth Intervals (LBI) and Open Birth Intervals (OBI).

** $(\bar{T}_i)' = 3(l_{i,0} + l_{i,120}) + 6(l_{i,6} + l_{i,12} + \ldots + l_{i,114})$

Table 14 provides the life table values based on an analysis of all closed birth intervals (ACBI) and the open birth interval (OBI), while Table 15 provides the life table values obtained by combining only last birth interval and the open birth interval. The mechanism of constructing these life tables has been described earlier.

The life tables have been prepared for women of each parity separately, commencing from para-1, and provide the values of $l_{ix}$, which indicates the probability that a woman of parity $i$ will continue to have the same parity at $x$ months after the birth of the i-th child. In order to keep the analysis simple, the life table probabilities have been worked out at intervals of 6 months, up to 120 months. The mean values of the life tables have also been computed, using the standard formula which is given at the foot of each table. From Table 14 it can be seen that the mean values of the birth intervals based on life table analysis of ACBI and OBI increase systematically from 26.4 months for the interval between the first and the second child to 44.3 months between the sixth and seventh child and subsequent intervals. This steady increase in the birth interval by birth order can be observed only in a life table analysis since we combine those women who do not give birth to a child with those who give birth to a child at different intervals of time. The age effect is more dominant in such a table.

Table 15 is the life table based on an analysis combining the last birth interval and the open birth interval. These values are also provided at 6 monthly intervals up to 120 months. The table reveals that even at the end of 120 months about 20 to 30 per cent of the women continue to remain in the same parity, compared to less than 15 per cent in Table 14, and thus for the sake of completeness, the life table analysis should have been carried out further - up to 240 (20 years). The mean values of the birth intervals obtained from this table has thus to be construed as the mean value of the birth intervals truncated up to 10 years. As in the previous case there is a systematic increase in the mean values with birth order, but the mean values for each birth order in this case is substantially higher than the corresponding value in Table 14. The current parity specific marital fertility rate of women $f_i$ is related to the corresponding mean birth interval $\bar{T}_i$ obtained through life table analysis by the simple relation $f_i = 1/\bar{T}_i$. Thus, from the knowledge of these mean birth intervals computed on the basis of life table analysis, an estimate of the parity specific fertility rate can be computed. Comparison of the values between the two life tables indicates very clearly that, while the life table technique resolves the problem of 'censoring' as used in the statistical sense, it does not and cannot handle the problems of *selection* and *truncation*. Whether we analyse the *All Closed Birth Intervals* or only the *Last Birth Interval* the selection and truncation bias continue to operate in them though in a different manner. If we assume such a bias is essentially a function of duration of marriage and parity, we can carry out the life table analyses separately for women of different age groups, and if the analysis is done at different points of time we can compare the changes in the life table function over time in the same age group.

Another way of adjustment for the selection bias would be to consider only women who had given birth to their $i$-th child at least 5 or 7 years before the date of the survey and make a life analysis of their experience within the next 5 or 7 years, i.e. up to the date of the survey. In this case we are giving an equal chance to every woman of parity $i$ to express their fertility, since the period of observation is controlled.

## 3.4 ESTIMATION OF BIOLOGICAL FACTORS AND LENGTH OF LACTATION

### 3.4.1. FECUNDABILITY

**Development of an Analytical Component Structural Model for the Closed Birth Interval**

As has been briefly mentioned in Section II, the closed birth interval $T_i$, between $i$-th and $(i + 1)$th births can be considered to be the sum of the following four components.

i) The period of post-partum amenorrhoea following the birth of the $i$-th child $(M_i)$;

ii) The total duration of menstruating intervals between two births denoted by $X_1 + X_2 + X_3 \ldots X_j$, if there are $j$ such intervals;

iii) The periods of pregnancies and post termination amenorrhoea of abortions or still births (if any) intervening the two live births denoted by $Y_1 + Y_2 + Y_3 + Y_j$, if there are $j$ such intervals, and

iv) The period of pregnancy associated with the $(i + 1)$th birth assumed to be nine months.

Assuming that there are $n$ foetal wastages between $i$ and $(i + 1)$th births we can write

$$T_i/N = M_i + X_1 + X_2 \ldots X_{n+1} + Y_1 + Y_2 \ldots Y_n + 9 \quad ..(8)$$

If there are $n$ foetal wastages there will be $n + 1$ menstruating intervals between $i$th and $(i + 1)$th birth because there will be $n$ spells of waiting time corresponding to the $n$ foetal wastages and one more waiting time for the last conception that ends in the $(i + 1)$th birth. Assuming that the component random variables $M$, $X$ and $Y$ are statistically independent of each other, and that the explicit functional form for each of these distributions are known we can derive the probability density functions of $T_i/n$. Now if $\theta_i$ denotes the probability that a conception between $i$-th and $(i + 1)$th birth ends in a live birth then the probability that there will be '$n$' foetal wastages in the birth interval '$T_i$' is given by $(1 - \theta)^n \theta$

If the probability density function of $T_i/n$ is assumed to be $g(t/n)$ the unconditional density function of '$T_i$' is given by

$$f(t) = \sum_{n=o}^{\infty} g(t/n)\,(1 - \theta)^n\, \theta \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

Hence the unconditional density function $f(t)$ can also be derived.

The waiting to conception or the number of menstruating intervals time before a conception occurs, is a function of the fecundability, or the monthly probability of conception of the woman in a susceptible state, that is, neither already pregnant nor in the period of amenorrhoea following a pregnancy termination. This monthly probability is influenced by a host of biological factors such as age, parity, nutritional conditions, and social practices such as frequency of coitus and contraceptive usage. Contraception can be considered as a means by which the fecundability of the woman is reduced. It can be assumed that this fecundability denoted by '$p$' is constant for single woman within a birth interval but varies over the women according to a defined frequency distribution. The distribution that is usually assumed for defining the distribution of fecundability over women in a given birth interval is a Beta-distribution, that is, the probability density at *'p'* is assumed to be

$$h(p) = \frac{1}{B(a, b)} p^{a-1} (1-p)^{b-1}$$

Under such an assumption the average fecundability of women becomes $a/a+b$ and the variance of the fecundability

becomes $ab/(a+b)^2 (a+b+1)$

In the literature many assumptions have been made on the distribution of each of the components of the birth interval $M$, $X$ and $Y$. One set of researchers have tended to use these variables as discrete variables and have developed the density function of $T_i$ in the discrete form. This can be justified on the grounds that the observed data on any of these components are of discrete type and a discrete model is more convenient to work with through the probability generating functions. Another set of researchers have tended to use continuous forms for each of the component variables in the light of the fact that time is a continuous variable and have developed the frequency distribution either directly through integration or through characteristic functions. Under both these sets of models it is necessary to assume that the components making up the birth interval $M$, $X$ and $Y$ are statistically independent of each other. If we assume that the distribution of $M_i$ or the post-partum amenorrhoea after the birth of the $i$-th child is known and also the distribution of $Y_i$'s the distribution of duration of non-susceptibility associated with the foetal wastage between $i$ th and $(i+1)$th birth is also known in the sense that the functional forms and the values of the parameters in the two distributions are known, then the only unknown parameters in the distribution of birth interval $T_i$ will be $\theta$, $a$ and $b$. Now these parameters can be estimated by fitting the theoretical distribution with the observed distribution of birth intervals in any given population. The estimates of these three parameters have been obtained by a variety of standard statistical techniques developed in the literature such as the method of moments, maximum likelihood method and minimum chi-square method. Though statistically the best estimates are obtained by maximum likelihood procedure the estimates can be arrived very easily by the method of moments wherein the first three moments of the observed distribution can be compared with the first three moments of the expected distribution and the estimates of $\theta$, $a$ and $b$ arrived at Suchindran[25] in his analysis of the efficiency of different methods of estimation of parameters based on birth interval data has concluded that for the range of values that are usually applicable in the human population the moment estimates are fairly efficient. It is to be recognised that the estimates through the method of moments may not yield very reliable results, when three unknown parameters are involved, since there may be erratic behaviour of the observed birth interval distribution with regard to the third moment. If we had an *a priori* knowledge of $\theta$ we can have reliable estimates of $a$ and $b$. We can also estimate these two parameters for various levels of $\theta$.

