Part One

STUDIES OF THE MEASUREMENT OF THE IMPACT OF FAMILY PLANNING PROGRAMMES ON FERTILITY: BACKGROUND MATERIAL PREPARED FOR THE EXPERT GROUP MEETING

METHODS OF MEASURING THE IMPACT OF FAMILY PLANNING PROGRAMMES ON FERTILITY: PROBLEMS AND ISSUES*

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INTRODUCTION

Purpose and scope of the study

At a time when a major portion of population policy efforts is committed to large-scale family planning programmes, there is naturally a growing concern about the results of those efforts and, hence, an increased interest in evaluative research. The Expert Group Meeting was devoted to an in-depth examination of one particular aspect of evaluation, namely, the measurement of the impact of family planning programmes on fertility. Specifically, the purpose of that meeting was to review the principal current methods of measuring programme impact on fertility and to determine which measurement method or group of methods are most appropriate in different circumstances.

Why was impact on fertility chosen for discussion? Programme impact can be assessed at various stages of implementation, by measuring changes occurring, for instance, in knowledge of birth control methods, use of birth control methods or desired family size. The interest in fertility derived at first mainly from the fact that a certain number of countries have population policies designed to reduce the rate of growth of their population and consider fertility reduction to be a major objective. In these countries, attempts to measure programme impact on fertility have been made on various occasions, but both the techniques employed and the interpretation of the results have raised a number of difficult issues.

The interest in measuring programme impact on fertility exists independently of policy objectives. Some policies favour fertility increases and others are not directed towards achieving any fertility changes. But fertility change is a plausible consequence of family planning programmes, irrespective of policy aims; and policy-makers, as well as programme administrators, may be interested, for various reasons, in the impact of such programmes on fertility. Indeed, measuring programme effects on fertility is not limited to finding out whether the programme is achieving its objectives. The population factor is often a major component of development planning; and demographic data about future population trends are generally required for the formulation of policies with respect to manpower, health, education etc. Population forecasts require the best available assumptions about future fertility trends. If family planning programmes are undertaken, planners will wish to know whether those programmes have any effects on fertility so as to be able to take such effects into account.

Measuring the effects of a family planning programme on fertility is recognized as a difficult task. If a change in fertility is believed to have occurred during a period of programme implementation, the evaluator is expected to determine what part of that change can be attributed to the programme. Even if no change in fertility is observed, the evaluator must investigate whether the unchanged fertility reflects the absence of any programme influence or whether the constant level of fertility results from the compensating effects or programme and non-programme variables. In other words, the evaluator is expected to establish whether and by how much the fertility of the population under study would have been different without the programme.

How does the evaluator undertake such measurements? The conditions under which he is working are characterized by the fact that many factors are at work in determining fertility, that their relationships are complex, that it is the complexity of these relationships rather than the number of variables involved which appear to raise the most difficult questions, and that wide gaps in knowledge still exist in understanding these interrelations. Ideally, a most rewarding method for evaluating programme impact would be one which, on the one hand, would account separately for programme and non-programme influences and, on the other hand, would weigh appropriately the influence of various variables within each category of influences. This method would, of course, require a model defining the various interrelations among variables, including a satisfactory set of assumptions whenever adequate knowledge was not available. In particular, the model would specify all the relevant variables and the form of their interrelationships, in order to elucidate direct and indirect effects, combined effects, overlapping effects, reciprocal effects etc.

With few exceptions, however, existing statistical and demographic techniques which have been adapted

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and new methods devised for evaluation purposes do not attempt to quantify the contribution of specific programme and non-programme factors to fertility change. The main emphasis is placed on distinguishing between programme and non-programme influences by comparing the fertility observed under programme conditions with the fertility that would have been observed had the programme not been undertaken. The first subsection given below describes as simply and concisely as possible the principal current evaluation methods. Next, various difficulties and methodological issues associated with the application of those methods are outlined. The last subsection briefly states the justification and purpose of the three case studies in which the same evaluation methods are applied comparatively to individual countries.

Methods of measuring family planning programme impact on fertility

There are a number of possible ways of classifying the methods that have been proposed to examine the impact of family planning programmes on fertility. In this paper, the methods described are grouped as follows, recognizing that these categories are not mutually exclusive:

(*a*) Standardization approach;
(*b*) Trend analysis;
(*c*) Experimental designs;
(*d*) Couple-years of protection (CYP);
(*e*) Component projection approach;
(*f*) Analysis of the reproductive process;
(*g*) Regression analysis (including path analysis);
(*h*) Simulation models.

One purpose of this paper is to give a brief account of the procedures used for evaluating programme impact on fertility. In order to facilitate comparison, the description follows a standard format, referring systematically to distinguishing aspects of the approach used in each method. These various points of comparison are: (*a*) the estimating technique itself; (*b*) the programme and non-programme factors utilized; (*c*) the fertility indicators used for measuring fertility change; (*d*) the main assumptions involved; (*e*) the population covered; and (*f*) the time reference for which evaluation is made.

Standardization approach

The standardization approach as applied to measure programme impact on fertility requires two steps. The first step consists in measuring fertility at two points in time to determine whether any change has occurred during the period under study. The second step consists in trying to account for the observed change, if any, by standardizing for various non-programme components which, depending upon the fertility indicator used, may affect observed fertility without reflecting a genuine fertility change. Standardization will thus "explain" part of the observed change and the residual portion which cannot be accounted for by the standardized components will require an additional analysis. On the basis of reasonable assumptions and satisfactory evidence, all or part of the residual can thus be attributed to the family planning programme. Caution is, however, required in using this method. Factors other than those standardized for can evidently affect observed fertility, although not all of the non-programme factors can easily be taken into account. Standardization for socio-economic factors, apparently not attempted so far, might be a fruitful effort to approach this difficulty.

Trend analysis

Trend analysis, the fertility projection approach, is used to estimate, on the basis of reasonable assumptions, how the fertility of the population under study would have evolved had the family planning programme not been undertaken. This potential trend in fertility is then compared with the actual trend and an attempt to interpret the difference between the two trends can be made in order to assess the possible effects of the family planning programme. Caution has, of course, to be taken so as not to attribute to the programme a trend difference resulting from erroneous projection assumptions. The method can be applied on the aggregate level to estimate over-all country effects or, if data are available, to specific groups, such as acceptors only. In the latter case, however, additional problems arise.

Experimental designs

The experimental-design approach endeavours to compare two groups of population: one, the "experimental group", is assumed to have undergone a treatment which, in the present case, would be the family planning programme; the other, the "control group", is assumed to have the same characteristics as the experimental group, except that it was not exposed to the treatment. The fertility of each group is recorded at one or several points in time; and, assuming that the two groups are comparable except for the programme factor, the evaluator would consider any difference in fertility between the experimental and control groups as resulting from the programme. Comparability of groups or non-exposure to treatment is, however, rarely found in real social settings, so that evaluators resort to variations of the classical experimental design. In practice, researchers resort to various forms of *ex post facto* matching procedures.

Couple-years of protection

The couple-years of protection index is an estimate of the protection against pregnancy resulting from the differential use of various methods of birth control. It is used to produce a measure of programme achievement in a period, by assessing the joint impact of methods adopted, taking into account the length of time a couple is likely to be protected by each method. The CYP index can also be used to produce an estimate of prevalence of use during a period by taking into account protection resulting from past distribution as well as protection derived in the period from current distribution. From this prevalence measure, one can estimate the number of births averted on the basis of a simple translation equation of the form 1 CYP = n births averted, n varying with the fertility levels prevailing in each country. The sources of data, the quality of data and the assumptions involved in the determination of both terms of this equation define this method as very simple, but somewhat crude, whose interpretation is difficult and whose reliability is uncertain. Although this method has been recommended or used for various administrative purposes, its conclusion requires independent verification.

Component projection approach

The component projection approach is also based on data about birth control practice. The number of acceptors of a given method, the duration of use and the effectiveness of the contraception must be taken into account, either explicitly or implicitly. In addition, the fertility of these acceptors, had the family planning programme not been undertaken (potential fertility) must be estimated for the period of time under analysis. These data allow the evaluator to obtain an estimate of the number of births averted over a given time period. These estimates are usually worked out by five-year age groups on an annual basis. The summation of births averted for all ages of the women's reproductive span and for all 12-month periods studied provides the total number of births averted during the period under study. This approach is not without difficulties, both for estimating the number of continuing users and for estimating their potential fertility. The timing of adoption in relation to the woman's reproductive cycle, the switching of family planning methods and the use of abortion are factors which raise a number of additional problems. Since the pioneering work of Lee and Isbister[1] in component projection, there have been a number of new developments, the purpose of which is to examine the effects of family planning programmes on both marital age-specific fertility rates and crude birth rates. Examples of these new developments can be found in studies referred to in the selected bibliography at the end of this paper, the most recent work in this field being that published by the Economic and Social Commission for Asia and the Pacific (ESCAP).

Analysis of reproductive process

Analysis of the reproductive process has been used to estimate births averted by a segment of contraceptive use. As applied by Potter[2] and by Wolfers,[3] the mean duration of interruption of pregnancy due to the acceptors' effective use of programme contraception is estimated by the life-table technique and compared with the mean duration between births, used as an estimation of the acceptors' potential fertility. If, because of the adoption of the programme contraceptive, the acceptors remain in a non-pregnant state for an average period equivalent to the length of an average birth interval, then one birth has been averted. In addition to the average duration per birth and the length of use of the contraceptive from the life table, these methods often include adjustments for the proportion of acceptors who are sterile at acceptance and who become sterile subsequently, overlap of contraceptive use with post-partum amenorrhoea, pregnancy rates while using contraception and a time "penalty" for such pregnancies. These methods, devised for intra-uterine methods, have been adapted for other contraceptive methods. In the application of this method, caution is required in establishing assumptions dealing with special situations, such as when one contraceptive is substituted for another or when one method is supplemented by another.

Regression analysis

Multiple regression analysis, including path analysis, can also be performed if the required data are available. The method consists in determining an equation or system of equations where the dependent variable is a fertility indicator and the independent variables are programme and non-programme factors. Through such a functional model, the evaluator can attempt to calculate quantitative estimates of the weight of the various independent variables in explaining differences in the dependent variable. The relation of various family planning programme components to differences in level of fertility within a given country is interpreted by this approach as pin-pointing the effect of these components upon changes in fertility that have occurred in the past. This method is not without difficulties and involves a series of crucial steps—selection of the variables, procedure for estimating regression coefficients etc.—whose bearing on the results and their interpretation is of fundamental importance.

Simulation models

Simulation models are also used for the study of births prevented by the use of birth control methods.

[1] B. M. Lee and John Isbister, "The impact of birth control programs on fertility", in Bernard Berelson and others, eds., *Family Planning and Population Programs: A Review of World Development* (Chicago, Ill., University of Chicago Press, 1966), pp. 737–758.

[2] Robert G. Potter, "Application of the life-table techniques to measurement of contraceptive effectiveness", *Demography,* vol. 3, No. 2 (1966), pp. 297–304; and *idem,* "Estimating births averted in a family planning program", in S. J. Behrman, Leslie Corsa, Jr. and Ronald Freedman, eds., *Fertility and Family Planning: A World View* (Ann Arbor, Mich., University of Michigan Press, 1969), pp. 413–434.

[3] David Wolfers, "The demographic effect of a contraceptive programme", *Population Studies,* vol. XXIII, No. 1 (March 1969), pp. 111–141.

This approach is, however, largely theoretical and has as its objective the study of the effects of family planning practices under various hypothetical conditions regarding, for instance, the type and effectiveness of method used and the reproductive characteristics of the women. Research in this field has investigated births prevented by contraception, by abortion, by sterilization and by contraception supplemented by abortion.

Major methodological issues

The second section of this paper is devoted to an in-depth examination of the main difficulties which evaluators face in applying the evaluation methods described in the second paper. Its principal purpose is to generate a discussion focused on these specific issues. The presentation is, however, concerned chiefly with raising questions rather than with suggesting answers, the latter area being the responsibility of the experts participating in the meeting. Another purpose of this paper is to set the stage for an organized systematic discussion of the results of the three country studies prepared for this meeting.

The methodological issues selected for discussion have been classified, somewhat arbitrarily, as follows:

(*a*) Potential fertility;
(*b*) Data requirement problems;
(*c*) Interaction problems;
(*d*) Uncontrolled variables;
(*e*) Independence of methods;
(*f*) Cost-precision analysis.

Most of the main issues are common problems of the social sciences related to the interdependence among variables. On the other hand, potential fertility as such is an issue specific to family planning programme evaluation, although the measurement of non-events is a problem shared in many areas of evaluative research. Cost-precision problems are partially of an administrative nature. There is often a trade-off between cost and precision which may affect in one way or another the reliability of the evaluation results and conclusions. Each of these six issues is briefly commented upon below.

Potential fertility

Many methods assessing the effects of family planning programmes on fertility rely on a comparison between the actual fertility of the population under study and its potential fertility, i.e., the fertility that population might have experienced in the absence of the programme. Allied to the question of potential fertility is that of substitution of contraception from the programme for methods practised outside the programme, or taking account of the possibility that those who practise for the first time within the programme would have adopted through other means in the absence of a programme. The estimation of potential fertility, including substitution effects, raises a number of problems, notably with respect to the type of data used, the assumptions involved, the indicator selected and the computation technique applied. Some procedures are more straightforward than others; and, in all cases, an evaluation of the quality of the estimate is needed. Its validity and accuracy are important because over-estimating or underestimating potential fertility would result in an over-estimation or an underestimation of programme impact. It is true that one can never know with certainty what fertility would have been in circumstances other than those which occurred. Reasonable estimates of potential fertility, however, can usually be obtained if caution is exercised in formulating the underlying assumptions.

Data requirement problems

When data required by a particular method are not available, substitute data may be obtained by estimating the missing data, by using data from another population with a similar background, or by making other assumptions about the unavailable data etc. When available data are known to be unreliable, estimates or adjustments sometimes can be performed to bring those data in line. In other instances, data cannot be corrected, although the magnitude of the error can sometimes be assessed, as in the case of sampling error. Even when data are corrected, error may still remain. Thus, whether treated or not before being used for evaluation purposes, data may be the source of sometimes extensive uncertainties affecting the validity of the evaluation results. Furthermore, data quality is not the only ground on which results may be questioned. Certain indicators—of fertility, for instance—may be better than others for specific measurements. Failure to interpret a given indicator in the light of its limitations—a crude birth rate uncorrected for age structure—is an additional source of inaccurate evaluation. A fair appraisal of errors associated with data utilization is a prerequisite of reliable evaluation conclusions.

Interaction problems

Discriminating between programme and non-programme effects and calculating the differential impact of various factors on fertility is the essential feature of programme impact measurement procedures. A non-programme factor may affect fertility directly, or through one or more non-programme factors, or even through one or more programme factors. Likewise, programme factors can affect fertility directly or through other factors. In some cases, the effects of two variables may be additive; in other cases, their effects may be overlapping. Improper measurement of the contribution of any given variable to a fertility change may over-estimate or underestimate its influence and lead to erroneous conclusions about the impact of the programme. A satisfactory assessment of the various interaction effects of the variables utilized in the application of a given method is thus imperative for a satisfactory evaluation of programme impact.

Uncontrolled variables

The number and complexity of the interrelations between fertility and its determining factors do not allow the evaluator to utilize all the relevant variables. Many methods make a selective use of variables, giving emphasis to those most expected to provide a satisfactory measurement of programme impact. Some variables are neglected because their role is not immediately obvious, others because they are difficult to quantify, still others because the required data are not available. The output of a method application is, of course, directly dependent upon its inputs. If inappropriate variables are used, for instance, or if some important variables are not controlled for at all, the validity of the evaluation exercise may be affected to an extent which is, in many instances, not easy to determine.

Independence of methods

The measurement of programme impact on fertility is complicated not only by the recognized limitations of all current methods but by the differing conditions and circumstances involved in programme implementation in different countries. It would be of great help if some of the difficulties encountered in identifying the various influences on fertility could be overcome by using two or more methods simultaneously. This might strengthen the evidence, thus increasing the probability that the conclusions about the effects of the programme are correct. Which methods can be best used as complementary approaches to measure the impact of a family planning programme on fertility under specific conditions? It appears reasonable to assume that methods which would assess programme impact independently would afford a greater guarantee of objective evaluation. But what are independent methods? One may refer here to the items of the standard format used in describing the various methods and consider whether some of these items could be considered criteria of independence; and, if yes, which constitute the most valid basis for establishing independent verification.

Cost-precision analysis

The accuracy of the results that can be obtained from the different measurement methods is still a largely unexplored field. Evidently, some methods yield a more precise assessment of the programme effect than others and the question of method precision deserves more systematic study. How precise an estimate of programme impact should be is another question. In some cases, a bare approximation of the programme effects could be simpler, easier and less time-consuming to obtain and still be satisfactory for a specific purpose. In other cases, more accurate results would be necessary. Whenever the more precise measurement methods require more work for data gathering and corrections, more expertise, more complex techniques of evaluation and the use of electronic computers, the additional cost may impose a restriction on the degree of precision feasible. Taken together, these considerations lead to the conclusion that the precision required for a given evaluation will be, by and large, a function of both the purpose of the evaluation and the cost involved. In other words, a cost-precision analysis is required in the light of financial possibilities and evaluation objectives. So far, little attention has been devoted to this question. How does one compare the various methods in terms of accuracy? What are the alternative decision-making processes through which an acceptable cost-precision balance can be reached?

Country studies

The main objective of the three country studies was to complement the material presented in the main sections of this paper by providing concrete comparative models of method application. Practically, their conclusions are expected to point out the method or methods that present the least difficulties and yield the best results in specific circumstances. Each study is carried out with this purpose in mind and focuses primarily on: (*a*) problems that arise when an evaluation method is put to use in specified circumstances; and (*b*) a comparison of the results obtained by each method and an analysis of the probable reasons for whatever differences are found to exist. Emphasis is placed not on the description of method application, but rather on the problem areas of method application and on the comparative validity of the results. The difficulties encountered by the evaluators are discussed, whenever it is pertinent, in terms of the methodological issues described below.

The problems arising when specific family planning evaluation methods are applied in given circumstances may be considered from three viewpoints: (*a*) selection of the method; (*b*) application of the method; and (*c*) interpretation of the results. As concerns the selection of the method, there may be cases where the conditions of programme implementation prevent the use of one or more specific evaluation procedures. These limitations are mainly related to the unavailability of the required data, especially when estimates of the needed, missing or inadequate data cannot be worked out. For instance, a method using data on acceptors would have to be discarded, if data on acceptors were not recorded or were very incomplete. Other limitations may, however, hamper the sound application of a specific method. Certain types of experimental design studies may not be feasible if a satisfactory control group cannot be established. A real analysis may be prevented if the required number of observation units cannot be obtained or if regional fertility differentials would not yield meaningful results.

Once a method is selected, the general background conditions and trends in these conditions have to be carefully borne in mind so as to guarantee a sound application of the given evaluation procedure. The non-programme factors are the chief indicators of these general conditions and selection of the most relevant factors is fundamental for assessing influences on fertility. With varying background conditions, fertility determinants may have varying roles so that specific variables may be more important in one country than in another. Religion, for instance, may be a chief factor in Catholic countries, but a secondary factor in other cultures. In addition to their role in selecting the relevant fertility determinants, general conditions also influence the adoption of specific assumptions required by the evaluation method. Past and/or expected changes in the level of modernization, in natality and mortality, or nuptiality, in economic development etc. are incorporated in several methods as assumptions for the calculation of potential fertility estimates.

The general background conditions also constitute a frame of reference for the interpretation of the results. These conditions are not comprehensively taken into account by the available evaluation methods which generally focus unevenly on various background variables. Such methodological short-comings can be taken into consideration in interpreting results and drawing conclusions. Indeed, at the stage of interpretation and conclusions, the validity and reliability of the findings can be assessed in the light of the specific country circumstances. In other words, one can discuss the application of the method and try to establish whether a given impact on fertility is likely to have occurred in the given circumstances, whether no other explanation for the resulting impact can be assumed. whether underestimates or overestimates should be hypothesized. For instance, widespread dissemination of birth control practices prior to the family planning programme may mean large-scale substitution effects; rapid social and economic change during the period under evaluation may mean a substantive contribution of non-programme factors to the observed fertility decline; the existence of a well-established mass-communication network associated with well-organized information campaigns may mean that non-programme contraception has been stimulated by the programme and that the programme impact is eventually underestimated.

The Measurement Methods

This section attempts to review the methods utilized by researchers to measure the impact of family planning programmes on fertility. These methods have been classified as follows:

(*a*) Standardization approach;
(*b*) Trend analysis;
(*c*) Experimental designs (control and experimental groups);
(*d*) Couple-years of protection;
(*e*) Component projection; approach;
(*f*) Analysis of the reproductive process;
(*g*) Regression analysis (including path analysis);
(*h*) Simulation models.

It is not the purpose of this review of measurement methods to provide a manual on means of applying the various techniques for assessing programme impact on fertility. Detailed descriptions of the different procedures reviewed in this paper can be found in references cited in appropriate bibliographies. Since the ultimate objective of the meeting for which this text is intended to serve as documentation is to ascertain which method or methods should be applied in specific circumstances for the best results, the objective here is only to provide a simple and concise description of each type of method. In order to facilitate discussion and appraisal of the methods as applied in the country case studies, the methods are described under the following headings:

(*a*) Type of method;
(*b*) Programme and non-programme factors affecting fertility change;
(*c*) Measurement of fertility change;
(*d*) Main assumptions;
(*e*) Population covered;
(*f*) Time reference.

Suggested readings for each method are given in the selected bibliography at the end of this paper.

Standardization approach

Type of method

Approach

The standardization approach is a method of assessing family planning programme impact by decomposing an observed fertility change into component parts, or constructing standardized fertility measures that control factors considered extraneous to the movement of marital fertility. It is a logical first step in assessing impact since it seeks to establish whether a decline in fertility that could be related to the programme did indeed occur. This approach requires several steps. First, a measure of fertility of a specified population is observed or estimated at two points in time. This estimate is generally made on the basis of a crude birth rate[4] and the composite nature of this fertility indicator appears as the first reason for standardization. The next step consists of decomposing the observed change into marital fertility and other factors, or standardizing for the factors considered extraneous. If the crude birth rate or general fertility rate is used as the fertility indicator, these extraneous fac-

[4] The crude birth rate is, indeed, often used even when other fertility indicators are available. The reason is that programme impact is often perceived in terms of population growth rate and the crude birth rate is the fertility component of that growth rate. The need to standardize the crude birth rate arises, of course, from the fact that this rate is a composite indicator of fertility.

tors will more often be age structure and marital status distribution. The number and kind of factors taken into account are limited only by data availability and the ability to express the observed fertility measure as an algebraic function of those factors. Educational distribution may be important where it is changing rapidly and age/education—specific fertility rates differ sharply.[5] The result of the decomposition or standardization then is a measure of the proportion of change in the fertility measure due to "extraneous" factors (such as age structure and marital distribution) and a proportion due to marital fertility which presumably reflects changing birth control practices.

The next step is to gather information in order to determine what part of this increase in family planning practice, and hence of the fertility decline, can be credited to family planning activities.[6] An essential feature of the standardization approach is thus to reduce the observed change to a residue to be investigated for family planning programme effects. The method or methods used to determine whether increased family planning practices are due to the programme vary with specific circumstances. If, for instance, it can be established that there was no pre-programme use of birth control methods, the entire residue may eventually be attributed to the programme. If birth control was already practised, an attempt can be made to link decrease in fertility to increase in programme acceptors. The estimated decline in fertility due to the programme can also, eventually, be compared with the fertility decline due to the programme as assessed by another evaluation method.[7]

Procedure

Various standardization techniques can be used with this approach. A common procedure is the "direct method" of standardization although in some studies the "indirect method" also is used. Authors of evaluation studies sometimes do and sometimes do not refer to the type of technique they have used. Data availability and the evaluator's judgement are often the main criteria for selecting a particular procedure. Judgement is also required when decomposing a change into components since the change can be accounted for by alternate decompositions.

Factors affecting fertility change

Non-programme factors

Factors utilized. Non-programme factors taken into consideration by the standardization approach account for the changes in the observed fertility measure that are not due to programme activities. The kinds of factors selected will depend upon the type of indicators used to assess fertility change, upon specific background circumstances, upon data availability etc. Although the standardization approach, as applied in evaluation studies, appears to focus more on the demographic, non-programme factors, aspects of socio-economic factors and biological factors also are examined below:

(a) *Socio-economic factors.* Modernization and socio-economic development are phenomena generally considered to induce smaller family values and, hence, increased practice of family planning. Indicators of social change appear, however, to be neglected in the standardization approach even when the circumstances of the country under study warrant that attention be given to such factors;

(b) *Demographic factors.* Whenever applicable standardization of some chief demographic variables is always systematically performed. Fertility changes undertaken on the basis of the crude birth rate are analysed with standardized age structure and marital distribution. The total fertility rate and age-specific fertility can be more easily defined as a function of marital status and marital fertility, and the latter measure can be examined further if legitimate and illegitimate fertility data are available. Standardization for other factors, such as mean age at childbearing or duration of marriage, does not appear to have been attempted.

(c) *Biological factors.* The standardization approach does not easily lend itself to the treatment of this category of variable, due more to lack of data than to any theoretical restriction.

Data requirements and sources. A general prerequisite of the standardization of fertility rates for various factors is that appropriate data be available. Age structure and marital distribution information are relatively accessible in standard demographic sources, but standardization for socio-economic categories requires differential fertility data for each of the categories, and this type of information is often difficult to obtain.

Programme factors

Factors utilized. There is no specific set of programme factors needed when the standardization approach is used. Depending upon circumstances, programme factors might not be needed at all. This would be the case if the residual portion of an observed fertility decline could be entirely credited to the family planning programme on the evidence that all other factors remained constant during the period under evaluation. If, however, the residual decline need be further analysed, the programme factors required will be whatever factors are needed by the evaluator to undertake this additional analysis.

Data requirements and sources. As stated above,

[5] John E. Anderson, "The relationship between change in educational attainment and fertility rates", *Studies in Family Planning*, vol. 6, No. 3 (March 1975), pp. 72–81.

[6] See, for instance, Jack Reynolds, "Costa Rica: measuring the demographic impact of family planning programs", *Studies in Family Planning*, vol. 4, No. 11 (November 1973), pp. 310–316.

[7] Sui-ying Wat and R. W. Hodge, "Social and economic factors in Hong Kong's fertility decline", *Population Studies*, vol. XXVI, No. 3 (November 1972), pp. 455–464.

the data requirements will reflect the evaluator's needs. The type of data will, of course, define the type of sources.

The measurement of fertility change

Levels and changes in observed fertility

Fertility is measured at two points in time in order to assess the direction and magnitude of the change, if any. The fertility indicators used to make this assessment are standard: crude birth rate, general fertility rates, age-specific fertility and total fertility rates etc. In fact, the crude birth rate is the basic indicator used in this approach because of its analytical function as a component of population growth. Analysis of the change, however, benefits from the use of age-specific rates since changes in fertility are often not uniform for all ages or age groups.[8]

Levels and changes in fertility in the absence of the programme

The standardization approach does not compute explicitly estimates of fertility in the absence of the programme. However, comparing fertility levels at two points in time can be interpreted as a comparison between potential and actual fertility. From this viewpoint, the observed rate at the end of the period under evaluation stands for actual fertility, and the observed standardized rate stands for potential fertility. This interpretation implies, of course, appropriate assumptions regarding standardization factors. If, for instance, it were assumed that, in the absence of a family planning programme, all factors associated with the initial period would have remained constant during the period under study, the fertility level at the beginning of the period would be an estimate of potential fertility at the end of the period. Indicators of observed fertility can thus be used to obtain estimates of fertility in the absence of the programme.

Main assumptions

Except for the assumptions required for data adjustments and estimates, such as linearity assumptions for interpolation procedures, the standardization approach does not call explicitly for any prerequisites or assumptions. However, in the course of applying this technique for programme evaluation, various assumptions are usually made, explicitly or implicitly, in connexion with various procedural steps. For instance, when a factor is standardized for, it is implicitly assumed that it affects fertility independently of the programme. Standardization for proportion marrying, for instance, thus implies that nuptiality is not affected by programme factors. It is also assumed that family planning programmes affect fertility only through changes in birth control practices.[9] When standardizing for age structure and marital status, for example, it is usually assumed that the effects of these factors are independent and additive. When a factor generally known to be associated with fertility is not standardized for, it is implicitly assumed that the factor has no effect on the observed change. This would be the case, for instance, for the duration of marriage. Once the appropriate standardizations are made, the analysis used to determine what part of the residual decline can be credited to the programme may also be associated with explicit or implicit assumptions.

Population covered

The standardization approach does not define what population coverage is most appropriate; and, in principle, the method can be applied to any kind of population. Practically, its usefulness is fullest when crude birth rates are used; and hence, when the population of a whole country is evaluated. This does not preclude the use of the method for other population subgroups if the requisite data are available.

Time reference

The standardization approach provides measurements of fertility levels and trends, as well as of fertility changes, in terms of calendar years. All rates are period rates and all changes are period changes.

Trend analysis

Type of method

Approach

The various procedures referred to in this discussion of trend analysis attempt to measure the impact of a family planning programme on fertility by comparing indicators of actual (observed) fertility over a specific period of time to projected fertility data for the same time period. The projected fertility data are assumed to represent the potential fertility of the population studied, i.e., the fertility of that population had the programme not been undertaken. Actual, or observed, fertility is the fertility really experienced by the same population over the same time span. The difference between actual and projected fertility is thus assumed to yield an estimate of the impact of the family planning programme on fertility.

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[8] Ronald Freedman and Arjun L. Adlakha, "Recent fertility declines in Hong Kong: the role of the changing age structure", *Population Studies*, vol. XXII, No. 2 (July 1968), pp. 181–198; and Ronald Freedman and others, "Hong Kong's fertility decline, 1961–68", *Population Index*, vol. XXXI, No. 1 (January-March 1970), pp. 3–18.

[9] The rationale for this assumption appears to be that family planning programmes encourage or promote the use of birth control methods and that the results of a successful programme would be a decline in fertility through decreasing family size rather than through, for instance, changes in age at marriage. Nuptiality changes resulting from a given population policy need to be taken into consideration if it is known that measures to change age at marriage are also taken.

This approach, although defined as a "projection" approach, differs from the standard meaning in that fertility is projected from the past up to the present rather than from the present into the future. An essential feature of this difference is that characteristics of the female population, such as number, age and marital status, are known and need not be estimated for the period under evaluation. Only the hypothetical fertility of this population has to be assessed. Another important feature is that the fertility assumptions need not be based on past fertility trends alone, but may also take account of social and economic changes during the period of evaluation. As with the standardization method, the impact of the family planning programme is identified as a residual. It is usually appropriate to analyse further this residual as is the case with the standardization approach.

Procedures

When studying the fertility of the entire population of a country or of a specific region, trend analysis often involves an extrapolation of past fertility trends from the date of initiation of the family planning programme. This set of projected fertility indicators is then compared with the actual fertility trend over the same time period to gauge the effect of the programme. Various procedures have been suggested for obtaining the hypothetical trend in the absence of the programme. One suggestion is to utilize the fertility assumptions incorporated into projections of the population made before the start of the programme and at a time when relatively little weight was given to such endeavours. Another is to carry forward the fertility trend prior to the programme by one or another method, such as projecting forward the annual rate of change in the fertility indicator; or fitting a trend line by inspection or by some technique such as least squares. Instead of using crude birth rates, resort could, of course, be made to the total fertility rate, age-specific or marital age-specific rates projected on the basis of pre-programme trends. Comparisons utilizing these indicators have the virtue of eliminating the effect of changing age structure and, in the case of marital rates, the effect of changing marital distributions.[10]

Mauldin states that this method is also used with subgroups of the population, particularly acceptors. Here, the observed post-acceptance fertility of acceptors is compared with that expected on the basis of their fertility levels prior to acceptance. In projecting the potential fertility of the acceptors, account is usually taken of their aging and, hence, their reduced fecundity, their reproductive status at the time of acceptance (the fact that typically acceptors are not pregnant and may be in a state of post-partum amenorrhoea), and sometimes the possibility that in the absence of the programme they would have resorted to other forms of contraception or abortion. Such projections of expected births or fertility levels are akin to simulation models based on parameters of the reproductive process; but, as the starting-point they take into account the known characteristics of acceptors.

Factors affecting fertility change

Non-programme factors

Factors utilized. The difference between a projected and an observed indicator of fertility does not necessarily constitute a straightforward estimate of the family planning programme impact. For a given situation, it should be ascertained that no other factors can account for the observed, or part of the observed, difference, if any. The three main categories of factors affecting fertility are examined below:

(1) *Socio-economic factors.* Whether this category of factors is taken into account depends upon the type of projection technique used. Fertility projections do not explicitly take into account the relevant socio-economic factors. Rather, when assumptions as to the hypothetical fertility trend are formulated, such assumptions take implicit account of these socio-economic factors. This type of projection permits explicit examination of ethnic differences or urban-rural differences, for example, through separate projections. New types of projection models are, however, being developed in which it should be possible to include certain socio-economic factors;

(2) *Demographic factors.* Simple extrapolation of past fertility trends usually appears to be unsatisfactory for programme evaluation; and such factors as age structure, nuptiality and non-programme family planning practice can be included in the projection procedure;

(3) *Biological factors.* Most techniques of extrapolating fertility trends are not designed to take biological factors into account. But when reproduction models are used to obtain the number of births expected to acceptors, biological factors are taken into consideration. Probabilities of conception or of foetal loss, length of sterile period etc. are some of the factors included in this category.