Appendix 1 derives explicit expression for the values of $a$ and $b$ for any given level of $\theta$ in terms of the first two moments of the birth interval distribution. The model developed by Srinivasan[26] has been utilised in deriving these expressions. This model is an extension of Perrin and Shops[27] model with the heterogeneity in the fecundability of women taken into account. The estimates of mean fecundability for any given level of $\theta$ in the population can be derived from a and b values estimated from the population. It is also possible to make a test of the goodness of fit of the theoretical model with the observed data by comparing the expected and the observed frequencies through a chi-square test. The estimation of fecundability levels in each birth interval for the population of Fiji from the data on closed birth interval distribution have been derived for different levels of $\theta$, probability of a conception ending in a live birth. If we have *a priori* knowledge of the incidences of foetal wastage in the population the mean fecundability levels in the population can be estimated uniquely. One way of getting the estimate of $\theta$ is to use the information obtained in retrospective surveys on the number of foetal wastages between $i$-th and $(i+1)$th births. The average number of foetal wastages between any two births is given by $1-\theta) / \theta$ and knowing the average number of foetal wastages, $\theta$ can be estimated. If we do not have reliable information on the incidence of foetal wastages between successive closed birth intervals, we can use the data on the number of foetal wastages in the interval between marriage and first child to get a maximum estimate of $\theta$.

25. Suchindran, C.H., 'Estimates of Parameters in Biological Models of Human Fertility', Department of Biostatics, University of North Carolina, Chapel Hill, *Institute of Statistics Mimeo Series,* No.849, October 1972.

26. Srinivasan, K., 'The Open Birth Interval as an Index of Fertility', *Journal of Family Welfare* (India), Vol.XIII, Dec. 1966.

27. Perrin, E.B. and M.C. Sheps, 'Human Reproduction - A Stochastic Process', *Biometrics,* Vol.20, March 1964.

**Table 16.** Estimates of Mean Fecundability in Different Birth Intervals for Different Levels of Foetal Wastage

| | Based on ACBI (Birth Order) | | | | | | Based on LBI (Birth Order) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Foetal Wastage $(1-\theta)$ | 0-1 | 1-2 | 2-3 | 3-4 | 4-5 | 5+ | 0-1 | 1-2 | 2-3 | 3-4 | 4-5 | 5+ |
| 0.00 p. | 0.0814 | 0.0688 | 0.0678 | 0.0664 | 0.0730 | 0.0719 | 0.0714 | 0.0499 | 0.0431 | 0.0417 | 0.0417 | 0.0448 |
| 0.05 p. | 0.0871 | 0.0734 | 0.0724 | 0.0707 | 0.0780 | 0.0768 | 0.0762 | 0.0531 | 0.0458 | 0.0442 | 0.0442 | 0.0475 |
| 0.10 p. | 0.0937 | 0.0787 | 0.0776 | 0.0758 | 0.0837 | 0.0823 | 0.0818 | 0.0567 | 0.0488 | 0.0471 | 0.0471 | 0.0506 |
| 0.15 p. | 0.1013 | 0.0847 | 0.0836 | 0.0816 | 0.0903 | 0.0888 | 0.0822 | 0.0608 | 0.0522 | 0.0503 | 0.0503 | 0.0541 |
| 0.20 p. | 0.1102 | 0.0918 | 0.0906 | 0.0884 | 0.0981 | 0.0963 | 0.0957 | 0.0655 | 0.0561 | 0.0540 | 0.0541 | 0.0582 |
| 0.25 p. | 0.1209 | 0.1002 | 0.0988 | 0.0963 | 0.1073 | 0.1053 | 0.1047 | 0.0710 | 0.0680 | 0.0583 | 0.0584 | 0.0628 |
| 0.30 p. | 0.1339 | 0.1103 | 0.1088 | 0.1059 | 0.1184 | 0.1161 | 0.1154 | 0.0776 | 0.0662 | 0.0634 | 0.0635 | 0.0683 |

Table 16 provides estimates of mean fecundability derived in each birth interval for different levels of foetal wastage. The estimation has been based on the simple probability model for closed birth interval suggested above, and details are furnished in the Appendix. In the model, the time factor is used as a discrete variable reckoned in calendar months, and the estimates have been obtained through the the method of moments. This table provides separate estimates of mean fecundability based on all closed birth intervals (ACBI) and the last birth interval (LBI). From the table it is seen that the mean fecundability of women in Fiji is generally small, mostly attributable to short duration of post partum amenorrhoea. At a foetal wastage level of 0.25, the mean fecundability estimated from all closed birth intervals (ACBI) is found to be 0.12 in first birth interval (0-1) and 0.11 in the interval 4-5; based on only last birth intervals (LBI) the mean fecundability is found to be 0.10 in the first interval (0-1) and 0.06 in the interval 4-5. In any given birth interval the mean fecundability increases with the level of foetal wastage. Since there is no knowledge of the exact level of foetal wastage in different birth intervals it is difficult to estimate precisely the fecundability levels in Fiji but it can be surmised that the fecundability levels vary from 0.07 to 0.13 based on all closed birth intervals (ACBI) and 0.04 to 0.12 based on last birth interval (LBI).

**Table 17.** Life Table for Duration of Post Partum Amenorrhoea ($a_{ix}$)*

| Ordinal Month (x) | Parity | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6+ | Combined |
| 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 1 | 0.7108 | 0.7112 | 0.7145 | 0.7697 | 0.7935 | 0.7948 | 0.7528 |
| 2 | 0.4561 | 0.4803 | 0.4909 | 0.5638 | 0.6125 | 0.6327 | 0.5487 |
| 3 | 0.2898 | 0.3160 | 0.3698 | 0.4030 | 0.4776 | 0.5061 | 0.4058 |
| 4 | 0.2424 | 0.2750 | 0.3193 | 0.3633 | 0.4325 | 0.4631 | 0.3615 |
| 5 | 0.2063 | 0.2411 | 0.2874 | 0.3350 | 0.3997 | 0.4270 | 0.3278 |
| 6 | 0.1512 | 0.1814 | 0.2254 | 0.2814 | 0.3577 | 0.3572 | 0.2683 |
| 7 | 0.1272 | 0.1607 | 0.2097 | 0.2644 | 0.3375 | 0.3417 | 0.2499 |
| 8 | 0.1134 | 0.1382 | 0.1935 | 0.2446 | 0.3082 | 0.3206 | 0.2296 |
| 9 | 0.0890 | 0.1092 | 0.1637 | 0.2124 | 0.2784 | 0.2949 | 0.2018 |
| 10 | 0.0837 | 0.0900 | 0.1562 | 0.1980 | 0.2549 | 0.2806 | 0.1879 |
| 11 | 0.0801 | 0.0754 | 0.1388 | 0.1907 | 0.2287 | 0.2669 | 0.1743 |
| 12 | 0.0127 | 0.0213 | 0.0377 | 0.0401 | 0.0691 | 0.0727 | 0.0457 |
| 13 | 0.0127 | 0.0213 | 0.0356 | 0.0373 | 0 0524 | 0.0634 | 0.0402 |
| 14 | 0.0106 | 0.0162 | 0.0291 | 0.0243 | 0.0524 | 0.0549 | 0.0343 |
| 15 | 0.0085 | 0.0162 | 0.0269 | 0.0208 | 0.0453 | 0.0464 | 0.0298 |
| 16 | 0.0085 | 0.0142 | 0.0246 | 0.0208 | 0.0429 | 0.0435 | 0.0279 |
| 17 | 0.0085 | 0.0142 | 0.0199 | 0.0208 | 0.0381 | 0.0406 | 0.0257 |
| 18 | 0.0085 | 0.0113 | 0.0174 | 0.0174 | 0.0238 | 0.0299 | 0.0193 |
| 19 | 0.0085 | 0.0113 | 0.0174 | 0.0174 | 0.0238 | 0.0279 | 0.0187 |
| 20 | 0.0085 | 0.0113 | 0.0174 | 0.0174 | 0.0214 | 0.0279 | 0.0184 |
| 21 | 0.0085 | 0.0057 | 0.0174 | 0.0174 | 0.0214 | 0.0279 | 0.0177 |
| 22 | 0.0085 | 0.0057 | 0.0174 | 0.0174 | 0.0214 | 0.0279 | 0.0177 |
| 23 | 0.0085 | 0.0057 | 0.0174 | 0.0174 | 0.0214 | 0.0279 | 0.0177 |
| 24 | 0.0021 | 0.0057 | 0.0067 | 0.0069 | 0.0080 | 0.0134 | 0.0079 |
| 25 | 0.0021 | 0.0057 | 0.0067 | 0.0069 | 0.0080 | 0.0134 | 0.0079 |
| 26 | 0.0021 | 0.0057 | 0.0067 | 0.0069 | 0.0080 | 0.0134 | 0.0079 |
| 27 | 0.0021 | 0.0057 | 0.0067 | 0.0069 | 0.0080 | 0.0134 | 0.0079 |
| 28 | 0.0021 | 0.0057 | 0.0067 | 0.0069 | 0.0080 | 0.0134 | 0.0079 |
| 29 | 0.0021 | 0.0057 | 0.0067 | 0.0069 | 0.0080 | 0.0134 | 0.0079 |
| 30 | 0.0000 | 0.0057 | 0.0022 | 0.0023 | 0.0040 | 0.0080 | 0.0041 |
| Mean** $\bar{a}_i$ = | 3.18 | 3.47 | 4.09 | 4.64 | 5.46 | 5.76 | 4.57 |

* $a_{ix}$ denotes the probability of a woman of parity not resuming menstruation till $x$ months after delivery.