Data requirements and sources. The main categories of data needed concern those required to determine the fertility trend of the population prior to the programme, to ascertain the current size, age and sex distribution, and other characteristics of the population under study, and to assess the possible social, economic and cultural changes that occurred during the evaluation period. Sources do not raise difficulties specific to the evaluation purpose, at least in so far as standard indicators are concerned. In certain cases, however, only special record-keeping procedures can provide the appropriate data for a given evaluation. Age-specific marital fertility of acceptors or biological

[10] W. Parker Mauldin, "Births averted by family planning programmes", *Studies in Family Planning*, vol. 1, No. 33 (August 1968), pp. 2–3.

characteristics, for instance, require special surveys or the maintenance of special clinic record.

Programme factors

Factors utilized. The programme factors are not explicitly identified in the projection approach. In assessing programme impact by estimating the difference between projected and actual fertility, the aggregate effect of the programme is assessed as a residual rather than inferred from specific programme activities indicators. Thus, no programme factors are specifically taken into consideration. However, should there be a need to analyse further the difference between observed and projected fertility, programme indicators similar to those which might be needed in similar circumstances with the standardization method could be required for the projection method.

Data requirements and sources. The required programme indicators and their sources will reflect the type of analysis chosen by the evaluator.

Measurement of fertility change

Levels and changes in observed fertility

The estimation of levels and trends in observed fertility has two objectives: (*a*) determining past trends in order to make fertility assumptions; and (*b*) determining the current fertility trend in order to have a term of comparison for the projected trend. Current observed fertility is often approached with standard fertility indicators, such as the crude birth rate and age-specific or age-specific marital fertility rates. For estimating fertility prior to the period under evaluation, additional indicators can be used to identify the timing and magnitude of a given change, if any. Such factors may include average family size, open birth intervals, parity rates etc.

Levels and changes in fertility in the absence of the programme

All standard fertility indicators can be used as indicators of projected fertility provided they are the same as the observed indications so that comparison will be feasible. A common fertility measure used is the crude birth rate, even when other data are available, because as a main component of population growth this rate appears to provide a better perception of population change. As this indicator does not, however, provide a reliable estimate of changes in fertility due to contraceptive use, more detailed approaches to projected fertility are performed. The comparison of age-specific fertility rates for five-year age groups, for instance, easily improves the analysis of potential changes. Reproduction models have also made use of pregnancy rates as a more sensitive indicator of short-term programme impact.

Main assumptions

The assumptions regarding trend analysis are associated with the estimation of fertility in the absence of the programme, specifically with the amount, the direction, the pattern and the date of onset of the assumed fertility changes. These explicit assumptions, along with the non-programme factors taken into consideration, tend to include in this approach a varying number of implicit assumptions. If, for instance, fertility is assumed to remain constant, it is implicitly assumed that non-programme background conditions have not changed. If the nuptiality factor is not taken into account explicitly, it is implicitly assumed that the population has remained homogeneous with respect to marital status. A linear extrapolation of a pre-programme fertility trend implicitly assumes that fertility is linearly associated with its determinants. Thus, in numerous instances, explicit assumptions are associated with implicit assumptions; likewise, failure to take some factors into consideration also may reflect implied assumptions. In the latter case, one may say that all non-programme factors that are not explicitly taken into account are implicitly accounted for in the very formulation of the fertility assumptions: if a fertility decline is assumed, it implicitly reflects the aggregate effects of all non-programme fertility determinants.

Population covered

Two main categories of population can be evaluated by trend analysis, the fertility projection approach. The first category includes the population living in a certain area: this means the entire country, administrative or geographical units, or areas where a family planning programme is being implemented. The second category includes populations that can be identified by a certain characteristic: the acceptors of programme services is the most common group in this category. Evaluation objectives and data availability are the major criteria for selecting a given coverage.

Time reference

Trend analysis yields results in terms of calendar years. It thus allows the evaluation of the effects of the programme beginning at a given date, say, from programme initiation or any time during programme implementation.

Experimental designs: control and experimental groups

Type of method

Approach

The experimental-design approach attempts to employ features of the classical experimental design to estimate the effects of a family planning programme on fertility. The classical design requires that two groups of population, as similar as possible before a treatment is given, be established. Often a "before" measure is taken in each group to determine the point from which changes are expected to occur and to provide a check on the equivalence of the two groups regarding the variable which is supposed to be affected. One of the two groups, the experimental group, is then exposed to a given treatment while the other group, the control group, is excluded from that treatment. At the end of the experiment, an "after" measure of the treated variable is taken for both the experimental and the control group and is compared. The effect of the treatment is taken as the difference between the two groups in the amount of change that occurred. Translated in terms of programme evaluation, the treatment consists of family planning programme activities and the "before" and "after" measures are one or more selected indicators of fertility. If fertility is found to change more rapidly in the experimental than in the control group, the difference is assumed to be due to the family planning programme. Here again, the effect of the programme is obtained as a residual.

In the classical design, the experimental and the control groups are constituted prior to the treatment and the persons included in each group are assigned randomly. When family planning evaluation is undertaken, the persons included in the experimental group are not assigned at random, but are self-selected on the basis of their decision to participate in the programme or are arbitrarily selected on the basis of an area chosen for programme implementation. As a result, comparability is not ensured between the experimental and the control group. Similarity and comparability of the two groups can, however, be greatly improved upon by a procedure of selective matching.[11]

Procedures

Designs without matching can utilize the general population of an area or programme acceptors as the experimental group. When a family planning programme is undertaken in only part of a country, that population constitutes the experimental group; and another part or the entire population outside the programme area forms the control group.[12] If programmes with different intensities are undertaken in different areas, the population of the area with the more intensive programme becomes the experimental group while the population of the area with the less intensive programme (or without programme) becomes the control group.[13] In one case, the purpose of the comparison is to evaluate the effects of the additional inputs provided to the more intensive programme area; in the other case, the over-all effect of the programme is assessed. When a family planning programme is undertaken on a nation-wide basis, so that no control area is available, the two comparative groups are formed on the basis of programme acceptance. Acceptors constitute the experimental group, and the control group is drawn either from the general population or from the non-acceptors only.

If, for instance, it is decided to use programme acceptors as the basis for the experimental group, comparability with this self-selected group can, as stated earlier, be improved by a matching procedure. Basically, this procedure consists of establishing a list of acceptors according to a number of demographic and/or socio-economic characteristics. This is the experimental group. The control group is then constituted by selecting from another source, household registration for instance, a number of non-acceptors with equivalent characteristics. This matching procedure can be carried out either on the basis of individuals or of the whole group. In the first case, each single characteristic of an acceptor has to be found in a corresponding non-acceptor. In the second case, individuals are ignored and acceptors are matched as a group where only the total number of individuals and the total number of each characteristic are considered relevant. Variations in socio-cultural and programme conditions lead, of course, to variations in the criteria for defining acceptance and non-acceptance as well as in matching criteria. When a programme is established in only one area of a country, another area with similar aggregate demographic and socio-economic characteristics is sometimes matched with it to serve as the control group.

Factors affecting fertility change

Non-programme factors

Factors utilized. Non-programme factors that may have affected fertility are taken into consideration implicitly and, when matching is performed, explicitly. Without matching, it is assumed that socio-economic and other factors which may affect fertility during the period under evaluation operate equally on the experimental and the control group, so that it is not necessary to identify those factors explicitly. However, since randomization has not been performed, a difference in fertility change might result from the fact that the experimental group has non-programme characteristics that are different from those of the control group. This possible differential effect of non-programme factors is mitigated when the two groups are matched for non-programme characteristics, thereby avoiding a confusion of programme and non-programme effects. Non-programme factors for matching therefore, must be explicit, and they usually can be subsumed under the three following categories:

(1) *Socio-economic factors*. This category contains

[11] L. M. Okada, "Use of matched pairs in evaluation of a birth control program", *Public Health Reports*, vol. 84, No. 5 (May 1969), pp. 445–450.

[12] Population Council, "India: the Singur study", *Studies in Family Planning*, vol. 1, No. 1 (July 1963), pp. 1–4.

[13] Jae Mo Yang, "Fertility and family planning in rural Korea", *Proceedings of the World Population Conference, Belgrade, 30 August–10 September 1965*, vol. II, Selected Papers and Summaries: *Fertility, Family Planning, Mortality* (United Nations publication, Sales No. 66.XIII.6), pp. 309–312.

a wide range of indicators, such as income, education, occupation, religion, ethnic group and type of residence. One or several of the most relevant indicators are chosen on the basis both of data availability and of their theoretical relationship with fertility in the group under study.

(2) *Demographic factors*. This category includes standard demographic indicators, such as sex, age, marital status, number of births and family size. When appropriate, other characteristics may be added, such as open birth interval on number of living sons, as well as the relevant Knowledge-Attitude-Practice (KAP) indicators.

(3) *Biological factors*. Although these factors might be of importance for certain matching studies, they are seldom used. This category would include length of anovulatory period, sterility etc.

Data requirements and sources. Non-programme data are required when matching is undertaken; they consist of indicators relevant to the selected matching factors. Since matching studies usually pertain to acceptors versus non-acceptors, KAP studies, follow-up surveys, clinic records and service statistics in general constitute the most appropriate source for the acceptor group; for the non-acceptors, data are obtained from standard demographic sources, such as fertility surveys, censuses and household registration. Certain types of non-programme data are also relevant when matching is not undertaken. This concerns age structure and nuptiality data, for instance, when crude birth rates are used as fertility indicators.

Programme factors

Factors utilized. As in the two methods previously described, the effect of the programme is calculated as a residual, as there are no provisions for taking programme factors explicitly into account. Programme factors would only be needed if any type of additional analysis were undertaken regarding the population under study. Such analysis would go beyond the experimental design approach.

Data requirements and sources. The type of data needed would depend upon the type of analysis undertaken. Service statistics would certainly be the most appropriate source.

Measurement of fertility change

Levels and change in observed fertility

Measures of both level and change are used in the experimental-design approach. As stated above, the "before" (or bench-mark) fertility measures of each group is needed in order to equate the two groups as concerns their fertility. The measure of fertility change is needed for the actual assessment of the impact of the programme. The "before" and "after" fertility measures in each group are obtained from observed data, and the change measure is obtained as the difference between the "before" and "after" measures. The data used to make these estimates usually consist of standard fertility indicators, such as the crude birth rate and age-specific fertility rates.

Levels and changes in fertility in the absence of the programme. The estimates of fertility trends in the absence of the programme are computed from the "before" and "after" fertility measures of the population constituting the control group. This group is, indeed, assumed to represent the fertility that would have been experienced by the population of the experimental group had the family planning programme not been undertaken. The fertility indicators selected to make this estimate are, of course, the same as those used to assess fertility changes among the population of the experimental group.

Main assumptions

A major condition for obtaining valid results with the experimental-design approach is that the experimental and the control groups be comparable. In the absence of randomization, a number of assumptions are implicitly made regarding their comparability. When no matching procedure is undertaken, it is usually assumed that the two comparative groups are, nevertheless, of similar characteristics and that the population of the control group is not influenced by the programme activities to which the experimental group is subjected. These assumptions are supposed to apply to populations of particular areas, or to non-matched acceptors and non-acceptors. When the experimental and the control groups have undergone a matching procedure, this procedure is assumed to have ensured comparability, but it is still implied that the programme activities do not affect the control group. More generally, it is also implied that the procedure used to record the "before" and "after" measures does not have a differential effect.

A crucial assumption related to the specific objective of evaluating a family planning programme is that the fertility of the population in the control group is assumed to stand for the fertility the population in the experimental group would have experienced had the family planning programme not been undertaken. It is thus further implicitly assumed that the social, economic, political and cultural events occurring during the period of time elapsing from the "before" to the "after" measure affect likewise the fertility of the population in each group; that the population in each group remains homogenous during the period of evaluation; and that the period for identifying the "before" and "after" measures refers to the same time span.

Population covered

Like the other methods discussed above, the experimental-design approach does not inherently specify the most appropriate population coverage. The method is flexible enough to cover the population of an area or of the whole country provided assumptions are met, data are available etc.

Time reference

The experimental-design approach, like the preceding approaches, measures fertility changes and programme effects on fertility in terms of calendar years and period rates.

Couple-years of protection

Type of method

Approach

Unlike the preceding methods, which assess the impact of the programme by comparing fertility experienced under programme conditions to estimates of fertility in the absence of the programme, the couple-years of protection method determines the impact of the programme directly from data on birth control methods and programme acceptors. The impact is thus assessed directly from information on programme activities rather than indirectly as a residual. The estimating approach consists of two stages. The first stage is directed towards determining the number of couples protected against the risk of pregnancy during one year, and it yields an index of couple-years of protection. This index is calculated by estimating the length of time a couple is likely to be protected by each "application" of a family planning method and then using this factor in conjunction with the number of units of each method distributed to obtain CYP by method and over all. The second stage consists of inferring, for a given amount of CYP prevalent in a year, the number of births which have been averted.

Procedure

Ideally, factors for estimating CYP from each method should be worked out separately (for each country) and changed with time (within countries) inasmuch as the conditions that determine the length of protection afforded by a unit of contraception are not constant. The couple-years of protection estimate can be computed from Wishik's prevalence index.[14] The prevalence of CYP in year T is the sum of protection conferred to cohorts of acceptors from previous years who are still wearing the device in year T, including insertions of intra-uterine devices (IUD) performed in year T:

CYP prevalence index in year T

$$= \frac{a}{r} \sum_{i=0}^{j} N_{T-i} \{e^{-ri} - e^{-r(i+1)}\} \qquad \text{where } j \leq 6$$

where r = rate of IUD attrition during one year:

N_{T-i} = number of insertions in year $(T-i)$;

j = the maximum value of i, which indicates the number of years the IUD program has been in effect.

An example of another formula which has been used to estimate CYP prevalence is:

$$CYP_n = 0.01\, C_n + (0.75\, I_n + 0.50\, I_{n-1} + 0.35\, I_{n-2}) + (S_n + 0.95\, S_{n-1} + 0.90\, S_{n-2})$$

where C = the number of conventional contraceptives;

I = the number of intra-uterine devices inserted;

S = sterilizations (vasectomies and tubectomies).

The coefficient 0.01 reflects the assumption that 100 units of conventional contraceptives must be distributed to provide one couple with protection for one year. The coefficients for I reflect the continuation rates assumed to be in force and serve to bring forward to the current year those women still protected from insertions in earlier years.[15] Where possible, these rates should be based on actual experience and changed with time. The effect of sterilizations performed in earlier years is assumed to decrease over time to reflect the diminished protection associated with the probability of marital dissolution, the onset of menopause etc. The formula can, of course, be modified to express separately the number of vasectomies and tubectomies, or by adding a pill component if this method happens also to be used. The number of births averted is then obtained by applying to the number of couple-years of protection the ratio of how many couple-years of protection are needed to prevent one birth in one year.

Factors affecting fertility

Non-programme factors

Factors utilized. Non-programme factors affecting fertility are not explicitly taken into consideration by the CYP method. The coefficients that appear in the formula of the CYP index do, however, account for some such factors indirectly. In theory, these coefficients define the extent of protection given by a particular method. Notably, in the case of sterilization, for example, the coefficient would account for secondary sterility or disruption of marital union, or both. With respect to IUDs, the coefficient as used focuses on device retention, but might include more than that particular factor. Defining the non-programme factors

[14] Samuel M. Wishik and K. H. Chen, *The Couple-Year of Protection Index: A Measure of Family Planning Program Output,* Manuals for Evaluation of Family Planning and Population Programs, No. 7 (New York, Columbia University, International Institute for the Study of Human Reproduction, 1973).

[15] Enver Adil, "Measurement of family planning progress in Pakistan", *Demography,* vol. 5, No. 2 (1968), pp. 659–665; and Lee L. Bean and William Seltzer, "Couple years of protection and births prevented: a methodological examination", *Demography,* vol. 5, No. 2 (1968), pp. 947–959.

utilized in the CYP approach consists mainly of describing the various factors that have been applied in the calculation of the coefficients.

Data requirements and sources. The needed data and their sources are determined by the non-programme factors that are taken into account in the calculation of the various coefficients. These requirements may involve life tables for calculating the probability of widowhood and clinic or survey data for the age distribution of secondary sterility.

Programme factors

Factors utilized. The impact of the programme is determined directly from indicators of programme services, namely, the number of contraceptives distributed, sterilizations performed and, eventually, abortions undertaken. These categories of programme services are thus the only summary indicators of programme factors utilized in the CYP method.

Data requirements and sources. The data needed are statistics of the number of conventional and oral contraceptives distributed, intra-uterine devices inserted, and sterilizations and abortions performed, as the case may be. The definition of "distributed" often depends upon the type of data-gathering procedure; as emphasized in the literature on the subject, distribution may mean "distribution to suppliers" or "acceptance by couples" or "acceptance and actual use" etc.[16] The whole range of service statistics, as well as private sources and follow-up surveys, can be considered useful sources.

Measurement of fertility change

The CYP method does not require the measurement of fertility changes during the period under evaluation. The impact of the programme is estimated directly from programme activities.