** $\bar{a}_i = \frac{1}{2}(a_{i,0} + a_{i,30}) + (a_{i,1} + a_{i,2} + \ldots a_{i,29})$

3.4.2. POST PARTUM AMENORRHOEA

Table 17 provides a life table analysis of the period of post partum amenorrhoea and furnishes the values of $a_{ix}$ namely, the probability of a woman of parity $i$ not resuming menstruation till $x$ months after delivery. (In Fiji, data on post partum amenorrhoea have been compiled only for the last birth, and since many women were continuing to be in the state of post partum amenorrhoea at the time of the survey, life table analysis has to be resorted to). The mean duration of amenorrhoea computed from the life table values, by the standard procedure, reveals that the period of amenorrhoea increases with parity from 3.2 months after the first child to 5.8 months after the sixth child. The mean duration of post partum amenorrhoea, irrespective of the parity of the mother, is found to be 4.6 months. It is interesting to note that the duration of post partum amenorrhoea is much shorter than those observed in developing countries in Asia, especially in India where different studies have revealed the post partum amenorrhoea to be between 11 and 14 months. The significantly short duration of post partum amenorrhoea in Fiji requires further investigation.

**Table 18.** Life Table for Duration of Breastfeeding $(m_{ix})$*

| Ordinal Month (x) | Parity | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6+ | Combined |
| 0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 1 | 0.7087 | 0.7790 | 0.7536 | 0.7792 | 0.8275 | 0.8267 | 0.7838 |
| 2 | 0.6224 | 0.7410 | 0.6993 | 0.7234 | 0.7711 | 0.7883 | 0.7316 |
| 3 | 0.5596 | 0.6337 | 0.6146 | 0.6329 | 0.7033 | 0.7163 | 0.6516 |
| 4 | 0.5366 | 0.6033 | 0.5861 | 0.6049 | 0.6839 | 0.7015 | 0.6288 |
| 5 | 0.5183 | 0.5863 | 0.5569 | 0.5846 | 0.6620 | 0.6857 | 0.6092 |
| 6 | 0.4743 | 0.5253 | 0.4990 | 0.5410 | 0.5980 | 0.6475 | 0.5598 |
| 7 | 0.4639 | 0.5046 | 0.4855 | 0.5218 | 0.5958 | 0.6355 | 0.5467 |
| 8 | 0.4299 | 0.4770 | 0.4630 | 0.5021 | 0.5753 | 0.6110 | 0.5217 |
| 9 | 03421 | 0.3629 | 0.3780 | 0.4039 | 0.4637 | 0.5213 | 0.4258 |
| 10 | 0.3135 | 0.3425 | 0.3526 | 0.3925 | 0.4446 | 0.4990 | 0.4041 |
| 11 | 0.2916 | 0.3301 | 0.3376 | 0.3762 | 0.4396 | 0.4882 | 0.3910 |
| 12 | 0.1602 | 0.1937 | 0.1983 | 0.2172 | 0.2204 | 0.2934 | 0.2254 |
| 13 | 0.1537 | 0.1861 | 0.1924 | 0.1998 | 0.2052 | 0.2870 | 0.2165 |
| 14 | 0.1398 | 0.1682 | 0.1741 | 0.1947 | 0.1974 | 0.2595 | 0.1990 |
| 15 | 0.1179 | 0.1493 | 0.1550 | 0.1813 | 0.1714 | 0.2431 | 0.1805 |
| 16 | 0.1080 | 0.1381 | 0.1462 | 0.1703 | 0.1608 | 0.2363 | 0.1716 |
| 17 | 0.1028 | 0.1310 | 0.1439 | 0.1620 | 0.1582 | 0.2343 | 0.1677 |
| 18 | 0.0943 | 0.1162 | 0.1275 | 0.1312 | 0.1474 | 0.2091 | 0.1489 |
| 19 | 0.0844 | 0.1137 | 0.1227 | 0.1312 | 0.1447 | 0.2049 | 0.1455 |
| 20 | 0.0844 | 0.1058 | 0.1177 | 0.1312 | 0.1391 | 0.1987 | 0.1409 |
| 21 | 0.0844 | 0.1058 | 0.1177 | 0.1312 | 0.1391 | 0.1976 | 0.1405 |
| 22 | 0.0844 | 0.1058 | 0.1177 | 0.1312 | 0.1391 | 0.1955 | 0.1398 |
| 23 | 0.0844 | 0.1058 | 0.1177 | 0.1312 | 0.1391 | 0.1933 | 0.1391 |
| 24 | 0.0491 | 0.0591 | 0.0729 | 0.0838 | 0.0531 | 0.1019 | 0.0746 |
| 25 | 0.0491 | 0.0563 | 0.0699 | 0.0838 | 0.0531 | 0.1019 | 0.0738 |
| 26 | 0.0491 | 0.0563 | 0.0699 | 0.0806 | 0.0531 | 0.1019 | 0.0734 |
| 27 | 0.0491 | 0.0563 | 0.0699 | 0.0774 | 0.0531 | 0.0996 | 0.0723 |
| 28 | 0.0491 | 0.0563 | 0.0669 | 0.0774 | 0.0531 | 0.0966 | 0.0719 |
| 29 | 0.0491 | 0.0563 | 0.0669 | 0.0774 | 0.0531 | 0.0985 | 0.0715 |
| 30 | 0.0350 | 0.0136 | 0.0049 | 0.0139 | 0.0082 | 0.0121 | 0.0094 |
| $\bar{m}_i$ ** | 7.39 | 8.35 | 8.36 | 8.96 | 9.55 | 10.98 | 9.21 |

* $m_{ix}$ – probability of a mother of parity $i$ continuing to breast-feed the child at $x$ months after the birth of the child.

** $\bar{m}_i = \frac{1}{2}(m_{i,0} + m_{i,30}) + (m_{i,1} + m_{i,2} + \ldots + m_{i,29})$

3.4.3. LACTATION

Table 18 presents a life table analysis of the duration of breastfeeding of women in Fiji after each parity. Since data on breastfeeding were available only for the last child and as a considerable number of women were continuing to breastfeed their children at the time of the survey, it was necessary to have recourse to the life table technique for the analysis of lactation length. The table provides the value of $m_{ix}$ which indicates the probability of a mother of parity $i$ continuing to breastfeed the child at $x$ months after the birth of the child. The life table mean values have also been computed by the standard procedure. From this table it can be seen that the average duration of breastfeeding increases systematically with the birth order from 7.4 months for the first child to 11.0 months for children of parity 6 and above. The average duration of breastfeeding is found to be 9.2 months. For a developing country this is slightly lower than what has been observed in developing countries of Asia.

In both, the analysis of post partum amenorrhoea and lactation through life table techniques, though the problem of censoring has been successfully handled, the effects of age and birth order cannot be isolated. The increase in the mean duration of amenorrhoea and lactation over the birth orders can be partly attributed to the fact that women of higher birth orders are likely to be older, and the age effect is confounded with parity effect in this type of analysis.

## 3.5. ESTIMATION OF PARITY PROGRESSION RATIOS AND MARITAL FERTILITY

### 3.5.1. PARITY PROGRESSION RATIOS

It was pointed out in Section IIB that the open birth intervals could be profitably used for estimating the incidence of secondary sterility. If $U_i$ represents the open interval after parity $i$ for women who are currently married at the time of the survey and within the reproductive group (15 to 45) and the parameters $\alpha_i$, $\beta_i$ and $\gamma_i$ are defined such that $\alpha_i$ represents the probability that a woman of parity '$i$' will ever proceed to parity $(i + 1)$, and $\beta_i$ represents the probability that the woman will not reach parity $(i + 1)$ but continues to live throughout her reproductive life in the married state, and $\gamma_i$ denotes the probability that a woman will get widowed or divorced before reaching parity $(i + 1)$ and before reaching 45 years of age. Then $\alpha_i$, $\beta_i$ and $\gamma_i$ are mutually exclusive probabilities and $\alpha_i + \beta_i + \gamma_i = 1$. This is because that any woman giving birth to $i$-th child has three mutually exclusive possibilities open to her in her future with regard to fertility.

i) She may progress to the next child $(i + 1)$, the probability of which is denoted by $\alpha_i$;

ii) She becomes sterile, either by voluntary means or otherwise, and does not progress to the next child $(i + 1)$, the probability of which is denoted by $\beta_i$; and

iii) She becomes widowed or divorced before reaching the next parity and before reaching the end of reproduction.

**Table 19.** Estimates of Parity Progression Ratios from Open Birth Interval ($\alpha_i$)

| Birth Order $(i - i + 1)$ | $E\,U_i$ | $E\,T_i$ | $E\,T^2_i$ | $E\,V_i$ | $E\,V^2_i$ | $\alpha_i$ | $(\alpha_i)$ India (1965) |
|---|---|---|---|---|---|---|---|
| 0-1 | 49.98 | 25.12 | 1080.03 | 298.86 | 91183.25 | 0.783 | 0.820 |
| 1-2 | 42.50 | 32.68 | 1558.16 | 282.63 | 81501.25 | 0.845 | 0.850 |
| 2-3 | 41.49 | 36.44 | 1976.09 | 255.56 | 67428.31 | 0.863 | 0.833 |
| 3-4 | 47.40 | 36.13 | 1832.08 | 232.51 | 56255.27 | 0.769 | 0.750 |
| 4-5 | 54.15 | 37.58 | 1996.93 | 212.47 | 47458.88 | 0.676 | 0.649 |
| 5-6 | 57.84 | 35.68 | 1733.16 | 159.46 | 28308.56 | 0.491 | 0.601* |
| & above | | | | | | | 0.394** |

* Includes Progression Ratios from 5-6 only

** Includes Progression Ratios from 6 & above

$$\alpha_i = \frac{EU_i - EV^2 i/2EV_i}{ET^2 i/2ET_i - EV^2 i/2EV_i}$$

$U_i$ – Open interval for women of parity $i$
$T_i$ – Last Closed Birth Interval (LBI), $(i - i + 1)$
$V_i$ – Interval from age at the birth of the $i$-th child to age 45 for women of parity '$i$'

Thus from a knowledge of mean open interval and the first two moments of the corresponding closed interval $T_i$ between the date of the birth of the $i$ th child and 45 years of age we can estimate $\alpha_i$, i.e., the probability that a woman of parity $i$ will ever progress to the $(i + 1)$th child $\alpha_i$ can be considered as good approximation of the parity progression ratios of women of parity $i$. The estimates of these probabilities have been derived from Fiji Fertility Survey data and furnished in Table 19.

It is found from the table that the parity progression ratios or the probability that a woman of parity $i$ will ever progress to parity $(i+1)$ in Fiji is of the range of 0.86 to 0.49 and varies with birth order. For comparison purposes, the estimates obtained by adopting the same procedure in a rural population in South India from data compiled in 1965 by Srinivasan have also been furnished in the same table. It is interesting to note from the table that the progression ratios are almost the same for Fijian and Indian population, excepting parities 0 and 5 and over, indicating a higher fertility among Indian women. It has to be recognized that these ratios do not represent the probabilities of progression to the next parity for any particular cohort but provide a picture for the mixed or synthetic cohort as estimated from recent experiences.

### 3.5.2. ESTIMATION OF REGRESSION EQUATIONS RELATING MEAN OPEN BIRTH INTERVAL TO MARITAL FERTILITY RATES

As was pointed out in the earlier, in Section II, the mean open birth interval is very highly correlated with the current fertility measures, especially when analysed by the age, marital duration or parity of the women. If for every age group 15-19, 20-24, .... 45-49 we have data from a survey, on the mean open interval and the age specific marital fertility rates for many subgroups of the population, such as for different administrative units or geographic zones, we can develop a regression equation relating mean open interval with these fertility measures. We can also develop an overall regression equation relating mean open interval for all age groups with the general marital fertility rate. All these regression equations have statistical stability and as such can be used to estimate marital fertility rates in the same population at different points of time in the future from a knowledge of the mean open birth intervals. Such regression equations have also developed from Fiji data (Table 20).

Table 20 provides a regression of age specific marital fertility rates on the mean open birth interval for different age groups. The regressions have been obtained by using the data on the mean open birth interval and the age specific marital fertility rates for different subgroups of population in Fiji. Ideally, if such data were available for different administrative units of the country or at different time points they could be used for the derivation of the regression equations. In the absence of such data, information on different overlapping subgroups of the population (which is not theoretically the ideal procedure) had to be used. It is seen that the regression of mean age specific marital fertility rates on open birth intervals reveal a systematic pattern over the age groups. For example, an addition of $X$ months to the mean open birth intervals in the age group 25-29 implies a reduction of 11.3 $X$ points in the age specific marital fertility rate, and in the age group 40-44 a reduction of 1.97 $X$ points in the fertility rate. In the younger ages 15-19 and 20-24, surprisingly there appears to be a positive regression between mean open birth interval and fertility rate, and this might be due to the small number of observations on which the regression is based. The overall regression of general marital fertility rate of the mean open birth interval, which is itself based on 10 observations, is found to be $Y = 242.84 - 1.0\,X$ indicating that a $X$-month increase in the open birth interval can be expected to reduce the general marital fertility rate by $X$ points. Such regression equations will be useful in estimating the level and change in fertility rates in the population from a knowledge of the mean open birth intervals. It is to be realized that such regressions are context specific and have to be worked out for each country separately, preferably taking as many such units as possible. The analogy, however, points out the advantages of regressing man open birth intervals on marital fertility rates.

**Table 20.** Regressions of Mean Open Birth Interval on Age Specific Marital Fertility Rate (MASFR)

| | Educational Status Groups | | | | | | | | | | Religion of Women | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | | 5 | | i | | 2 | | 3 | | 4 | | 5 | | 6 | |
| | Means of OBI (X) | ASFR (Y) | Means of OBI (X) | ASFR (Y) | Means of OBI (X) | ASFR (Y) | Means of OBI (X) | ASFR (Y) | Means of OBI (X) | ASFR (Y) | Means of OBI (X) | ASFR (Y) | Means of OBI (X) | ASFR (Y) | Means of OBI (X) | ASFR (Y) | Means of OBI (X) | ASFR (Y) | Means of OBI (X) | ASFR (Y) | Means of OBI (X) | ASFR (Y) |
| 15-19 | 13.3 | 266.7 | – | – | 9.9 | 325.9 | 9.0 | 185.2 | – | – | 8.1* | 266.7 | 10.9 | 236.4 | 7.5* | 625.0 | 10.1 | 258.6 | 10.0 | 450.0 | 13.7* | 166.7 |
| 20-24 | 17.1 | 394.4 | 11.0* | 1000 | 18.9 | 326.1 | 15.2 | 292.1 | 15.0* | 300.0 | 16.0 | 303.6 | 17.9 | 330.5 | 16.1 | 352.9 | 18.5 | 320.0 | 17.4 | 333.3 | 13.7* | 363.6 |
| 25-29 | 45.7 | 121.7 | 20.3* | 333.3 | 34.3 | 240.7 | 31.0 | 256.9 | 22.4* | 363.6 | 27.9 | 350.6 | 32.9 | 241.0 | 36.5 | 250.0 | 36.6 | 211.7 | 38.6 | 200.0 | 48.5* | 0.0 |
| 30-34 | 65.6 | 85.3 | – | – | 50.9 | 176.3 | 48.7 | 73.5 | 27.1* | 375.0 | 44.0 | 228.6 | 44.4 | 207.0 | 41.6 | 166.7 | 59.5 | 108.6 | 71.3 | 92.3 | 50.9* | 142.9 |
| 35-39 | 76.0 | 87.0 | – | – | 75.7 | 136.6 | 67.9 | 54.1 | – | – | 76.0 | 132.4 | 64.5 | 155.3 | 78.5* | 41.7 | 82.4 | 86.3 | 80.3 | 78.9 | – | – |
| 40-44 | 124.0 | 31.0 | – | – | 102.7 | 54.6 | – | – | – | – | 78.3 | 150.0 | 99.7 | 53.3 | 89.0* | 43.5 | 123.8 | 14.7 | 129.5 | 58.8 | – | – |
| Combined | 68.3 | 125.8 | 18.0* | 500.0 | 47.6 | 211.9 | 28.0 | 213.7 | 21.5 | 254.5 | 43.6 | 253.2 | 58.5 | 212.7 | 45.9 | 210.2 | 52.0 | 178.1 | 54.5 | 195.2 | 30.5 | 157.9 |