Main assumptions

A number of assumptions are explicit in the coefficients found in the CYP formula shown. The coefficient of C, for instance, means that it is assumed that 100 units of conventional contraceptives per couple prevent one birth per annum, provided that sexual intercourse takes place twice a week, on the average, during that year. The coefficients both for the intra-uterine devices and for sterilizations are the assumed protection provided by those methods during the initial and successive 12-month periods of use. A final explicit assumption is that regarding the number of couple-years of protection needed to prevent one birth. In Pakistan, it is estimated that three or four couple-years of protection are needed to prevent one birth. This figure will, of course, vary with the type of population being evaluated.

[16] L. L. Bean and W. Seltzer, *loc. cit.*

In addition to these explicit assumptions, however, there are a number of important implicit assumptions whose validity will determine the reliability of the method. Most notably, it is assumed that all family planners included in the computation are programme acceptors; and that all conventional methods distributed or accepted are used, that they are used during periods of pregnancy risk and that they are used efficiently. It is also assumed that the retention rates for IUDs are constant and evenly distributed between and within age groups; that couples do not substitute programme methods for non-programme methods already being used, that couples do not switch from one method to another during the evaluation period, that couples do not supplement one method by another; that couples are fecund at the time of acceptance, that they remain at risk of conceiving during the evaluation period and that their fecundability remains constant.

Population covered

The population covered by the CYP method includes, in principle, all and only programme acceptors, i.e., couples who receive and actually use family planning methods provided by the programme or under programme auspices. A definition of the concept of "acceptor" is, however, required for each particular utilization of the method if a meaningful interpretation of the results is expected.

Time reference

The couple-years of protection approach is a calendar-year approach. Results are provided in terms of 12-month periods.

Component projection approach

Type of method

Approach

Like the CYP technique, the component projection approach is directed towards calculating births prevented and makes use of data on programme acceptors as a basis for computation. It is thus also a method which infers programme impact directly from programme acceptance. The rationale of the method consists of estimating the acceptors' potential fertility and assuming that the number of births they would have had in the absence of the programme are all births averted by the programme. This method can be used to estimate future changes in age-specific fertility rates or, as in the present interpretation, to provide estimates of births averted from the past up to the current time. In the latter use, the recorded number of acceptors and continuing users are used instead of projected estimates of acceptors. In addition to number of acceptors still in the programme at a given period of time, estimates of their potential fertility are also needed.

Procedure

The number of births averted by the family planning programme in age group i in year t is given by:

$$Q_{i,t} \cdot g_i$$

where Q_i is the number of acceptors belonging to age group i who were practising totally effective contraception in year $t-1$; and g_i is the potential fertility of the acceptors in age group i.[17] Various approaches to estimating Q_i and g_i have been developed, some being more elaborate than others. Venkatacharya[18] introduces, for instance, a factor for the family planning method use-effectiveness. The Q_i can be calculated from continuation rates applied to the number of couples who entered the programme in year $t-x$, $x=1$, $2, \ldots n$, or can be obtained directly from a follow-up study.

The procedure to estimate g_i also varies. In applying their method to the Republic of Korea, Lee and Isbister estimated potential age-specific marital fertility rates of acceptors by increasing the marital fertility rates of the general population by 20 per cent on the assumption that acceptors have higher fertility than the general population. In studying the probable impact of IUDs and sterilizations in India, Venkatacharya estimated the potential number of births on the basis of a matrix of annual probabilities of live births taking into account, among other factors, the acceptors' initial susceptibility to conception. Any appropriately designed model could, of course, be used to estimate the probable number of births in the absence of a programme. Estimates of g_i can also be based on the acceptors' own pre-programme fertility rates, or a range of values can be used to study the effect of alternate estimates on the number of births averted.

Factors affecting fertility change

Non-programme factors

Factors utilized. Which particular non-programme factors are utilized in the component projection approach depends upon the procedures used to estimate Q_i and g_i. Where non-programme factors are not explicitly taken into consideration, they are, in fact, often implicitly accounted for. For instance, if Q_i is calculated on the basis of the original number of acceptors, mortality can be explicitly included in computing the number of surviving continuing users; if Q_i is based on a follow-up study, the mortality factor is implicitly taken into account. Such factors include:

(a) *Socio-economic factors.* This category of factors is not explicitly taken into consideration. However, in establishing the levels of potential fertility of the acceptors, assumptions can be made which permit imputations as to expected social and economic influences, especially in countries that are undergoing rapid social change;

(b) *Demographic factors.* The effect or lack of effect of some factors, such as divorce, mortality or widowhood, can be determined explicitly or implicitly. This is also true for interruption of contraceptive use or for the use of non-programme family planning methods;

(c) *Biological factors.* Consideration for this category of factors depends mainly upon the procedure used to estimate the acceptors' potential fertility. If potential fertility is calculated in terms of age-specific rates, biological factors are not explicitly included; but the use of reproduction models would include biological parameters, such as post-partum amenorrhoea and fecundity.

Data requirements and sources. The requisite non-programme data consist mainly of those acceptor characteristics which affect their number and whose effects on fertility should not be credited to the family planning programme. For example, if an IUD acceptor gets divorced, or becomes a widow, she is no longer exposed to the risk of pregnancy. Data of this type can be obtained from service statistics, follow-up and evaluation surveys or, eventually, from life tables as regards mortality and widowhood. The data requirements for estimating potential fertility are determined by the procedure utilized. They may involve fertility rates or marital fertility rates, by age prior to or during the period of fertility evaluation of the acceptors' own pre-programme fertility. If a reproduction model is used, the data required will be, as indicated above, of a more biological nature.

Programme factors

Factors utilized. The impact of the family planning programme depends upon the number of programme acceptors[19] in each age group, by the method of fertility control applied. In so far as acceptors of contraceptives are concerned, the rate of continuation is a factor of vital importance.

Data requirements and sources. The required data are the number of acceptors by age, type of conventional contraceptives, oral contraceptives, intrauterine device insertions, and/or the number of abortions and sterilizations performed, as indicated. The annual number of current family planners can be obtained from appropriate continuation rates applied to the number of initial acceptors. Depending upon the data-gathering procedures, the statistics may be obtained from follow-up recordings or follow-up surveys; or from private clinics or physicians, if they are included in the programme plan etc.

[17] B. M. Lee and J. Isbister, *loc. cit.*

[18] K. Venkatacharya, "A model to estimate births averted due to IUCDs and sterilizations", *Demography,* vol. 8, No. 4 (November 1971), pp. 491–505.

[19] The term "programme acceptors" refers to acceptors registered in the records of an official programme.

Measurement of fertility change

As with the CYP method, the component projection approach yields estimates of family planning programme impact in terms of births averted and thus does not require measuring fertility changes that may have occurred during the evaluation period.

Main assumptions

A number of assumptions are implied in this approach, and their nature and number depend upon the particular procedures used to obtain $Q_{i,t}$ and g_i. Lee and Isbister assumed that births averted in year t result from acceptors who were current users in year $t-1$ and that there is no mortality between years $t-1$ and t. In the computation of the current number of acceptors, assumptions are made regarding the rate of "consumption" of renewable contraceptives (e.g., condoms) or the rate of retention of non-renewable contraceptives (e.g., IUDs), as well as regarding the rate of use effectiveness of each family planning method. An assumption can also be included regarding the use of family planning for postponing a birth rather than for limiting the size of the family. Assumptions for divorce, mortality, widowhood etc. may also be necessary. Of course, some of these assumptions may not be necessary, if acceptors can be followed individually on an annual basis.

Assumptions regarding the acceptors' potential fertility can also vary in nature and number, depending upon how this factor is obtained. It can be assumed that the potential fertility is equal to, higher or lower than the acceptors' own pre-programme fertility, or than the fertility of the general population or the married population. The use of reproduction models to estimate potential fertility requires assumptions regarding such biological factors as post-partum amenorrhoea, foetal losses and sterility.

Population covered

The population covered by the component projection approach should consist of programme acceptors only, i.e., couples who have accepted a family planning method through any of the official or private programme services. As mentioned previously, the concept of "acceptor" requires an operational definition.

Time reference

The various evaluation procedures associated with this method yield estimates of births averted in calendar years.

Analysis of the reproductive process

Type of method

Approach

The two methods of analysing the reproductive process, described below, also attempt to estimate the number of births averted by a family planning programme using data on contraceptive acceptance and use. They have in common the utilization of the life-table technique to calculate the proportion of acceptors who, after a specified period, are still using a given family planning method. Specifically, the technique is intended to estimate births averted per segment of IUD[20] use, by comparing the average duration that childbearing is interrupted because of the programme contraceptive used, with the average duration of interruption per birth had the IUD not been adopted. Thus, if a woman uses programme contraception effectively and prolongs her non-pregnancy state for a period equal to this average, it is assumed that a birth has been prevented.

Procedures

Potter[21] summarizes his procedure as follows:

$$B = \frac{I}{D}$$
$$I = F(R - A - PW)$$

where B = births averted per first segment of contraception;
I = average duration that childbearing is interrupted;
D = average duration per birth required in the absence of programme contraception;
F = proportion of couples not sterile at time of acceptance;
R = mean time programme contraception is used among couples not sterile at time of acceptance;
A = allowance for post-partum amenorrhoea;
P = proportion becoming accidentally pregnant;
W = penalty for accidental pregnancy.

In computing R, allowance is made for mortality, secondary sterility, and discontinuation of contraceptive use. Ideally, R is estimated by a life-table analysis in which the components are entered as competing risks. As applied to the intra-uterine device, discontinuation is due either to accidental pregnancy, or to expulsion or removal of the device.

Other factors that can affect the R-value, such as divorce, can also be entered if applicable. In so far as family planning is being adopted for birth postponement rather than limitation, the results should be considered to be applicable for the short run only.

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[20] Reference is made here only to the IUD because the method was originally devised for this contraceptive.

[21] For a complete description of the method, see R. G. Potter, "A technical appendix on procedures used in the manuscript 'Estimating births averted in a family planning program'," paper prepared for Major Ceremony V, University of Michigan Sesquicentennial Celebration, 1 June 1967. See also R. G. Potter, "Application of life-table techniques to measurement of contraceptive effectiveness"; and *idem,* "Estimating births averted in a family planning program".

Wolfers'[22] procedure, like Potter's, was devised to compare periods of effective contraceptive use due to the programme with mean birth intervals that would have been experienced by the acceptors in the absence of the programme. The number of births averted is obtained in several stages. The first stage consists of calculating (as applied to intra-uterine devices) monthly continuation rates with allowance made for accidental pregnancies, expulsions and removals. The procedure is then extended, at a second stage, to take into consideration such factors as post-partum amenorrhoea, secondary sterility and probability that an accidental pregnancy will result in a live birth. Simultaneously, the expected birth intervals in the absence of the programme are included in the computation, and estimates of births averted per 100,000 acceptors are obtained for each year after acceptance.

Factors affecting fertility changes

Non-programme factors

Factors utilized. Analysis of the reproductive process makes allowance for various factors which may influence the calculation of the number of births averted by the programme, in order not to credit the programme with effects originating outside the programme:

(a) *Socio-economic factors.* These factors are seen as a major determinant of family planning acceptance in the absence of a programme. Hence, it is assumed that couples who became acceptors might, in the absence of the programme, have become contraceptive users, had social change favoured such a development. The procedures of both Potter and Wolfers leave room to take this possibility into account.

(b) *Demographic factors.* A number of standard demographic factors which may affect the measurement of programme impact are taken into consideration. These factors include mortality and widowhood, as well as divorce occurring among acceptors. Another major factor affecting the number of births averted estimate is the extent of family planning practice among programme acceptors which existed before acceptance. Further, the number of acceptors who discontinue the programme method or have an accidental pregnancy are taken into consideration by one or the other procedure.

(c) *Biological factors.* The biological factors taken into account include post-partum amenorrhoea and sterility.

Data requirements and sources. The data required concern acceptors' characteristics: family planning practice before acceptance; practice after acceptance; and, of course, reliable data on continuing users. With Potter's procedure, the estimation of potential fertility requires that the acceptors' own pre-programme fertility be known; Wolfers' procedure requires data on birth intervals for the general population. In addition, data are also needed to estimate the biological parameters included in the analysis. All standard and family planning programme sources are used to obtain these data, including service statistics, KAP studies, follow-up studies and appropriate life tables for mortality estimates.

Programme factors

Factors utilized. The impact of the family planning programme is obtained from the number of programme acceptors.

Data requirements and sources. The needed data consist of the number of acceptors of each category of family planning method provided by the programme. In the case of non-renewable contraceptives, such as the intra-uterine device, data on reinsertions are also needed if accurate estimates of programme impact are expected. Service statistics provide the main source of required data regarding the number of acceptors enrolled in the programme. Statistics from private sources that distribute contraceptives are also needed if they are considered as being part of the official programme effort.

Measurement of fertility change

As with previous methods measuring programme impact directly from contraceptive inputs, no measure of changes in fertility is needed.

Main assumptions

Although the two procedures have a similar structure, some differences both in approach, related in part to the programmes, and in estimating techniques can be mentioned. Potter, for instance, assumes that acceptors have higher fecundity than the average population, whereas Wolfers does not share this view. Potter also assumes homogeneity of risk within five-year age groups and treats age-specific risks as constants unvarying with time elapsed from insertion. He also assumes that a proportion of acceptors are sterile at the time of acceptance, while a proportion of those fertile discontinue "immediately" to account for the high rates of discontinuation during the initial two or three months. While Wolfers also assumes homogeneity within age groups, he does not make the other assumptions and takes into account time elapsed since acceptance. Both procedures make assumptions regarding secondary sterility and post-partum sterility. Potter, in addition, makes explicit assumptions regarding mortality and, if applicable, divorce. Both procedures assume that family planning is undertaken for the purpose of limiting rather than postponing births, and both also allow inclusion of assumptions regarding acceptors who would have used contraception in the absence of the programme.[23]

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[22] D. Wolfers, *loc. cit.*

[23] References to these main assumptions are found in R. G. Potter, "Estimating births averted in a family planning program", pp. 418–422 and 430; and D. Wolfers, *loc. cit.*, pp. 115–118 and 140.

Population covered

The population covered includes all acceptors included in the programme record-keeping system, whether the services are obtained from official or private sources.

Time reference

Estimates of births averted are obtained in total for first segment of use or for successive years of contraceptive use since time of acceptance.

Regression analysis

Type of method

Approach

Determination of programme impact by regression analysis is rather different from the methods previously described, in that this method is directed specifically towards inferring the role of all the factors included in the analysis. This method allows the inclusion of a large range of explanatory variables; and when applied to family planning programme evaluation, it permits the handling of both programme and non-programme factors. In dealing with programme impact on fertility, a fertility indicator becomes the main dependent variable; and socio-economic, demographic and possibly biological factors, as well as programme indicators, constitute the independent variables. Programme impact is thus assessed directly through the regression parameters, rather than indirectly as a residue. As discussed here, the unit of analysis is an areal subdivision of a country rather than an individual, and aggregate data for these units are used in the analysis.

A special type of regression analysis, path analysis, has also been used to assess programme impact on fertility. A path analysis is always based on an explicit model where all variables are ordered in time, the direction of the relationship is explicitly stated and the presence of direct and indirect effects upon the dependent variables is specified.[24] This approach, which is based on standard multivariate regression techniques, is specially designed to assess the magnitude of the indirect effects, in addition to the direct effects obtained by a standard regression analysis.

Procedure

Estimation of the regression parameters can be carried out through various procedures which vary generally with the type of regression model. A simple and much-used estimating procedure is the ordinary least-square technique. This technique can be applied to a single equation model or to a set of several equations, provided that the assumptions associated with a particular model satisfy the least-square criteria. If some of the conditions are not met, other techniques, usually more complex, are available. The estimating procedure must therefore be selected in accordance with the type of regression model and the relevant assumptions.

Factors affecting fertility changes

Non-programme factors

Factors utilized. The regression approach does not identify the particular variables that can or should be included in the regression equations. The selection of these variables depends upon the model used to account for changes in fertility behaviour. The types of socio-economic, demographic or biological factors taken into account are thus chosen on the basis of the model developed to "explain" fertility levels or changes in fertility, as discussed below:

(a) *Socio-economic factors.* A number of socio-economic factors that are associated with industrialization and economic development are usually considered to be associated with fertility and can be included in a regression analysis to account for these non-programme effects. Examples of such factors are income, literacy, level of education, industrialized or agricultural composition of the labour force and urbanization indexes;

(b) *Demographic factors.* Which of these factors are included depends in part upon the measure of fertility used as a dependent variable. Thus, factors representing age structure or nuptiality may be introduced when the dependent variable is the crude birth rate or age-specific fertility rates. In addition, a measure of infant mortality is often utilized because of the presumed effect of this factor on subsequent fertility. Occasionally, a measure of the initial fertility level of an area or a lagged value of the dependent variable is included in the model;

(c) *Biological factors.* Aggregate values of biological factors are not usually available and hence cannot be included in a regression analysis. By now, it will have become clear that the biological variables commonly taken into consideration in family planning programmes evaluation are fecundity, sterility, post-partum amenorrhoea; no attempt has been made, so far, to include such variables in a regression model.

Data requirements and sources. The data utilized will depend both upon the factors selected for inclusion in the regression and upon the availability of data. In addition, the choice of specific data is also guided by the particular interrelations between variables that the evaluator has assumed. Thus, it may be subsumed, for example, that the relationship between family planning acceptance and industrialization is best indicated by measures of the proportion of labour force engaged in agriculture or by the proportion of males engaged in agriculture. Similarly, the education factor can be identified by data on literacy, the educational

[24] An effect is defined as "indirect" when it is exerted on the dependent variable through another variable.

level attained by males or females; or by the proportion of children of a given age attending school etc. The demographic data used can range from crude birth rates to age-specific marital fertility rates and from crude death rates to infant mortality or expectation of life. Many kinds of data can be utilized in this method, and a wide range of sources is needed.

Programme factors

Factors utilized. A variety of programme factors can be employed to allow for the programme effects on fertility. Services provided by the programme, abortions, sterilizations, contraceptives distributed; and administrative, medical and paramedical personnel involved in the programme are only a few among such possible factors. Regression analysis is the only method that allows for the inclusion of programme indicators beyond acceptors for assessing programme impact on fertility.

Data requirements and sources. Man-month of use of various personnel components, number of acceptors of various family planning methods etc. constitute significant indicators of the programme activities. Service statistics and follow-up surveys represent the best sources of data for construction of these indicators.

Measurement of fertility change

Levels and changes in observed fertility

The main dependent variable that appears in regression analysis is, of course, fertility. The determination of fertility levels for the various units of observation can be measured according to various indicators: crude birth rates and standardized crude birth rates; general fertility rates; age-specific and age-specific marital fertility rates; etc. Data on observed fertility are gathered for the year of observation, but depending upon the model used, fertility of previous years can also be included in the analysis as lagged dependent variables.

Levels and changes in fertility in the absence of the programme

The regression approach does not require estimates of potential fertility, nor is there any estimate of potential fertility associated with this method. The use of observed fertility measures and potential fertility estimates implies a comparison between these two indicators; regression analysis does not rely on such a comparison.

Main assumptions

The ordinary least-square technique for estimating regression parameters is a straightforward and relatively simple procedure; hence, it is often preferred to more complex approaches. But this procedure requires that a number of conditions associated with the regression model be met, thus restricting somewhat its use. However, only assumptions related to ordinary least squares are examined here, without any attempt to be exhaustive. These assumptions vary with the type of regression model used—a single equation versus a system of equations, for instance—and should, of course, reflect the process described by that particular model.

The ordinary least-square procedure assumes that the association between the dependent and the explanatory variables is linear. It also assumes that the error term has an independent distribution, a mean equal to zero and a constant variance. It further assumes that the explanatory variables are independent of the error term. As stated above, assumptions may vary with the type of regression model: in the case of a system of equations, for instance, ordinary least squares can be applied only if it can be safely assumed that the system is recursive. It is also assumed that the variables are measured without error.

Population covered

Regression analysis can be applied to any category of population provided the required data are available. This method is easier to apply on a nation-wide basis, because aggregate data for a sufficient number of units are more likely to be at hand.

Time reference

No particular specifications are set regarding regression analysis: a regression model can be a cross-section model, a time-series model or a mixed model, and thus may encompass both cross-section and time series. In each case, results are in calendar years.

Simulation models

Type of method

Approach

A number of simulation models have been designed to study the occurrence of births, and some have been used to investigate the effects of family planning practice as well as other fertility determinants on the number of children born to a particular population. When used for evaluation purposes, the effect on family planning practice is the only programme factor taken into account. The models developed may be distinguished along several different dimensions. On the one hand, one may distinguish demographic models which focus on the vital events—i.e., birth, death, marriage—which change a population over time from biological models which decompose the birth probabilities into their biological components—fecundity, sterility, foetal loss, gestation and anovulatory periods etc. On the other hand, models may be distinguished as analytical or numerical, stochastic or deterministic (expected value models); and as macro-simulation (in which probabilities or proportions are applied to subgroups of the population of interest) or micro-simulation (in which probabilities are applied to individuals).

In studying the effects of a family planning programme on fertility, the usual practice is to simulate the natality process of two or more populations in which one or more would be subject to the programme and one or more would operate in the absence of the programme. By comparing the resultant fertility of say, two cohorts of women, similar in all respects except for the practice of family planning, an indication of the births averted by the programme is obtained.

Procedures

The procedures used to generate sequences of births over time vary with the type of model. In a deterministic model, the proportion of births expected is applied to women (or couples) with specified characteristics and the fertility outcomes are uniquely determined by the proportions used. In a stochastic model, a Monte Carlo simulation is used whereby women (or couples) are exposed to the appropriate probabilities in conjunction with sequences of random numbers. This procedure generates states or events on a stochastic basis.[25]

An analytical procedure, used mainly with biological models, resorts to the stochastic theory of renewal processes to simulate the reproductive history of women. It formulates the family-building process in terms of recurrent events and waiting times, with intervals between consecutive births taken as independent random variables having the same distribution. A particular formulation of this theory allows the initial birth interval (from marriage to first birth) to be distributed differently from the subsequent intervals. This procedure, however, requires a number of simplifying assumptions about homogeneity among women and over time.[26] Some of these assumptions are avoided by other models; for example, by a macro-simulation deterministic model called ACCOFERT.[27]

Factors affecting fertility change

Non-programme factors

Factors utilized. Since the natality process is approached through a variety of models, the factors taken into consideration can vary widely. A major difference, already noted, concerns models that do or do not take into account the biological factors leading to a birth. Another difference arises from the point in time when the simulation is initiated. If a group of women is taken through its reproductive life from age 15 to age 45 or 50, it is theoretically required that the probability of primary sterility, of dying before marriage and of marrying be included in the model, whereas a simulation of a group of fecund married women does not take these factors into account. Likewise, a model dealing with a hypothetical cohort of homogeneous women will resort to different characteristics than a model attempting to represent a more diverse hypothetical population. Non-programme factors include:

(a) *Socio-economic factors.* Only in cases where the models attempt to reproduce a realistic population are these factors taken into account. In such cases, the initial population can be simulated with due consideration to such factors as ethnic group, residence (urban or rural) and income;

(b) *Demographic factors.* First marriage, death, widowhood, divorce, remarriage, desired family size etc., are the most common factors in this category to be taken into consideration. Some models also consider infant or child mortality. Few models, however, take all these factors into account;

(c) *Biological factors.* Only models designed to simulate the reproductive process include biological factors. The most common factors taken into account by these models are fecundity, sterility, miscarriages, spontaneous abortions, stillbirths, length of gestation and anovulatory periods.

Data requirements and sources. The factors included in the models as parameters must be quantified in a sufficiently realistic way to make the results of the simulation meaningful; they must, therefore, be based on relevant empirical data. This is true of all the factors and particularly so for factors that may strongly affect estimates of programme impact. Thus, models that give strong weight to the non-susceptible period may require highly accurate data on breast-feeding and the anovulatory period. This requirement raises the question of sources, and although demographic data may be relatively accessible for the population under study, biological data are often much more difficult to obtain. However, these data may sometimes be supplied by imputation using data from available studies of similar populations.

Programme factors

Factors utilized. Simulation models are usually designed to assess the effects of one or several family planning methods on fertility; therefore, family planning practice and its use-effectiveness are the only programme factors used.

Data requirements and sources. The type of data needed depends mainly upon the parameters inherent

[25] See, for example, Albert Jacquard, "La reproduction humaine en régime malthusien", *Population* (Paris), vol. 22, No. 5 (September–October 1967), pp. 897–920.

[26] Edward B. Perrin and Mindel C. Sheps, "Human reproduction: a stochastic process", *Biometrics*, vol. 20, No. 1 (March 1964), pp. 28–45; and Robert G. Potter, "Renewal theory and births averted", in *International Population Conference, London, 1969* (Liège, International Union for the Scientific Study of Population, 1971), vol. I, pp. 145–150.

[27] Robert G. Potter, "Description of ACCOFERT II", Providence, Rhode Island, Brown University; and Ann Arbor, Michigan, University of Michigan (mimeographed).

in a particular model. Some models account for just one method of contraception; others include several methods, and still others also include sterilization or abortion as family planning methods. Available data on the age distribution of acceptors, continuation rates, use-effectiveness etc., drawn from such sources as service statistics and follow-up studies, may be needed as input by some models.

Measurement of fertility change

Levels of and change in observed fertility

In the usual approach, the observed fertility is the fertility obtained by simulating the natality history of a group whose family planning practice is assumed to result from programme activities. Unless the initial population is assumed to have already reached a given fertility level, changes in levels are not relevant since most simulations begin when both observed and potential fertility are still zero. Indeed, populations are often simulated from the beginning of their reproductive life.

Levels of and change in fertility in the absence of the programme

Levels of fertility in the absence of the programme are obtained from the simulation of women or couples who are not practising family planning or who are practising non-programme family planning methods.

Main assumptions

Each simulation model involves a number of assumptions, and the variety of models gives rise to a long list of assumptions that cannot be detailed here. Mention can be made, however, of some of the more general categories. One source of assumptions arises from the mathematical structure employed. For example, models based on renewal theory assume, in generating the reproductive histories, that the same probabilities apply to all women, that all parameters are fixed in time and are independent of age, and that the reproductive period is sufficiently long.[28] Monte Carlo methods, as well as others, do not necessarily have such constraints but produce results subject to sampling fluctuation. Differences between models also arise in treating factors as fixed or subject to certain distributions and, in the latter case, in the distributions employed. Models of course also differ in the number and type of factors incorporated, in the interrelationships assumed to exist among factors, and in the values assigned to the parameters of the model.

Population covered

The population covered is defined and characterized by the simulation model utilized. Certain models deal with single women at age 15; other models simulate cohorts of married women, beginning at age 20. In some cases, the hypothetical population is homogeneous; in other cases, an initial population is generated with heterogeneous characteristics. The population is thus model-specific.

Time reference

Most models are longitudinal studies of cohorts of women. Some model applications can, however, yield results in terms of calendar periods.

Major methodological issues

This section deals with some of the more important methodological issues encountered in the application of the evaluation methods described above. These issues, which have been selected somewhat arbitrarily, are as follows:

(*a*) Estimation of potential fertility;
(*b*) Data requirement problems;
(*c*) Correlated variables and interaction;
(*d*) Uncontrolled variables;
(*e*) Independence of methods;
(*f*) Cost-precision analysis.

In examining these issues, emphasis is placed on the definition of problems encountered in evaluation, rather than on possible solutions to the problems. The relation of each evaluation technique to each methodological issue is merely illustrated; the country case studies that were prepared for the meeting constitute the basis for a more systematic, analytical discussion. The purpose here is to provide a framework for discussions of the extent to which evaluation techniques currently in use are capable of solving methodological issues and of the advantages and disadvantages of each method with respect to those issues.

Potential fertility

As was made clear in the preceding section, a number of methods used to measure the impact of family planning programmes on fertility do so by comparing, under specific sets of assumptions, the actual fertility of a particular population with the fertility that population would have experienced had the programme not existed. "Potential fertility" is the concept identifying this hypothetical fertility, which can be defined as the fertility a population subjected to a programme would have experienced in the absence of that programme. Except with regard to evaluation methods that do not utilize this concept (i.e., correlation analysis), potential fertility is a major component of evaluation procedures and, as such, requires estimates of the highest possible accuracy.

Indeed, the difference (or the ratio) between actual and potential fertility indicators is assumed to yield the magnitude of the programme impact on fertility. Con-

[28] R. G. Potter, "Estimating births averted in a family planning program", *loc. cit.*, pp. 413–434.

sequently, any over-estimation or underestimation of one of the components of comparison will result in a corresponding over-estimation or underestimation of the magnitude of the programme impact. The computation of satisfactory estimates of the potential fertility of a population presents a number of problems.

Problems in assessing potential fertility

In order to deal with the problems of assessing potential fertility, it is necessary at the outset to bear in mind two factors. The first is that estimating potential fertility consists of determining a particular fertility level that did not materialize. It is not possible to know with certainty what such a fertility level would have been and this problem cannot be solved. The purpose of the procedure is thus to compute reasonable estimates. The second consideration is that there are two types of population which can be observed for evaluation purposes: (*a*) the population living within defined boundaries, namely, that living in a country, an administrative area or a family planning programme area;[29] (*b*) the population known to participate in the family planning programme and which constitutes the group referred to as "acceptors". Problems are somewhat different for these two groups and are treated separately.

Potential fertility of the general population

Conceptual problems. Substantial efforts have been made to define the concept of "acceptor" and its significance, but no such attempts appear to have been made in respect of the "general population". The concept of "general population" is ambiguous, because there are no criteria for defining it and researchers rarely attempt to identify the potential biases that may occur when a given population is used as the general population. Thus, the general population is usually that which the evaluator arbitrarily selects on the basis of unspecified criteria. Theoretically, the general population can include all women in the area under study, or non-acceptors only, or married women only, or non-sterile, non-pregnant women only, or women who did or did not give birth during a defined period of time preceding the interview etc. The estimate of potential fertility will vary, depending upon which of these groups is taken as the general population. The problem is thus to develop a concept of the general population that would provide, under specified conditions, a satisfactory estimate of "potential fertility".

Methodological problems. Generally speaking, there are basically two distinct approaches to estimating the potential fertility of a general population. In the first, some set of observed fertility rates are equated with potential fertility; in the second, a set of observed fertility rates is combined with various assumptions to produce the estimates of potential fertility. When a family planning programme is introduced into a country or area, the fertility levels observed prior to and at the time of introduction in that country or area may be taken as the potential fertility that would have occurred in the absence of a programme. In effect, the prior experience of the country or area serves as a pseudo-control group. In a more strict experimental design, if the programme is introduced into certain areas only, non-programme areas deemed otherwise comparable may be selected as the control group; and the fertility for those areas over the same time period for which the programme was operational in the experimental areas is taken as a measure of potential fertility. In the latter case, the adequacy of the approach depends, among other things, upon the comparability of the two types of areas and upon the absence of contamination of the non-programme areas by the programme activities ongoing in the experimental areas.

In the second approach to estimating potential fertility, one projects the past fertility of the population under observation into the future, on the assumption that no family planning programme had been initiated. This approach involves, as a first step, proper identification of the past trend, which will be influenced by the length of the reference period used and the method of sorting out short-term fluctuations. Then, assumptions are made about the nature and magnitude of social and economic factors that might have affected fertility even in the absence of a family planning programme. Though it is sometimes helpful to establish a range of values for potential fertility under different assumptions, the possibility of inferring anything useful about the effect of the programme diminishes as the range for potential fertility increases.

The evaluation methods that explicitly or implicitly produce a measure of potential fertility for the general population use one or another of the two approaches outlined above and, in addition, differ in the way they take into account the social and economic changes that may affect fertility. The experimental design method, for example, utilizes the first approach and assumes that any social changes that occur over the time period of observation affect the control and experimental groups equally. In the decomposition or standardization procedure, it is implicitly assumed that the factors used for standardization capture the changes bearing on fertility. A projection approach, which simply extrapolates pre-programme trends into the period of observation, is implicitly assuming that the rate of change of non-programme factors is the same in both periods, an assumption which may or may not be realistic.

Potential fertility of acceptors

The evaluation methods based on data pertaining to acceptors emphasize the usefulness of information on

[29] The population defined by geographical boundaries is, for the purpose of this discussion, called the "general population"; this term is meant also to include the population of a community, a neighbourhood, a maternity ward etc.

persons who have been reached by the programme and the consequent changes in their fertility. It is assumed that if acceptors can be identified, changes in their fertility can be credited more easily to the programme than is possible when dealing with the whole population. Thus, for practical reasons[30] and to increase the probability that a correct inference is made, a number of methods tend to limit the evaluation of programme impact to those who are defined as acceptors.

Conceptual problems. As concerns the concept of "acceptors" it would appear at the outset that a fertility decline among acceptors might be readily linked to programme activities. There are reservations regarding this relationship, but the problem of covariance between these two variables is not the only question. A preliminary question is how the concept of "acceptor" is to be understood. Definitions of this concept vary to the extent that they affect markedly the composition and size of a group of acceptors and, consequently, also the impact on fertility. An acceptor may be defined as a person who accepts and uses a contraceptive method (or a sterilization or an abortion) offered by either private or public family planning programmes. Whether the acceptor participates in the programme for the first time or whether he or she accepts a particular programme method for the first time is also of particular relevance. A distinction may also be made between "acceptors" having used contraceptives prior to entering a programme and persons who accept (and use) a family planning method for the first time.[31]

A number of studies of acceptors' fertility prior to acceptance have indicated that this group may be a self-selected group characterized by higher than average fertility. If the past fertility of this group is above average, it may be hypothesized *a priori* that in the absence of the programme, the acceptors' fertility level would have remained above average and, hence, that their potential fertility should be estimated on the basis of their own past fertility. This assumption is critical to the whole problem of estimating the acceptors' potential fertility and raises, among others, the following questions: (*a*) whether acceptors have genuinely higher than average fertility; (*b*) if so, whether their fertility would have remained at a higher than average level had the programme not been undertaken.