* Figures not considered for the analysis of regression equation owing to number of observations less than 30.
$X$ = Mean of Open Birth Interval
$Y$ = Age Specific Marital Fertility Rate (ASMFR)

The regression equation of $Y$ on $X$ is $Y = a + bX$.
The regression equations for the respective age groups are:
15-19, $Y = 168.72 + 8.07\,X$
20-24, $Y = 246.88 + 4.94\,X$
25-29, $Y = 633.05 - 11.26\,X$
30-34, $Y = 346.83 - 3.84\,X$
35-39, $Y = 230.16 - 1.68\,X$
40-44, $Y = 276.18 - 1.97\,X$
Combined, $Y = 242.84 - 1.0\,X$

# 4 Summary and Conclusions

This paper has been prepared with the following objectives in mind:

1. To develop simple analytical methods for checking the quality of data on birth intervals reported in retrospective surveys and methods of adjustments for defective or incomplete data in such variables;
2. To identify and discuss the methodological issues involved in the analyses and interpretation of data on birth intervals, closed as well as open, compiled from retrospective surveys, especially when used as indicators of levels and changes in fertility;
3. To develop a simple framework for the analysis of data on birth intervals, closed as well as open, obtained from World Fertility Survey type enquiries; and
4. To make an illustrative application for the purposes of highlighting the issues involved in the analyses of retrospective survey data on intervals to such data collected by the World Fertility Survey.

The analysis of fertility of a population can be considered in two dimensions: first, how women space their children; and second, how many women of a given parity proceed to the next. The closed birth intervals are useful tools in studying the pattern of reproduction of those women who continue to reproduce, that is, the first dimension. They do not throw light on the number and proportion of women of any parity who do not have any more children. The open birth intervals can be used to measure the extent to which fertility limitation, either involuntary or voluntary, is practised by the population, that is, the second dimension.

The birth intervals, closed as well as open, have been used in the literature, both as independent variables for the explanation of fertility differentials and as dependent variables to be used in themselves as indicators of fertility levels and changes.

A review of the relevant studies in this direction has been provided. The closed birth intervals can be measured according to different ascertainment plans and four types of intervals have been discussed; all closed birth intervals (ACBI), last closed birth interval (LBI), straddling birth intervals (SBI) and prospective birth intervals (PBI). The uses and limitations of each type of birth intervals and the types of errors and biases present in them are also discussed. The extent of digit preferences prevalent in the interval data can be used as an index of the quality of data.

The closed birth intervals could also be used for estimation of various biosocial parameters of the population, such as fecundability, incidence of foetal wastage, post partum amenorrhoea, etc. through the use of appropriate models. On analytical considerations, the open birth intervals (OBI) can be expected to be most highly correlated with current fertility levels of the population and could be used for estimation of parity progression ratios, and, through appropriate regression equations, the marital fertility rates. In populations where it is difficult to measure the age of a woman accurately, because of factors of illiteracy of respondents, non-response, etc., the data on open birth intervals could be obtained with relatively higher reliability and could be used for study of levels and changes in fertility of the population.

The data on birth intervals collected through pregnancy histories in *World Fertility Survey* type of surveys can be analysed on a logical sequence to meet the following purposes:

1. Checking the quality of data through birth interval analysis;
2. Study of levels and differentials in birth intervals through appropriate controls for age and marital duration and life table techniques; and
3. Estimation of fecundability, parity progression ratios, and marital fertility rates from a knowledge of the birth interval distributions.

These steps are applied to data on birth intervals collected in the Fiji Fertility Survey 1974, and the usefulness and limitations of such an analysis and the implications of the findings have been illustrated. It is found that the quality of fertility data compiled in the Fiji Fertility Survey can be considered to be generally good for a developing country. The fertility differentials observed in the population in various socio-economic groups are found to be mostly due to differentials in the extent of fertility limitation rather than due to spacing of children. Estimates of fecundability and parity progression ratios have also been obtained from a knowledge of the distributions of the closed and open birth intervals, respectively. Regression of equations relating mean open intervals to marital fertility rates by age, and for all ages together have been worked out. The study clearly indicates the potential values of repeating the same type of analyses to data on birth intervals compiled through fertility surveys, especially the World Fertility Survey, in other developing countries.

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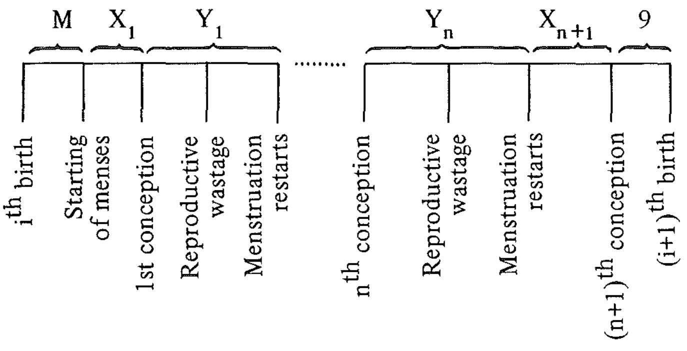
# Appendix I A Probability Model for the Closed Birth Interval (Ti) Used for Estimation of Fecundability

The different components making up the closed birth interval $T_i$, given that there are *'n'* foetal wastages within the interval, can be represented as follows:

$$T_i/n = M + X_1 + X_2 + \ldots + X_{n+1} + Y_1 + Y_2 + \ldots Y_n + 9 \quad (i)$$




Here all the random variables are specific to interval $(i) - (i+1)$ and should be strictly denoted by $M$, $X_{1i}$, $\ldots X_{(n+1)i}$, $Y_{1i}, \ldots Y_{ni}$ and only for the sake of algebraic simplicity the suffix $i$ is omitted. The random variables $X_1, \ldots X_{n+1}$ denote the waiting times to conception and $Y_1 \ldots Y_n$ the periods of nonsusceptibility associated with *'n'* foetal wastages. Making the following notations

Q(s) – Probability Generating function (p.g.f.) of M

$$\text{ie.} = \sum_{\mu=0}^{\infty} s^r \text{ Prob } (M = r)$$

$\mu$ – Mean of $M$

$\sigma^2$ – Variance of $M$

$p$ – Fecundability or the monthly probability of conception

$\theta$ – Probability that a conception ends in a live birth.

Now, assuming that the period of nonsusceptibility associated with a foetal wastage is a constant and equals 5 months (3 months of pregnancy at which the termination occurs and 2 months of amenorrhoea following the termination and assuming the statistical independence of the variables $M$, $X$, and $Y$, we can easily prove that the probability generating function of $T_i$ given that there are $n$ foetal wastages in the interval and the fecundability of a woman is *'p'* is given by

$$H(s/n,p) = Q(s)\, s^{5n}\, (p/1 - qs)^{n+1}\, s^9 \quad \ldots\ldots\ldots\ (ii)$$

If $N$ denotes the random variable of number of foetal wastages

Prob $(N = n) = (1-\theta)^n\, \theta$. Hence for any $n$

$$H(s/p) = (\Sigma\, \theta\, (1-\theta)^n\ H(s/n,p) = \frac{p\,\theta\, s^9\, Q(s)}{1 - qs - p(1-\theta)s^5}$$

Now assuming that *'p'* is distributed as a Beta function over women ie., the density function of *'p'* is given by

$$f(p) = \frac{1}{B(a,b)}\, p^{a-1} (1-p)^{b-1}$$

We have the p.g.f. of $T_i$ for any woman chosen at random from the population given by

$$H(S) = \frac{\theta\, s^9\, Q(s)}{B(a,b)} \int_0^1 \frac{p^a (1-p)^{b-1}}{1 - qs - p(1-\theta)s^5}\, dp \quad \ldots (iii)$$

Now for the first interval between marriage and first child, the component of post-partum amenorrhoea is absent and hence we will have by putting $Q(s) = 1$ in the above equation

$$H_0(S) = \frac{\theta\, s^9}{B(a,b)} \int_0^1 \frac{p^a\, q^{b-1}}{1 - qs - p(1-\theta)s^5}\, dp \quad \ldots (iv)$$

Now we know that any p.g.f. $H(s)$ of a random variable $T$ has the properties

$$\frac{\partial H}{\partial s} = \frac{ET}{at\ s = 1}$$

and

$$\frac{\partial^2 H}{\partial s^2} = \frac{ET^2 - ET}{at\ s = 1}$$

Consequently, differentiating the expression for $H(S)$ in (iii) successively twice and putting s = 1 and noting that

$$\frac{\partial\, Q(s)}{\partial\, s}\Big|_{s=1} = \mu \quad and \quad \frac{\partial^2\, Q(s)}{\partial s^2}\Big|_{s=1} = \sigma^2 = \mu^2 - \mu = \pi \ (say)$$

We have

$$E(T_i) = \mu + 4 + \frac{1}{\theta}(5 + b/a - 1) \quad \ldots\ldots\ldots\ldots\ldots\ (v)$$

and

$$E\,T^2_i - E\,T_i = (12 + 8\mu + \pi) + \frac{1}{\theta}(10 + 10\mu)$$

$$+ \frac{2b}{a-1}(\mu - 1) + \frac{1}{\theta 2}(50 + 20\frac{b}{a-1} + \frac{2b(b+1)}{(a-1)(a-2)} \quad (vi)$$

Similarly differentiating $H_0$ (s) given in (iv) twice and putting $s = 1$ we have

$$E\,T_o = 4 + 1/\theta\left(5 + \frac{b}{a-1}\right) \quad \text{.......... (vii)}$$

$$E\,T^2_o - E\,T_o = 12 + \frac{1}{\theta}\left(10 - \frac{2b}{a-1}\right) + \frac{1}{\theta^2}\left(50 + 20\frac{b}{a-1}\right.$$

$$\left. + \frac{2b\,(b+1)}{(a-1)(a-2)}\right) \quad \text{.......... (viii)}$$

If we have knowledge of $\theta$, or $1 - \theta$, which is the probability of a conception ending as a foetal wastage in any birth interval, equations (v) and (vi) enable us to obtain unique solutions for the two fecundability parameters $a$ and $b$ in the inter-live birth intervals and equations (vii) and (viii) assist in estimating the fecundability parameters in the first interval from a knowledge of the observed mean and variance of the closed birth interval ($T$).

Having obtained $a$ and $b$ the mean fecundity is given by $a/a + b$ and variance by $ab/(a+b)^2\,(a+b+1)$. The fecundability parameters can also be estimated for different levels of $\theta$ and compared with the fecundability levels estimated in different populations for any given level of $\theta$.

# Appendix II Digit Preference Quotients Detailed Tabulations

This appendix contains detailed tables - Tables 2.1 to 2.6 - on Digit Preference Quotients ($Q_1$ and $Q_2$) for different types of birth intervals, classified by birth order and education, religion, and contraceptive usage.

**Table 2.1.** Digit Preference Quotients($DPQ_1$) for Different Types of Birth Intervals, Including and Excluding Imputed values

| | Birth Order of the Intervals | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-1 | | 1-2 | | 2-3 | | 3-4 | | 4-5 | | 5+ | | Combined | |
| Type of Intervals | All Intervals | Excluding Imputed Intervals | All Intervals | Excluding Imputed Intervals | All Intervals | Excluding Imputed Intervals | All Intervals | Excluding Imputed Intervals | All Intervals | Excluding Imputed Intervals | All Intervals | Excluding Imputed Intervals | All Intervals | Excluding Imputed Intervals |
| ACBI | 0.20 (3728)* | 0.16 (2854) | 0.09 (3558) | 0.05 (2940) | 0.10 (2911) | 0.05 (2355) | 0.13 (2271) | 0.08 (1771) | 0.13 (1748) | 0.07 (1307) | 0.13 (3485) | 0.04 (2576) | 0.12 (17701) | 0.07 (13803) |
| LBI | 0.18 (548) | 0.19 (480) | 0.09 (671) | 0.09 (634) | 0.07 (652) | 0.07 (600) | 0.09 (531) | 0.08 (483) | 0.09 (490) | 0.10 (411) | 0.07 (1261) | 0.05 (1025) | 0.08 (4153) | 0.06 (3638) |
| OBI | 0.11 (466) | 0.12 (450) | 0.08 (555) | 0.08 (545) | 0.04 (589) | 0.05 (580) | 0.06 (568) | 0.06 (558) | 0.06 (472) | 0.06 (454) | 0.06 (1329) | 0.04 (1268) | 0.06 (3979) | 0.03 (3855) |
| Straddling at Age | | | | | | | | | | | | | | |
| 20 | 0.12 (749) | 0.09 (607) | 0.10 (924) | 0.07 (804) | 0.15 (530) | 0.09 (404) | 0.15 (202) | 0.11 (138) | 0.27 (68) | 0.16 (50) | 0.56 (19) | 0.55 (12) | 0.11 (2492) | 0.05 (2015) |
| 25 | 0.17 (153) | 0.18 (118) | 0.08 (393) | 0.07 (339) | 0.10 (543) | 0.08 (477) | 0.11 (538) | 0.11 (453) | 0.15 (374) | 0.11 (284) | 0.14 (298) | 0.08 (225) | 0.09 (2299) | 0.05 (1896) |
| 30 | 0.35 (22) | 0.32 (17) | 0.16 (69) | 0.16 (57) | 0.11 (137) | 0.09 (124) | 0.15 (193) | 0.13 (169) | 0.14 (285) | 0.10 (233) | 0.12 (642) | 0.09 (520) | 0.10 (1348) | 0.07 (1119) |
| 35 | 0.82 (3) | 0.91 (2) | 0.45 (10) | 0.55 (9) | 0.30 (21) | 0.29 (20) | 0.29 (42) | 0.27 (36) | 0.22 (51) | 0.22 (42) | 0.10 (441) | 0.07 (364) | 0.09 (568) | 0.05 (473) |
| Prospective at Age | | | | | | | | | | | | | | |
| 20 | 0.25 (933) | 0.20 (774) | 0.08 (1565) | 0.05 (1378) | 0.08 (1920) | 0.05 (1654) | 0.12 (1851) | 0.09 (1510) | 0.12 (1557) | 0.07 (1206) | 0.12 (3213) | 0.05 (2462) | 0.10 (11039) | 0.06 (8984) |
| 25 | 0.21 (122) | 0.16 (98) | 0.10 (275) | 0.11 (240) | 0.10 (477) | 0.06 (474) | 0.12 (698) | 0.07 (592) | 0.12 (882) | 0.09 (717) | 0.12 (2712) | 0.05 (2102 | 0.10 (5166) | 0.05 (4163) |
| 30 | 0.38 (21) | 0.45 (18) | 0.24 (50) | 0.26 (47) | 0.17 (73) | 0.13 (63) | 0.15 (126) | 0.13 (108) | 0.13 (199) | 0.13 (159) | 0.09 (1414) | 0.04 (1111) | 0.08 (1883) | 0.05 (1506) |
| 35 | 0.32 (3) | 0.91 (2) | 0.55 (7) | 0.55 (7) | 0.55 (8) | 0.73 (6) | 0.29 (15) | 0.27 (12) | 0.36 (30) | 0.38 (25) | 0.09 (368) | 0.06 (291) | 0.09 (431) | 0.07 (343) |

* Figures in brackets indicate the number of observations on the intervals.