With respect to the question of the acceptors' genuinely higher fertility, two levels of measurement are implied in the concept of genuine fertility. One is the amount of "excess" fertility that is observed in empirical studies comparing acceptors with non-acceptors or with the general population. The other concept of excess fertility, defined here as "genuine" higher fertility, refers to the assumption that acceptors have a higher than average probability of producing a live birth. Genuinely higher fertility cannot be directly observed but only inferred, and this assumption is critical in deciding whether higher than average fertility would have continued to be experienced by acceptors had the programme not existed.

References about genuinely higher fertility and its effect on potential fertility will be aided by decomposing the differentials in observed fertility between acceptors and non-acceptors. To the extent that one can determine whether the observed differences are due to the factors related to exposure to intercourse (length and stability of sexual union); exposure to risk of conception (e.g., coital frequency, use of contraception, breast-feeding patterns); probability of conceiving (fecundability, primary and secondary sterility) and risks of foetal wastage, one is better able to judge whether the observed fertility differentials are likely to persist in the future.

Certain features of family planning programmes help distinguish acceptors and non-acceptors on these various components. For example, in so far as women become acceptors shortly after a birth, they are less likely to be sterile than a woman of the same age selected at random from the population, who may be primarily sterile or who may have developed secondary sterility since her last birth, which occurred, on average, earlier than that of the acceptor. The differential in the likelihood of sterility will be relatively large at the older ages. By the same token, if the observed difference in fertility between acceptors and non-acceptors is based on a short period of observation, the difference may be largely a reflection of the fact that acceptors have had a recent birth rather than any difference in fecundity.

Though differences in observed fertility between acceptors and non-acceptors are often taken to imply differences in fecundity, this assumption must be examined carefully even when based on moderately long periods of observation. Simulation studies[32] have shown that chance factors in fecundity operating on a group with identical probabilities will produce a subgroup with above-average fertility, which is thereby disposed towards acceptance.

The chance factor in fecundity also complicates, in another way, the assumption that acceptors would continue to have higher fertility than non-acceptors. Brass[33] has shown that even if acceptors are correctly assumed to have higher fecundity than non-acceptors, due to the chance factor, the future differential in fertility may be less than that observed in the past. That is, over short durations in particular, the chance

[30] As is shown in the discussion of "interaction", there are serious difficulties in identifying who has been influenced by the programme among those who are not recorded for having done so.

[31] This procedure requires accurate and detailed record-keeping; one should be able to identify not only "acceptors" who are simply switching methods but those who increase their use-effectiveness as a result of the programme.

[32] Jeanne C. Ridley and others, "On the apparent subfecundity of non-family planners", *Social Biology*, vol. 16, No. 1 (March 1969), pp. 24–28.

[33] William Brass, "Assessing the demographic effect of a family planning programme", *Proceedings of the Royal Society of Medicine*, vol. 63, No. 11 (November 1970), pp. 29–31.

element may be more important than systematic differences in fecundability.[34] Moreover, empirical studies that compare the post-acceptance fertility of acceptors with non-acceptors may be misleading when based on short periods of observation, in that acceptors are rarely pregnant at the time of acceptance, but the comparison group of non-acceptors will have a certain proportion of pregnant women.[35] Thus, the period of observation is important when comparing acceptors and non-acceptors, with regard both to pre-acceptance fertility and to post-acceptance fertility.

Another conceptual difficulty has to do with the so-called "substitution problem". Acceptors are often distinguished from non-acceptors not only by higher fertility but by a greater interest in family planning. In determining the potential fertility of acceptors one must take into account the possibility that some acceptors are substituting programme methods of family planning for methods privately obtained. In this case, one would want to credit the programme only with any net gain in effectiveness that resulted from this substitution. Another facet of this problem is the possibility that acceptors who are not current or prior users of family planning might have adopted some method privately even in the absence of a programme. These problems cause severe complications in the estimate of potential fertility and permit no ready solution even at a conceptual level.

As Wolfers'[36] review of several studies indicates, the proportion of ever-users who are current users varies greatly. The fact that a woman was using a family planning method at the time of acceptance or at some time previously does not demonstrate that she would have used a method privately if she had not become an acceptor.

It should also be mentioned in passing that in so far as attention is restricted to the potential fertility of acceptors, the programme cannot be credited with any indirect effects of encouraging couples to adopt family planning privately. Indeed, if this practice takes place to any appreciable extent, it may detract from the apparent impact of the programme by diminishing the fertility differentials between acceptors and non-acceptors.

Methodological problems. With respect to measurement of the acceptors' past fertility the various conceptual problems discussed above would be meaningless if the acceptors' fertility were measured as higher than average only because of the unreliability of the data or method, or if the magnitude of the excess fertility were over-estimated or underestimated for similar reasons. The measurement of the acceptors' excess fertility is obtained by comparing fertility data of acceptors, on the one hand, and those of non-acceptors or the general population, on the other hand. The difference between these observed rates is considered to be the excess fertility. Various factors can affect the magnitude of this difference. If comparisons are based on samples, both the absence of biases and the significance of the fertility differences have to be ascertained. Excess fertility of acceptors can vary, depending upon whether one uses non-acceptors or the general population as the unit of comparison. Excess fertility will also vary with respect to the accuracy of the data being compared, especially with respect to the difference in accuracy between the two sets of fertility indicators.[37]

The length of the span of time over which fertility is estimated may also affect the estimated level of fertility and, hence, the magnitude of the acceptor's excess fertility. In addition to points discussed previously, it should be noted, for example, that if acceptors enter a programme shortly after a birth, an upward bias may be introduced if too short a reference period is used. Estimates of the acceptors' own fertility prior to the programme is often recorded for three- or five-year periods. Assuming that the length of the reference period is the same for both groups, the question of an optimum length—and minimum bias—to estimate fertility for evaluation purposes is still unanswered.

As concerns measurement of the acceptors' potential fertility a number of procedures utilized to estimate potential fertility have been outlined in the preceding section. The discussion here deals only briefly with some issues that may affect the validity of a particular procedure. One problem is whether the fertility of the general population or that of the acceptors themselves should be used as a basis for calculating potential fertility. Most methods use the acceptor's own fertility on the assumption that their fertility is and will remain higher than average. Only one author[38] recommends the use of data obtained from selected groups of the general population.

Another question is what kind of fertility measure is best for the purpose of estimating potential fertility. This problem has been raised mainly in connexion with Potter's and Wolfers' procedures,[39] the former using age-specific fertility rates and the latter birth intervals. Both procedures are based on a comparison of "units of time", namely, the period of useful retention or use of a contraceptive during which no conception occurs, as compared with the average interval between two births

[34] David Wolfers, "Births averted", in C. Chandrasekaran and Albert I. Hermalin, eds., *Measuring the Effect of Family Planning Programs on Fertility* (Liège, International Union for the Scientific Study of Population for the Development Centre of the Organisation for Economic Co-operation and Development, 1975), pp. 163–214.

[35] W. Brass, *loc. cit.*

[36] D. Wolfers, "Births averted".

[37] John A. Ross, "Cost of family planning programs", Bernard Berelson and others, eds., *Family Planning and Population Programs: A Review of World Development* (Chicago, University of Chicago Press, 1966), pp. 759–778.

[38] D. Wolfers, "The demographic effect of a contraceptive programme".

[39] R. G. Potter, "Estimating births averted in a family planning program"; and D. Wolfers, "The demographic effect of a contraceptive programme".

had the contraceptive not been used. To compute the potential fertility estimate, Potter records the acceptors' own fertility rates for a given pre-programme span of time; he then translates these rates into a unit of time defined as the average duration per birth that might have been required had the IUD not been adopted. The translation of birth rates into time periods is obtained by using a method based on the reciprocity of birth intervals and fertility rates.[40]

Wolfers[41] questions this procedure for obtaining mean birth intervals, preferring to obtain the birth intervals required for estimating potential fertility directly from interviewing randomly selected women at the time of delivery or from women all of whom have given birth within a certain specified period.

Conclusion

A number of approaches to solving some of the problems of estimating potential fertility rely on model simulation. According to one suggestion, for instance, use should be made of a theoretical model to determine the appropriate length of the pre-programme reference period so as to minimize the biases in estimating past fertility. Use of stochastic models of human reproduction has also been recommended as a means of estimating the expected number of births during specific periods of time in the absence of a family planning programme.

As the estimate of potential fertility is crucial to a number of evaluation procedures and is beset with many difficulties, close examination of the advantages and disadvantages of the various approaches is warranted.

Data requirement problems

The problems referred to in this section concern a selected number of difficulties associated with the selection, measurement, utilization and interpretation of data needed for applying methods of measuring the impact of family planning programmes on fertility. The quality of the data and the use of appropriate measures are, among other data requirements, major preconditions for drawing meaningful conclusions. Even the more sophisticated evaluation procedures cannot be expected to provide reliable results if the data inputs are unsatisfactory. It is to be anticipated that some problems cannot be completely solved. Their presence should, however, be explicitly acknowledged at the interpretation phase so as to give a proper perspective to the conclusions drawn by the evaluator.

[40] The actual formula is $D(w) = 12{,}000/b(w)$, where $b(w)$ denotes the birth rate for women of average age w and $D(w)$ is the corresponding duration, in months, per birth. See R. G. Potter, a technical appendix on procedures used in manuscript "Estimating births averted in a family planning program".

[41] D. Wolfers, "The demographic effect of a contraceptive programme"; and *idem*, "The estimation of potential fertility for family planning evaluation", *Proceedings of the Royal Society of Medicine*, vol. 63, No. 11 (November 1970), pp. 41–44.

The data problems reviewed and the items discussed are illustrative rather than exhaustive. Special emphasis is given to the use of fertility data, since measuring whether an observed difference in fertility over a given period of time reflects actual changes is a major component of many methods. Common statistical problems, such as the necessity of testing for significance of differences, are therefore mentioned. Specific data problems peculiar to certain methods can be examined in more detail when the country case studies are reviewed. Most of the problems, which are illustrated by fertility data, also arise in connexion with other demographic data, as well as with standard socio-economic data. The items discussed are as follows: (*a*) measurement problems are examined as they appear to be a major source of obtaining invalid results; (*b*) a number of questions are raised regarding the interpretation of results, even when data can be assumed to have been measured without errors.

Measurement problems

The measurement problems reviewed here are illustrative of a number of difficulties that are expected to be encountered in the measurement of the impact of family planning programme on fertility. These problems result from a variety of sources: unfavourable data-collection circumstances as they are found in the developing countries; faulty or unreliable data-collection procedures; reporting errors; classifications errors; chance errors, etc. An extensive body of literature is available on the major types of errors that are encountered in both sample surveys and complete enumeration, and on solutions that may be applied. The primary concern here is with a selected number of questions that might arise in connexion with evaluation studies and that may be illustrated by the case studies that complement the present review.

The problems at issue are specifically errors in measurement. They fall, for the purpose of this discussion, into two categories. The first category includes non-random errors and biases that are either constants and affect all units alike or that follow a particular distribution and affect the true values differentially. Although errors in this category are often suspected, it is nevertheless difficult to ascertain their magnitude and direction. Information originating outside the scope of the particular study is often required, or specific new information is generally needed to establish the nature and magnitude of these non-random errors. Once these errors are established, the observed data are often subject to adjustment as in the case of the age distribution of a population. Assessing the presence and magnitude of the errors, on the one hand, and determining the quality of the adjustments undertaken, on the other hand, constitute the major issues of measurement as far as non-random errors are concerned.

The second category of errors includes random errors. They are classified separately because of their stochastic nature. Specifically, the approach to random errors is quite different from that of non-random errors, mainly because they can be dealt with by means of statistical theory. A large body of research has been devoted to this type of error; it is thus expected that some of the solutions and insights can be of use to problems encountered in evaluation studies. Although standard statistical theory considers the total error in measurement as resulting from sampling and non-sampling errors, the terminology used here, namely, random and non-random errors, is utilized because the category of random errors includes both sampling errors (i.e., random errors due to the sampling procedure) and random errors of non-sampling origin (i.e., random errors resulting from chance factors that are assumed to occur even in complete enumerations).

From a conceptual standpoint, the measurement of a variable can be shown in the formula:

$$X_i = X'_i + B_i + e_i \text{ where the error } = B_i + e_i$$

where X = the observed value of the individual characteristic being measured;
X'_i = the true value of that characteristic;
B_i = the bias;
e_i = the random error associated with the measurement.

The survey bias can be further defined both for total enumerations and for sample surveys:

$$B = E(X) - E(X') \text{ or } B = \bar{X} - E(X')$$

where B = the survey bias;
$E(X)$ = the expected value of the observed individual characteristics of the universe;
$\bar{X}$ = $E(\bar{X})$ = the expected value of the sample mean; and
$E(X')$ = the true mean of the universe.

Non-random errors

Non-random errors constitute a major source of biases in the measurement of observed variables, and the field of family planning programme evaluation is not exempt from this problem. Generally speaking, the problem of errors can be approached in two steps. The first consists of assessing the existence and the magnitude of suspected errors; the second step consists of adjusting the erroneous data. In the social sciences, in general, and in the field of demography in particular, such sources of errors as under-enumeration, non-responses, digit preferences, recall lapses, constitute major sources of biases, whether data are obtained from samples or from attempted complete enumerations. The experience gained by demographers in the gathering and adjustment of data often makes them readily aware of inaccurate results. But estimating the magnitude of such errors and correcting them presents great difficulties, as do their effects, which constitute yet another problem.

Although the assessment of random sampling errors can be undertaken directly on the basis of statistical theory and techniques of inference, non-random errors require some complementary information for assessing both the existence and the magnitude of the suspected biases. Response errors, for instance, as well as under-reporting, can be estimated by matching the data with statistics from other sources. The effect of non-random errors may not only affect the measurement of a particular indicator but, under given conditions, may affect the measurement of the accuracy of sample results. Assuming, for instance, that a simple random sample n is taken from a universe N where N_1 would respond and N_2 would not, the proportion $N_1/N = W_1$ is then the proportion of response in the population, and $N_2/N = W_2$ is the proportion of non-response in the population. The amount of bias in the sample mean x resulting from non-responses would be

$$\begin{aligned} E(\bar{x}_1) - \bar{X}' &= \bar{X}_1 - \bar{X}' \\ &= \bar{X}_1 - (W_1\bar{X}_1 + W_2\bar{X}_2) \\ &= W_2(\bar{X}_1 - \bar{X}_2) \end{aligned}$$

where the bias is equal to the product of the proportion of non-response and the difference between the two means in the two population strata.[42] The question is how such theoretical findings can be of benefit in evaluation studies: in other words, how the amount of bias can actually be estimated and what magnitude can be considered negligible, say, with fertility data.

Generally speaking, when sampling errors are estimated on the basis of the standard deviation, the estimate of the error is not satisfactory when the bias B is large compared with the standard error.[43] In the presence of large biases, the square root of the mean square error, $\sqrt{\text{MSE}}$, appears to be the best measure of accuracy of an estimate. The mean square error, which is equal to the variance of the estimate plus the square of the bias, is obtained, for a sample mean, as follows:

$$\text{MSE}_{\bar{x}} = \sigma^2_{\bar{x}} + (\bar{X} - \bar{X}')^2$$

where $\bar{X} = E(\bar{x})$ and $\bar{X}'$ is the true value. The effects of biases have been studied on the basis of specific models[44] and, according to Cochran,[45] have led to the conclusion that constant biases pass undetected in the sample data and that the computation of confidence

[42] W. G. Cochran, *Sampling Techniques* (New York, John Wiley and Sons, Inc., 1961), p. 294.

[43] According to Cochran, the effect of a bias on the accuracy of an estimate is negligible if $B/\sigma < 0.10$.

[44] Models used are of the type $X_i = X'_i + B_i + e_i$, where X' is the correct value; B_i a constant or a variable bias; and e_i the random component.

[45] W. G. Cochran, *op. cit.*, p. 307.

limits become, under specified conditions, misleading. The problem here is to determine under what conditions the effects of biases can be estimated and corrected as far as evaluation studies are concerned.

Selection of an appropriate technique for adjusting non-random errors is a difficult matter. A number of methods are available and the question of relevance is what method is appropriate in particular circumstances. Som[46] indicated three methods as being appropriate to correct the effects of non-response: the use of selected random substitutes from the responding units; the Hansen-Hurwitz method, i.e., a random subsample of the non-responding units; and the Hartley-Politz-Simmons method which proposes a means of adjusting for biases without resubmitting questionnaires. Then, a number of methods have been devised specifically for handling biases common in demographic inquiries, for example the Coale-Demeny stable population approach, the Brass method and the Som method for recall lapses.[47] Of course, this raises the basic question whether these methods can be used properly for evaluation purposes. The first aspect of this question concerns the requirements set forth for using the techniques. The Brass method, for instance, assumes relative constancy of age-specific fertility as does the stable population approach.[48] These techniques assume, in fact, precisely the contrary of what the evaluation methods are expected to measure, namely a fertility decline due to family planning practice. The second aspect is whether these methods provide sufficiently precise corrections for estimating small fertility changes that may occur over short periods of time.[49]

There are alternative techniques that can be used to adjust for suspected or known errors. The use of interrelations, such as linearity, between proportions tabulated as childless and as "parity not given" can be used to adjust such errors.[50] Corrections have also been made on the basis of data of populations assumed to have "similar" characteristics. In various cases, where phenomena are not directly observable, such as fecundability or post-partum anovulation, missing information is based on indirect observations and assumptions. Fecundability estimates have been obtained by Henry from observed fertility data and are still used, with some adjustments, for modelling and estimating programme impact in developing countries.[51] The duration of post-partum anovulation has been equated, in some cases, with the length of the breast-feeding period. Since a number of evaluation studies take no account of post-partum amenorrhoea, the question raised here is twofold: what is the magnitude of the bias introduced by ignoring such a factor; and how valid are the assumptions used to perform any particular adjustment. It will be interesting to see how the case studies account for such problems.