Note: $DPQ_1$ values based on frequencies of less than 60 should not be considered reliable.

**Table 2.2.** Digit Preference Quotients ($DPQ_2$) for Different Types of Birth Intervals, Including and Excluding Imputed Values

| | Birth order of the Intervals | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-1 | | 1-2 | | 2-3 | | 3-4 | | 4-5 | | 5+ | | Combined | |
| Type of Interval | All Intervals | Excluding Imputed Intervals | All Intervals | Excluding Imputed Intervals | All Intervals | Excluding Imputed Intervals | All Intervals | Excluding Imputed Intervals | All Intervals | Excluding Imputed Intervals | All Intervals | Excluding Imputed Intervals | All Intervals | Excluding Imputed Intervals |
| ACBI | 0.11 (3728) | 0.04 (2854) | 0.08 (3558) | 0.01 (2940) | 0.08 (2911) | 0.03 (2355) | 0.11 (2271) | 0.03 (1771) | 0.11 (1748) | 0.03 (1307) | 0.12 (3485) | 0.02 (2576) | 0.09 (17701) | 0.02 (13803) |
| LBI | 0.09 (548) | 0.09 (480) | 0.04 (671) | 0.04 (634) | 0.05 (652) | 0.05 (600) | 0.09 (531) | 0.08 (483) | 0.07 (490) | 0.05 (411) | 0.06 (1261) | 0.03 (1025) | 0.05 (4153) | 0.05 (3638) |
| OBI | 0.09 (466) | 0.07 (450) | 0.05 (555) | 0.05 (545) | 0.04 (589) | 0.03 (580) | 0.02 (568) | 0.02 (558) | 0.05 (472) | 0.05 (454) | 0.04 (1329) | 0.02 (1268) | 0.08 (3979) | 0.02 (3855) |
| Straddling at Age | | | | | | | | | | | | | | |
| 20 | 0.06 (749) | 0.03 (607) | 0.06 (924) | 0.04 (804) | 0.15 (530) | 0.08 (404) | 0.10 (202) | 0.07 (138) | 0.25 (68) | 0.15 (50) | 0.54 (19) | 0.60 (12) | 0.09 (2492) | 0.03 (2015) |
| 25 | 0.08 (153) | 0.11 (118) | 0.09 (393) | 0.06 (339) | 0.04 (543) | 0.05 (477) | 0.09 (538) | 0.05 (453) | 0.11 (374) | 0.08 (284) | 0.15 (298) | 0.07 (225) | 0.07 (2299) | 0.04 (1896) |
| 30 | 0.29 (22) | 0.26 (17) | 0.13 (69) | 0.15 (57) | 0.09 (137) | 0.08 (124) | 0.11 (193) | 0.09 (169) | 0.09 (285) | 0.08 (233) | 0.10 (642) | 0.06 (520) | 0.08 (1348) | 0.03 (1119) |
| 35 | 0.60 (3) | 0.80 (2) | 0.28 (10) | 0.33 (9) | 0.23 (21) | 0.20 (20) | 0.26 (42) | 0.20 (36) | 0.13 (51) | 0.11 (42) | 0.08 (441) | 0.04 (364) | 0.07 (568) | 0.02 (475) |
| Prospective at Age | | | | | | | | | | | | | | |
| 20 | 0.08 (933) | 0.05 (774) | 0.04 (1565) | 0.03 (1378) | 0.05 (1920) | 0.02 (1654) | 0.09 (1851) | 0.03 (1510) | 0.09 (1557) | 0.03 (1206) | 0.10 (3213) | 0.02 (2462) | 0.07 (11039) | 0.02 (8984) |
| 25 | 0.13 (122) | 0.09 (98) | 0.97 (275) | 0.09 (240) | 0.07 (477) | 0.04 (474) | 0.09 (698) | 0.05 (592) | 0.08 (882) | 0.04 (717) | 0.09 (2712) | 0.02 (2102) | 0.08 (5166) | 0.02 (4163) |
| 30 | 0.34 (21) | 0.33 (18) | 0.10 (50) | 0.14 (47) | 0.13 (73) | 0.10 (63) | 0.09 (126) | 0.08 (108) | 0.06 (199) | 0.03 (159) | 0.07 (1414) | 0.02 (1111) | 0.07 (1883) | 0.02 (1506) |
| 35 | 0.60 (3) | 0.80 (2) | 0.31 (7) | 0.31 (7) | 0.50 (8) | 0.60 (6) | 0.24 (15) | 0.30 (12) | 0.24 (30) | 0.31 (25) | 0.08 (368) | 0.06 (291) | 0.07 (431) | 0.06 (343) |

* Figures in brackets indicate the number of observations on the intervals.

Note: $DPQ_2$ values based on frequencies of less than 60 should not be considered reliable.

**Table 2.3.** Digit Preference Quotients ($DPQ_1$) Classified by Type of Interval and Education, Religion and Contraceptive Practice of the Women

| Characteristics of the women | ACBI All Interval | ACBI Frequency | LBI All Interval | LBI Frequency | OBI All Interval | OBI Frequency |
|---|---|---|---|---|---|---|
| Educational Status | 0.10 | 11,000 | 1.00 | 1,000 | 1.00 | 1,000 |
| No Education | 0.20 | 4,548 | 0.13 | 827 | 0.18 | 684 |
| Unrecognised | 0.23 | 211 | 0.29 | 34 | 0.48 | 22 |
| Primary | 0.10 | 11,868 | 0.07 | 2,843 | 0.10 | 2,721 |
| Secondary | 0.12 | 892 | 0.12 | 393 | 0.11 | 496 |
| College | 0.10 | 182 | 0.16 | 56 | 0.16 | 56 |
| Religion | | | | | | |
| Catholic | 0.11 | 1,396 | 0.09 | 332 | 0.09 | 316 |
| Methodist | 0.08 | 5,590 | 0.06 | 1,348 | 0.06 | 1,264 |
| All Other Chr. sects | 0.08 | 674 | 0.12 | 173 | 0.09 | 160 |
| Hindus | 0.15 | 8,261 | 0.10 | 1,908 | 0.04 | 1,874 |
| Islam | 0.18 | 1,595 | 0.09 | 351 | 0.07 | 325 |
| Others | 0.14 | 185 | 0.25 | 41 | 0.32 | 40 |
| Hindus with Education | 0.20 | 3,468 | 0.14 | 632 | 0.19 | 524 |
| Contraceptive Use | | | | | | |
| Never used | 0.16 | 3,944 | 0.10 | 1,058 | 0.05 | 1,125 |
| Used After Interval | 0.12 | 11,952 | 0.08 | 1,964 | 0.04 | 1,814 |
| Used During or Before the Interval | 0.07 | 1,805 | 0.06 | 1,131 | 0.05 | 1,040 |

$DPQ_1$ values based on frequencies less than 60 should not be considered reliable.

**Table 2.4.** Digit Preference Quotients ($DPQ_2$) Classified by Type of Interval and Education, Religion and Contraceptive Practice of the Women

| Characteristics of the Women | Type of interval | | | | | |
|---|---|---|---|---|---|---|
| | ACBI | | LBI | | OBI | |
| | All Interval | Frequency | All Interval | Frequency | All Interval | Frequency |
| Educational Status | 1.00 | 10,000 | 1.00 | 1,000 | 1.00 | 1,000 |
| No Education | 0.17 | 4,548 | 0.10 | 827 | 0.17 | 684 |
| Unrecognised | 0.16 | 211 | 0.27 | 34 | 0.44 | 22 |
| Primary | 0.06 | 11,868 | 0.05 | 2,843 | 0.10 | 2,721 |
| Secondary | 0.05 | 892 | 0.09 | 393 | 0.09 | 496 |
| College | 0.08 | 182 | 0.15 | 56 | 0.14 | 56 |
| Religion | | | | | | |
| Catholic | 0.05 | 1,396 | 0.03 | 332 | 0.06 | 316 |
| Methodist | 0.05 | 5,590 | 0.04 | 1,348 | 0.04 | 1,264 |
| All Other Chr. Sects | 0.04 | 674 | 0.09 | 173 | 0.07 | 160 |
| Hindu | 0.13 | 8,261 | 0.07 | 1,908 | 0.03 | 1,874 |
| Islam | 0.16 | 1,595 | 0.05 | 351 | 0.06 | 325 |
| Others | 0.10 | 185 | 0.13 | 41 | 0.32 | 40 |
| Hindus With No Education | 0.17 | 3,468 | 0.10 | 632 | 0.19 | 524 |
| Contraceptive Practice | | | | | | |
| Never Used | 0.11 | 3,944 | 0.07 | 1,058 | 0.05 | 1,125 |
| Contraceptive Use after the Interval | 0.09 | 11,952 | 0.07 | 1,964 | 0.04 | 1,814 |
| Contraceptive Use During or Before the Interval | 0.04 | 1,805 | 0.04 | 1,131 | 0.04 | 1,040 |

$DPQ_2$ values based on a frequency of less than 30 should not be considered reliable.