Non-random errors may affect all categories of variables; and in some cases, depending upon the factor affected, they may have greater or less influence on the final results of the evaluation. The accuracy of the fertility data, for instance, is crucial and an observed fertility decline should, of course, be verified on the basis of strong evidence. Because non-random errors are difficult to pin-point, they present particularly dangerous features when affecting, for example, the socio-economic variables utilized in the matching procedure or in the regression analysis approach. In the latter case, there can be as many errors as there are variables in an equation; and if several equations are involved, errors attached to one equation may reappear in another. Since under unsatisfactory data-gathering conditions the amount of inaccuracy due to non-random errors may be large, compared with random errors, particular attention should be paid to this category of errors.

Random errors

Two types of non-exclusive random errors can be thought of conceptually. One type includes random errors resulting from the use of a sampling procedure. In this case, an estimate of the sampling errors can be obtained on the basis of statistical theory and inference techniques. The existence of such errors arises from the sampling, and only their magnitude and direction need be estimated. The sampling error is commonly estimated by the standard deviation of the estimates. Naturally, the magnitude of the standard error has important implications for any conclusions; sampling techniques and sample size can be set up to control for this type of error. However, as mentioned earlier, biases affect the measure of accuracy of sample estimates. Control for sampling errors and level of significance through sample size needs to be done if biases are suspected, on the basis of the root mean square error as exemplified by Seltzer.[52]

The other type of random error is not necessarily associated with sampling procedures. These errors are assumed to derive from the net cumulative effect of a large number of small influences originating in a variety of factors difficult to identify. They are associated

[46] R. K. Som, *A Manual of Sampling Techniques* (London, Heinemann, 1973), pp. 296–297.

[47] *Manual IV. Methods of Estimating Basic Demographic Measures from Incomplete Data* (United Nations publication, Sales No.: 67.XIII.2), pp. 7–30 and 31–40 and R. K. Som, *Recall Lapse in Demographic Inquiries* (Bombay, Asian Publishing House, 1973).

[48] *Ibid.*, p. 33 and p. 46.

[49] P. M. Hauser, "Family Planning and Population Programs. A Book Review Article", *Demography* (Washington, D.C.), vol. 4, No. 1 (1967), p. 406.

[50] M. A. El-Badry, "Failure of enumerators to make entries of zero errors in recording childless cases in population censuses", *Journal of the American Statistical Association* (Washington), vol. 56 (December 1961), pp. 909–924.

[51] See, for instance, D. Wolfers, "The demographic effect of a contraceptive programme", p. 118.

[52] William Seltzer, "Measurement of accomplishment: the evaluation of family planning efforts", *Studies in Family Planning*, vol. 1, No. 53 (May 1970), pp. 9–16.

with phenomena assumed to be of a stochastic nature, such as fecundability, and sometimes with the unpredictable element of randomness found in human responses.[53] In some cases, random errors are also assumed to result from the fact that indicators generally do not adequately represent theoretical concepts; in other cases, they are merely errors of observation that happen to be distributed at random.

Often, the presence of random measurement errors may be suspected if the observed variable fluctuates when measured on an annual basis. In the light of this observation, it may be underlined that measuring fertility changes, especially over short periods of time, becomes difficult even if no systematic bias is assumed. Annual measures of fertility may be subject to variations of considerable magnitudes. When fertility is measured at two points with the view of determining changes in its level, it is of crucial importance to determine what part of the change reflects a trend and what part may reflect random factors. Assuming that in a time series the observed crude birth rate B_y is the result of the sum of two unobservable components, a polynomial of degree n (or less) and random disturbance component:

$$B_y = f(y) + e_y$$

Seltzer and Fand[54] attempted to estimate the level of disturbance associated with annual crude birth-rate series and to examine how stable these estimates of residual variability appear to be.

The amount of misinformation regarding the change is, of course, greater when the period of observation is shorter, and fertility is sometimes averaged over several calendar years in order to attenuate chance effects. In this case, the fertility level and, hence, the amount of change becomes a function of the length of the reference period utilized. The question is, therefore, what optimum length of the reference period can be used to obtain the best estimate of fertility, and how such an optimum length can be determined. One proposed solution was the use of simulation models. While the focus here is on fertility data, it should be borne in mind that all variables can be subject to measurement errors of a stochastic nature. This point is important notably for applying regression analysis procedures to assess programme impact, where both dependent and independent variables can be affected.

Determining the effects of random measurement errors and, eventually, the amount of misinformation resulting from such errors appears to be a complex undertaking. When random errors are studied, it is generally assumed that there are no other systematic biases. In some cases, conclusions can be reached easily. If, for instance, a factor X_i is measured with:

$$X_i = X'_i + e_i \text{ and } E(e_i) = 0$$

where X' is the true value and e the random error, it can be shown that under specified assumptions the expected value of X_i is not affected by the error. Its variance, however, is affected and is shown to become:

$$\sigma_x^2 = \sigma_{x'}^2 + \sigma_e^2$$

The question, then, is whether such a bias is important or negligible and under what conditions it would affect conclusions.

The assessment of the effects of measurement errors appears somewhat more complex when correlation and regression analyses are under scrutiny. The misinformation yielded by correlation or regression coefficients, for instance, varies with the type of regression model used, the assumptions made, the estimating procedure utilized etc. Research on regression parameters, for example, have concluded that in the case of a two-variable linear relation of the type:

$$Y = a + bX + w$$
$$\text{with } X = X + u,\ Y = y + v, \text{ and } y = a + bx$$

where X and Y indicate the observed measures, x and y the true values; and u, v and w the measurement errors, the slope coefficients estimated through the least-square method are, under specified assumptions, underestimated, compared with the true values.[55] A similar conclusion has been reached regarding the squared multiple correlation coefficient whose value becomes reduced in multivariate normal models with independent errors of measurement.[56] Models for tracing the effect of more complex error patterns, as when there is correlation among the error terms or when the error is correlated with the variable being measured, have also been developed.[57]

[53] J. C. Barrett and W. Brass, "Systematic and chance components in fertility measurement", *Population Studies*, vol. 28, No. 3 (November 1974), p. 473, underline the fact that even if couples had the same fecundity characteristics, there would still be differences in family size because of chance effects.

[54] William Seltzer and R. S. Fand, "A note on the annual variability of the crude birth-rate", *Proceedings of the Social Statistics Section, 1973* (Washington, D.C., American Statistical Association, 1974), pp. 326–391.

[55] See J. Johnston, *Econometric Methods* (New York, McGraw-Hill, 1963), p. 150. Johnston shows that in the case of the two-variable model and on the assumptions, notably, that the errors are independent of one another and of the true values, B_n, the least-square estimator of b on the basis of n sample observations is both biased and inconsistent, with:

$$\text{plim } B_n = \frac{b}{1 + \sigma_u^2/\sigma_x^2}$$

[56] W. G. Cochran, "Some effects of errors of measurement on multiple correlation", *Journal of the American Statistical Association*, vol. 65, No. 329 (March 1970), p. 22.

[57] Paul M. Siegel and Robert W. Hodge, "A causal approach to the study of measurement error", in *Methodology in Social Research*, H. M. Blalock and Ann B. Blalock, eds., (New York, McGraw-Hill, 1968), pp. 28–59; and John J. Chai, "Correlated measurement errors and the least-squares estimator of the regression coefficient", *Journal of the American Statistical Association*, vol. 66, No. 335 (1971), pp. 478–483.

Though the models described above are helpful in understanding the effects of measurement error, the results obtained hold only for the assumptions specific for a model and wider generalizations might prove misleading and unwarranted. In practice, it is often difficult to determine which error model is most appropriate for the data obtained; and, in many cases, the actual pattern of measurement error will be more complex than that specified by any model. This situation has led one observer to conclude that efforts must be directed at eliminating measurement error at the source, as the models that account for it are only simplifications of the reality.[58]

Questions of interpretation

The correct interpretation of analytical results is a crucial phase of all scientific investigations. Attention is drawn here only to aspects of particular relevance to the evaluation of family planning programmes and to the problems of data discussed in this section.

An important aspect of any interpretation is acknowledging the presence of any errors in the observed data and assessing their effects on the results. As mentioned above, this effort can often be accomplished to a limited degree, particularly with non-random errors. As a result, there is some tendency to focus on sampling errors, for which statistical techniques are often available. Even here, however, care must be exercised to utilize techniques appropriate to the data. For example, estimates of sampling error based on simple random sampling may be misleading when a more complex sampling design has been employed, as is often the case. Where possible, techniques appropriate to the design should be employed.[59] At the same time, non-sampling errors usually merit more attention than they are given because they often constitute a large part of the total error. It should also be recognized, however, that in certain circumstances, biased results may be acceptable if they have a small variance and lie closer to the expected value than unbiased results with large variances.

Non-random errors are difficult not only to observe but to correct. At times, however, methods for correcting unreliable, missing or incomplete data are undertaken. In such cases, attention should be given to the robustness of the procedure employed when the data deviate from the assumptions of the technique. An assessment should also be made of the precision of the correcting technique in relation to the magnitude of the event being measured. In some cases, for example, the range of precision associated with a technique may be large in relation to the amount of change observed. This is a troublesome problem in the evaluation of family planning programmes, where one is often dealing with rather small and short-range changes in fertility and other key variables.

As so many of the variables used in evaluation are rates of one type or another, it is worth noting that assessment of error should be carried out both for the numerator and for the denominator. Often it is the numerator, such as the number of acceptors or the number of births, that is more problematical, but the denominator cannot be assumed to be error-free. This procedure is particularly important when changes in rates are a major component of evaluation, as a relatively small change in the degree of error in the denominator can account for a large proportion of the total amount of change observed. Caution is also required with respect to rates or ratios when sampling error is being assessed. When the numerator and denominator are both random variables, the sample ratio is not an unbiased estimate of the population ratio, though in most applications the amount of bias is very small.[60]

In interpreting the results of an analysis, it is also desirable to assess the effect that alternate definitions or estimates of variables might have on the results. In the evaluation of family planning programmes, this need can arise in many ways. For example, note has been taken previously that the concept of acceptors may be made operational in a number of different ways; and where a specific definition has been used, consideration should be given to the possible effect on the results of alternative definitions. The same consideration applies to other key concepts, such as potential fertility and to fertility itself. A related concern is the sensitivity of results to estimates utilized in the evaluation procedure. Would slight changes in these estimates affect the results to an appreciable extent?

On a somewhat more general level, it is well at the interpretation stage to consider the possible effects of alternate specifications of the models utilized: whether any variables have been omitted from the model which might affect the results appreciably; or whether alternative assumptions about the interrelationships among the variables would produce different answers. Although a final resolution to such issues is not to be expected, an awareness of their importance will contribute to comparative analytical investigations which will lead to more reliable and secure results.

In addition to the foregoing aspects, appropriate inference must also be attentive to the level of analysis. When the unit of analysis is an area, the results obtained should not be taken as holding among individuals because, except in very particular circumstances, analyses at different levels of aggregation will not produce the same results. If areas are employed, the evaluation problem should be formulated as appropri-

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[58] R. Schoenberg, "Strategies for meaningful comparison", in Herbert L. Costner, ed., *Sociological Methodology, 1972*, (San Francisco, Jossey-Bass, 1972), pp. 1–35.

[59] L. Kish and M. R. Frankel, "Inferences from complex samples", *Journal of the Royal Statistical Society*, vol. 26, No. 1, series B (1975), pp. 1–37.

[60] L. Kish, N. K. Namboodiri and K. Pillai, "The ratio bias in surveys", *Journal of the American Statistical Association*, vol. 57, No. 300 (December 1962), pp. 863–876.

ate to that level and the interpretation should be consistent with the aggregate nature of the data.

Correlated variables and interaction: interaction problems

On the general level, measuring the impact of a family planning programme on fertility is an attempt to estimate the magnitude and direction of the effects of specified programme and non-programme factors on fertility. From this view, one identifies a set of cultural, socio-economic, demographic and programme factors as determinants of fertility. The variables identified, plus their posited interrelationships, constitute in effect a system or theoretical model within which it is usual to distinguish the main dependent variable, fertility; the independent or exogenous variables, which are not determined within the model; and a set of intervening or intermediate variables, which are determined by the independent factors and which also have an effect on the dependent variable.

From this standpoint, it may appear that a fruitful system or model will account for or "explain" a high proportion of the variation in the dependent variable, in this case changes or levels of fertility, and allow an allocation of this proportion into programme factors and non-programme factors. However, the nature of the interrelations among the variables in the model may prevent the successful decomposition of the explained variance in this manner. The difficulty arises in many models because of correlations between the explanatory variables and/or interaction effects. In what follows, these difficulties are first illustrated with reference to multiple regression, and then their relevance for other evaluation techniques is shown.

Correlated variables in multiple regression

Consider a three-variable linear multiple-regression equation of the type:

$$Y_i = a + b_{y_{1 \cdot 2}} X_{1i} + b_{y_{2 \cdot 1}} X_{2i} + e_i \qquad (1)$$

where Y = a measure of fertility;
X_1 = a non-programme variable;
X_2 = a programme variable.

From the data, it is possible to estimate values of the partial regression coefficients, $b_{y_{1 \cdot 2}}$ and $b_{y_{2 \cdot 1}}$, which measure, respectively, the effect of the non-programme variable on fertility after taking into account or "holding constant" the programme factor; and the effect of the programme variable on fertility, after taking into account or "holding constant" the non-programme variable. The regression coefficients show how much change in fertility is expected from a change of one unit in the independent variables. They thus indicate the relative importance of each variable and are useful in cost-benefit analysis when the relative cost of achieving a change in each independent variable can be determined.

It is also possible to determine from the data the proportion of the total variation in fertility accounted for by both independent variables, sometimes referred to as the coefficient of determination or R^2. Only in special circumstances, however, can this proportion be decomposed into the amount due to X_1 and the amount due to X_2.

If the two independent variables are not correlated with each other, then the regression coefficients obtained above will be the same as those obtained from two simple regression equations in which fertility is regressed against each of the variables in turn. Similarly, the coefficient of determination, R^2, obtained above will be equal to the sum of the proportion of variation obtained from each of the two simple equations. However, these relations do not hold if the two independent variables are correlated. In this case, the regression coefficients from the multiple regression equation may be greater or less than that obtained from the simple bivariate case, while the multiple R^2 likewise may be greater or less than the sum of the R^2 from each equation.

Since in most systems the factors do not exercise their influence independently of one another, attention is directed to the pattern of interrelationships or structure of the model, assumed to hold among the variables. Indeed, as one observer states,[61] insufficient attention is accorded to appropriate representation of the phenomenon in question at the expense of concern with the proportion of variance explained and its partitioning among variables. Description of the structure is needed as a guide to the most appropriate measures and proper inferences from the results.

As illustration of the utility of giving explicit attention to the structural model underlying a given problem, figures I and II present two possible configurations of the variables in equation (1).

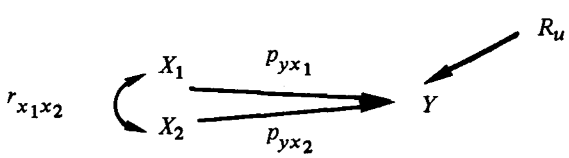

Figure I. Structural model without intermediate variable

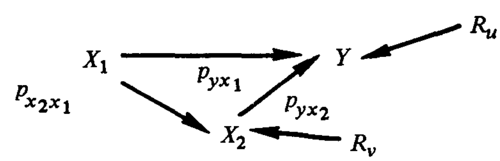

Figure II. Structural model with one intermediate variable

The representation uses the conventions of path analysis, a multivariate technique useful in explicating linear causal models.[62]

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[61] Otis Dudley Duncan, "Partials, partitions, and paths", in Edgar F. Borgatta and G. Bohrnstedt, eds., *Sociological Methodology, 1970* (San Francisco, Jossey-Bass, 1970), pp. 38–47.

[62] For detailed expositions of these techniques, see S. Wright,

The variables in the figures are arranged in the presumed temporal and causal sequence. Each variable occurs earlier in time than those appearing to the right of it and later than those to the left, and can be affected by all the variables that precede it. The direct influences from one variable to another are represented by the one-way straight arrows and the sign and magnitude of these are the path coefficients, P_{ij} (read as representing the direct effect on variable i from variable j). The curved bidirectional arrow represents the correlation between the exogenous variables not analysed within the model, and the value shown is the zero order correlation coefficient, r.