**Table 2.5.** Digit Preference Quotients ($DPQ_1$) for Straddling and Prospective Intervals Classified by Education, Religion and Contraceptive Practice of the Women

| | Type of Interval | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Straddling at Ages | | | | | | | | Prospective at Ages | | | | | |
| | 20 | | 25 | | 30 | | 35 | | 20 | | 25 | | 30 | |
| Characteristics of the Women | All Int-ervals | Fre-quency | All Int-ervals | Fre-quency | All Int-ervals | Fre-quency | All Int-ervals | Fre-quency | All Int-ervals | Fre-quency | All Int-ervals | Fre-quency | All Int-ervals | Fre-qency |
| Educational Status | | 1000 | | 1000 | | 100 | | 100 | | 1000 | | 1000 | | 100 |
| No Education | 0.20 | 602 | 0.21 | 502 | 0.18 | 318 | 0.23 | 137 | 0.18 | 2427 | 0.19 | 1218 | 0.17 | 47 |
| Unrecognised | 0.36 | 23 | 0.39 | 24 | 0.39 | 20 | 0.27 | 11 | 0.19 | 137 | 0.24 | 73 | 0.26 | 3 |
| Primary | 0.11 | 1700 | 0.09 | 1591 | 0.10 | 944 | 0.07 | 403 | 0.09 | 7702 | 0.08 | 3613 | 0.07 | 131 |
| Secondary | 0.14 | 153 | 0.15 | 146 | 0.27 | 45 | 0.55 | 9 | 0.11 | 610 | 0.10 | 177 | 0.25 | 3 |
| College | 0.43 | 14 | 0.30 | 36 | 0.39 | 21 | 0.73 | 8 | 0.09 | 163 | 0.17 | 85 | 0.22 | 2 |
| Religion | | | | | | | | | | | | | | |
| Catholic | 0.10 | 168 | 0.13 | 204 | 0.17 | 134 | 0.22 | 66 | 0.10 | 1043 | 0.12 | 553 | 0.12 | 21 |
| Methodist | 0.11 | 675 | 0.07 | 814 | 0.11 | 577 | 0.14 | 265 | 0.07 | 4202 | 0.06 | 2207 | 0.08 | 86 |
| All Other Christian Sects | 0.11 | 88 | 0.17 | 102 | 0.23 | 54 | 0.30 | 22 | 0.10 | 465 | 0.10 | 203 | 0.14 | 7 |
| Hindu | 0.13 | 1316 | 0.13 | 1006 | 0.13 | 491 | 0.18 | 178 | 0.14 | 4426 | 0.14 | 1829 | 0.15 | 61 |
| Islam | 0.18 | 216 | 0.17 | 152 | 0.13 | 81 | 0.38 | 31 | 0.16 | 791 | 0.20 | 323 | 0.19 | 9 |
| Others | 0.27 | 29 | 0.31 | 21 | 0.64 | 11 | 0.73 | 6 | 0.19 | 112 | 0.26 | 51 | 0.33 | 1 |
| Hindus With No Education | 0.21 | 485 | 0.21 | 397 | 0.19 | 252 | 0.24 | 109 | 0.19 | 1867 | 0.19 | 934 | 0.19 | 37 |
| Contraceptive Use | | | | | | | | | | | | | | |
| Never Used | 0.17 | 585 | 0.13 | 510 | 0.11 | 315 | 0.14 | 156 | 0.12 | 2392 | 0.12 | 1210 | 0.14 | 48 |
| Used After Interval | 0.09 | 1686 | 0.10 | 1438 | 0.11 | 810 | 0.12 | 322 | 0.11 | 7213 | 0.10 | 3217 | 0.09 | 113 |
| Used During or Before Interval | 0.12 | 221 | 0.07 | 351 | 0.13 | 223 | 0.13 | 90 | 0.07 | 1434 | 0.08 | 739 | 0.08 | 26 |

$DPQ_1$ values based on a frequency less than 60 should not be considered reliable.

**Table 2.6.** Digit Preference Quotients ($DPQ_2$) for Straddling and Prospective Intervals Classified by Education, Religion and Contraceptive Practice of Women

| | Type of Interval | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Straddling at Ages | | | | | | | | Prospective at Ages | | | | | |
| | 20 | | 25 | | 30 | | 35 | | 20 | | 25 | | 30 | |
| Characteristics of the Women | All intervals | Frequency | All intervals | Frequency | All intervals | Frequency | All intervals | Frequency | All intervals | Frequency | All intervals | Frequency | All intervals | Frequency |
| Educational Status | | | | | | | | | | | | | | |
| No Education | 0.16 | 602 | 0.18 | 502 | 0.14 | 318 | 0.19 | 137 | 0.16 | 2427 | 0.15 | 1218 | 0.14 | 472 |
| Unrecognised | 0.32 | 23 | 0.22 | 24 | 0.25 | 20 | 0.29 | 11 | 0.12 | 137 | 0.13 | 73 | 0.06 | 32 |
| Primary | 0.08 | 1700 | 0.06 | 1591 | 0.06 | 944 | 0.06 | 403 | 0.05 | 7702 | 0.05 | 3613 | 0.05 | 1317 |
| Secondary | 0.11 | 153 | 0.09 | 146 | 0.28 | 45 | 0.29 | 9 | 0.05 | 610 | 0.08 | 177 | 0.16 | 33 |
| College | 0.43 | 14 | 0.22 | 36 | 0.40 | 21 | 0.60 | 8 | 0.09 | 163 | 0.13 | 85 | 0.19 | 29 |
| Religion | | | | | | | | | | | | | | |
| Catholic | 0.07 | 168 | 0.09 | 204 | 0.11 | 134 | 0.19 | 66 | 0.05 | 1043 | 0.08 | 553 | 0.13 | 216 |
| Methodist | 0.09 | 675 | 0.05 | 814 | 0.08 | 577 | 0.11 | 265 | 0.03 | 4202 | 0.03 | 2207 | 0.02 | 868 |
| All Other Christian Sects | 0.11 | 88 | 0.13 | 102 | 0.18 | 54 | 0.23 | 22 | 0.08 | 465 | 0.07 | 203 | 0.13 | 70 |
| Hindu | 0.11 | 1316 | 0.12 | 1006 | 0.11 | 491 | 0.16 | 178 | 0.13 | 4426 | 0.13 | 1829 | 0.13 | 614 |
| Islam | 0.16 | 216 | 0.17 | 152 | 0.12 | 81 | 0.37 | 31 | 0.12 | 791 | 0.17 | 323 | 0.15 | 97 |
| Others | 0.27 | 29 | 0.32 | 21 | 0.27 | 11 | 0.40 | 6 | 0.11 | 112 | 0.11 | 51 | 0.18 | 18 |
| Hindus with No Education | 0.16 | 485 | 0.18 | 397 | 0.14 | 252 | 0.16 | 109 | 0.17 | 1867 | 0.16 | 934 | 0.15 | 374 |
| Contraceptive Use | | | | | | | | | | | | | | |
| Never Used | 0.14 | 585 | 0.10 | 510 | 0.07 | 315 | 0.10 | 156 | 0.08 | 2392 | 0.09 | 1210 | 0.11 | 484 |
| Used After Interval | 0.08 | 1686 | 0.09 | 1438 | 0.08 | 810 | 0.10 | 322 | 0.08 | 7213 | 0.08 | 3217 | 0.06 | 1132 |
| Used During or Before Interval | 0.10 | 221 | 0.04 | 351 | 0.09 | 223 | 0.09 | 90 | 0.05 | 1434 | 0.07 | 739 | 0.07 | 267 |

$DPQ_2$ values based on a frequency of less than 30 should not be considered reliable.