In the algebraic representation of the model, each variable is in standard form and each dependent variable is treated as completely determined by some set of other variables in the model, including as necessary the residual effects of unmeasured variables, represented by the R_i in the diagrams. Thus, for figure I there would be only one equation:

$$Y = p_{yx_1}X_1 + p_{yx_2}X_2 + p_{yu}R_u \qquad (2)$$

For figure II, there would be two equations, one for Y exactly as presented in equation (2) and one for X_2:

$$X_2 = p_{x_2x_1}X_1 + p_{x_2v}Rv \qquad (3)$$

To understand the nature of the interrelationships among the variables and the difficulty of partitioning R^2, it is instructive to solve for the path coefficients in terms of the observed correlations among the variables.[63] Since the variables are in standard form:

$$r_{x_2y} = \frac{\Sigma X_2 Y}{N}$$

and substituting for Y in equation (2) yields:

$$r_{x_2y} = \frac{1}{N}\Sigma X_2(p_{yx_1}X_1 + p_{yx_2}X_2 + p_{yu}R_u)$$

$$r_{x_2y} = p_{yx_1}r_{x_1x_2} + p_{yx_2} \qquad (4)$$

since $\frac{\Sigma x_1 x_1}{N} = 1$, and $r_{x_2}R_u = 0$, on the assumption that the residual effects are uncorrelated with the exogenous variables.

The same process applied to r_{x_1y} yields:

$$r_{x_1y} = p_{yx_1} + p_{yx_2}r_{x_1x_2} \qquad (5)$$

For figure I, since only equation (2) is involved, one is able to see from equations (4) and (5) how the model generates the observed correlations. Equation (4) shows that the correlation between Y and X_2 is made up of the direct effect of X_2 on Y given by p_{yx_2} and by a joint effect it shares with X_1, that is, an effect arising from the correlation of X_2 with another cause of Y, namely, X_1. This effect is represented by the first term on the right side of equation (4). Similarly, the observed correlation between X_1 and Y can be seen to be the sum of a direct effect of X_1 on Y plus a joint effect of the type just described.

The proportion of variance in Y accounted for by X_1 and X_2 can be expressed in terms of the same notation as:

$$R^2 = p^2_{yx_1} + p^2_{yx_2} + 2p_{yx_1}p_{yx_2}r_{12}$$

From this, it can be seen that there are three components of the explained variance: those due to X_1, to X_2, and to X_1 and X_2 jointly. Thus, a decomposition of the explained variance into a portion attributable to X_1 and a portion attributable to X_2 is not possible.[64] (It is also true that:

$$R^2 = p_{yx_1}r_{yx_1} + p_{yx_2}r_{yx_2}$$

but this does not provide the desired decomposition as either of the terms can be negative and it has been shown in equations (4) and (5) that the two correlations include joint effects.)

For figure II, there is the additional relation represented by equation (3). The same algebra as used in the preceding paragraph provides for this equation the result that the path coefficient is simply the zero-order correlation:

$$r_{x_1x_2} = p_{x_2x_1} \qquad (6)$$

Substituting for $r_{x_1x_2}$ in equations (4) and (5) gives:

$$r_{x_2y} = p_{yx_1}p_{x_2x_1} + p_{yx_2} \qquad (7)$$

$$r_{x_1y} = p_{yx_1} + p_{yx_2}p_{x_2x_1} \qquad (8)$$

Though no values have changed, the interpretation of the situation is different. Looking first at equation (8) along with figure II, the correlation between X_1 and Y is seen to be due to the direct effect p_{yx_1}, and the indirect effect by means of X_2 represented by the second term on the right. Equation (7) and figure II reveal that the correlation between X_2 and Y consists of the direct effect p_{yx_2} and a component of correlation due

"The method of path coefficients", *Annals of Mathematical Statistics,* vol. 5, No. 3 (September 1934), pp. 165–215; Otis Dudley Duncan, "Path analysis: sociological examples", *American Journal of Sociology,* vol. 72, No. 1 (July 1966), pp. 1–16; D. Heise, "Problems in path analysis and causal inference", in Edgar F. Borgatta, ed., *Sociological Methodology, 1969* (San Francisco, Jossey-Bass, 1969), pp. 38–73. An application in terms of an areal multivariate analysis of family planning programme effects is given in Albert I. Hermalin, "Regression analysis of areal data", in C. Chandrasekaran and Albert I. Hermalin, eds., *Measuring the Effect of Family Planning Programs on Fertility* (Liège, International Union for the Scientific Study of Population for the Development Centre of the Organisation for Economic Co-operation and Development, 1975), pp. 245–300.

[63] Under the assumption used here that the exogenous variables in each equation are uncorrelated with the residual term, the path coefficients are equal to the standardized partial regression coefficients, the beta coefficients, obtained from the ordinary least-squares solution of each equation.

[64] O. D. Duncan, "Partials, partitions, and paths".

to the fact that X_2 and Y are both affected by common cause, X_1.

Thus, a given set of observed correlations which yields a particular solution for the partial regression coefficients of equation (1) can be interpreted as arising, in one case, from direct and joint effects; or, in the other, from direct, indirect and effects due to a common cause, depending upon the system of interrelationships assumed to hold among the variables.[65]

Figure II also allows some additional perspective on partitioning the explained variance, though it does not permit of a unique decomposition. It can be shown[66] that:

$$R^2 = r^2_{yx_2} + p^2_{yx_1}(1 - r^2_{x_1x_2}) \quad \text{or} \qquad (9)$$

$$R^2 = r^2_{yx_1} + p^2_{yx_2}(1 - r^2_{x_1x_2}) \qquad (10)$$

Equation (9) expresses R^2 as the total effect due to the programme variable (X_2) including that transmitted from the non-programme variable (X_1), plus an increment due to including X_1. Equation (10) expresses R^2 as the total effect arising from the most remote cause X_1, and an increment gained by including the intervening variable X_2.

In the foregoing sections, the problems of correlation between independent variables have been treated within the context of a linear additive model represented by equation (1). In such a situation, it is possible to obtain estimates of the direct effect of each variable, represented essentially by the partial regression coefficients, even though it is not possible to partition the explained variance and the interpretation of the interrelationships will depend upon the underlying model posited, as illustrated by figures I and II.

In some situations, however, there may be so-called "interaction effects", whereby the effect of one variable depends on the level of a second variable. This might be the case, for example, where the effect of a family planning programme is different across countries, or in different areas within a country, depending upon the level of socio-economic development. This situation may be interpreted as an example of a particular effect arising from the presence of both explanatory variables that is not simply the sum of their independent effects. Thus, an additive model no longer is applicable. Often a regression analysis of such a model will employ an equation of the following type:

$$Y = a + b_1 X_1 + b_2 X_2 + cX_1 X_2 + e \qquad (11)$$

This equation assumes that there are independent effects plus an interaction effect captured by the simple multiplicative term. In some cases, the interaction effect will be better represented by other than a simple cross-product. Whether a model of the type represented by equation (11) is to be preferred to that of equation (1) can be tested by noting whether the additional variance explained is significant. Where interaction is present, the ability to partition effects in the sense of equation (1) is no longer possible.

The problems treated in this section are, of course, directly relevant to the application of regression analysis to the study of family planning effects. They also enter into other evaluation techniques. For example, in the decomposition or standardization approach, if one attempts to decompose a change in crude birth rate into components on the assumption that the factors remained constant as of the initial date, one or more components representing correlation of change across factors may be needed to account fully for the observed change in crude birth rate.[67] More generally, in the standardization approach, the question of the independence of factors, often assumed, should be explicitly considered.

The logic of this section should also prove helpful in analysing key concepts in evaluation, such as the way socio-economic variables and the family planning programme influence motivation to accept, or the possible influence of the programme on adoption of private means of contraception. This section may also be relevant in analyses that seek to determine the nature of and interrelationships among factors associated with such important parameters as the probability of secondary sterility or the length of post-partum amenorhoea.

Uncontrolled variables

The problem of uncontrolled variables arises when one or several factors that are important in the understanding of variations in a variable under study have not been taken into consideration. The reasons for such short-comings vary. A major reason is, of course, that social phenomena are complex and often not well understood, so that one cannot identify all relevant determinants or the relevancy of certain determinants is imperfectly known. In other cases, it may not be possible to apply a particular evaluation method to as many variables as would be desired or to certain types of factors (for example, qualitative variables); or the method may not deal satisfactorily with certain categories of variables (such as biological factors). Lastly, variables may be excluded simply because the required data are not available. The omission of one or more variables from a model is referred to as "specification error". This term also refers to the situation, illustrated in the previous sections, of an incorrect

[65] Other possible arrangements of the three-variable case and analysis of four-variable systems are given in O. D. Duncan, "Partials, partitions, and paths"; and *idem, Introduction to Structural Equation Models* (New York, Academic Press, 1975).

[66] O. D. Duncan, "Partials, partitions, and paths", pp. 41–42.

[67] Evelyn M. Kitagawa, "Components of a difference between two rates", *Journal of the American Statistical Association*, vol. 50, No. 272 (December 1955), pp. 1178–1179.

temporal or causal arrangement of the variables included in the model or of an incorrect functional form.

Conceptually akin to specification error is the problem of errors in measurement and of unobserved variables. If a variable is incorrectly measured, then in a sense that variable is not properly controlled in the model and the desired variable is unobserved. The term "unobserved variables" is also used for the situation where the underlying concept is more highly abstract and measurements relevant to the concept are regarded as indicators rather than operational definitions.[68]

A simple example of the effect of omitting a variable can be illustrated with reference to the equations in the preceding section. Assume that in equation (1) the non-programme variable, X_1, is omitted and one is interested in the possible effects of this omission on the estimated effect of the programme variable X_2. If X_2 is uncorrelated with X_1, then the regression coefficient for X_2 is unaffected by the omission of X_1. On the other hand, if the two variables are correlated then the estimate of the effect of X_2 is biased and its regression coefficient may be larger or smaller when X_1 is included in the equation. The strategy suggested for studying the effect of omitted variables is to counterpose against the model being used a competing "true" model and to trace out the differences between the models and their consequences.[69]

Various aspects of measurement error have been discussed above and therefore are not further pursued here. The point worth noting in the light of the discussion in this and the previous section is that no study of the effects of measurement error is possible without assumptions about their nature. In sum, models of error should be incorporated into the substantive models in order to improve the inferential process.

One strategy for dealing with abstract concepts which do not lead to a single operational definition is to regard various observations as indicators or manifestations of the unobservable variable. Under certain conditions, developments in causal modelling permit inferences about the unobservable variable to be made on the basis of the behaviour of their indicators.[70] These developments appear relevant to problems in family planning evaluation in that certain key concepts, such as modernization or programme inputs, might be regarded as unobservables for which there are multiple indicators.

[68] H. M. Blalock, Jr. "Making causal inferences for unmeasured variables from correlations among indicators", *American Journal of Sociology*, vol. LXIX, No. 1 (July 1963), pp. 53–62.

[69] The application of this strategy to more complex models is given in O. D. Duncan, *Introduction to Structural Equation Models*, pp. 101 ff.

[70] Philip M. Hauser and A. S. Goldberger, "The treatment of unobservable variables in path analysis", in Herbert L. Costner, ed., *Sociological Methodology, 1971* (San Francisco, Jossey-Bass, 1971), pp. 81–117; and O. D. Duncan, *Introduction to Structural Equation Models*, pp. 129 ff.

Independence of method

The multiplicity of evaluation techniques arises in part from the complexity of the relationships involved in analysing fertility and in part from the type, amount and quality of data available for the purpose of evaluation. Some techniques focus on certain dimensions of the problem and certain categories of data while other techniques have different foci. Since the country studies will reveal the results of applying different techniques to the same setting, it is important to consider the possible outcomes of multiple application.

There are a large number of combinations of possible outcomes from the application of two or more techniques, and no attempt is made here to enumerate them all. For example, if two techniques differ in their implications of programme effect, both may be tenable because they differ in coverage or the dimension of the problem being analysed. Or it may turn out that the data associated with one method are much more unreliable than that of another. A third possibility, of course, is that the results differ because of differences in basic assumptions, and it then remains to determine whether there is any evidence to support the plausibility of one set of assumptions as against the other.

If two techniques agree in their implication of programme effect, by how much are the conclusions strengthened as against having just one of the results? The question may be conceptualized as one of independence of methods. If the methods overlap considerably so that the results obtained by one technique are largely constrained to parallel those from the other, then relatively little is gained. On the other hand, if the methods were viewed as largely independent, one would interpret agreement of results from each method as strengthening the particular conclusion. The question thus resolves itself into determining the degree of independence among the several evaluation techniques.

Intuitively, two methods may be viewed as independent if they utilize different frames of reference in assessing programme impact. What is needed, however, is a set of rather specific criteria which can be applied uniformly by different investigators to assess the relative distinctness of each method. This is clearly a complex question which is likely to engender considerable discussion in the review of the country studies. The criteria listed below are designed to facilitate such discussion without attempting to reach any conclusion on this important issue:

(*a*) Number and type of assumptions utilized by each technique: how independence of assumptions can be analysed;

(*b*) Type of factors utilized: demographic *versus* biological etc.;

(*c*) Type of estimating technique employed: standardization *versus* regression *versus* projection etc.;

(*d*) Direct *versus* indirect measurement of programme effect: some techniques assess programme effect as a residual, while others obtain an estimate of effect directly from programme factors;

(*e*) Coverage: whether a method that focuses on over-all fertility change is independent of a method that utilizes only data on acceptors.

The mere enumeration of several possible criteria illustrates the difficulty of the problem. Within any one criterion there must be further specification of how differences across techniques is to be analysed. Following this, consideration must be given to the degree of overlap across criteria. Are all the criteria listed, and possibly others, required to assess independence of methods or would a small subset suffice?

Cost-precision analysis

The problem of cost-precision analysis is not specifically a methodological issue. The selection of one or several programme evaluation methods constitutes the first step in family planning programme evaluation. In light of the cost and objectives of programme evaluation and the limited resources available for the exercise, evaluators should determine which approach would yield the highest return in terms of quality of results. As quality of results is highly dependent upon the precision obtained, the problem is one of balance between method precision and cost.

In dealing with this problem, the first assumption is that the precision of the method is known, or can be determined or assessed. The second assumption is that some criteria can be worked out to assess the precision required. Depending upon the purpose of the evaluation, greater or less precision may be needed. The third assumption considers that the cost of an evaluation undertaking can be assessed fairly well. Another assumption is that a methodology exists or can be worked out to undertake the cost-precision trade-off that would give the evaluator a means of selecting the evaluation method or methods that would yield the greatest precision for a given amount of expenditures. These four assumptions are examined below.[71]

Precision of method

The meaning of precision is to be understood here as the magnitude of the errors that may accompany measurements of programme impact on fertility. Method precision depends chiefly upon the data-gathering process and the estimating techniques involved. In some cases, the concept of precision is well established. In probability sampling, for example, precision means the difference beteen the sample results and the results that would have been obtained from a complete enumeration under similar over-all conditions. This means that biases present in both sample and total enumerations would not be revealed by standard statistical techniques for measuring error.

The field of sampling error has been widely investigated, and the determination and assessment of sampling error can be undertaken in varying circumstances. Errors may be reduced by manipulating sampling design, although it is not worth while to engage in complex sampling techniques when non-sampling errors are suspected to be large. The contribution of standard confidence intervals to appraisal of precision needs no comment, and both the standard deviation and the mean square error are also indicators that can be utilized in assessing method precision. In applying evaluation methods, loss of precision can occur at various stages. A major source of error is, of course, that which occurs at the data-gathering stage. But errors and imprecise results can also occur as a consequence of erroneous application of the method (e.g., assumptions not met), of model simplifications (e.g., omission of important variables), use of unsatisfactory indicators (e.g., unstandardized crude birth rates) etc.

The problem of method precision is, therefore, not only inherent in the method itself but inherent in its proper application. In order to assess method precision, one should assume that the method is properly applied. A discussion on method precision might also treat the problems of random errors and non-random errors separately, except when their combined effect can be examined in terms of mean square error. In some cases, direct measurement of precision cannot be accomplished, but experience can provide information on the existence and the direction of certain types of errors.

Due to the novelty of the field of family planning programme evaluation, there have not been thorough studies of over-all precision of the evaluation methods.

Precision required

The precision required from a particular evaluation depends chiefly upon the objectives of the exercise. If only a rough approximation is needed for, say, a specific administrative purpose, a method that would give only a trend direction or an order of magnitude of the change might suffice. If, on the other hand, the evaluation is directed to obtaining a precise measurement of fertility change, to assess the role of a new programme component (a new contraceptive, for instance), a different method with a more specific and precise outcome would be needed. The precision required is thus a function of both the known precision of the various methods and the objectives of the evaluation. It is the judgement of the administrators of the programme and the evaluators that will decide this question, which implies, of course, that there is some criterion for determining an "acceptable" margin of error with respect to a given evaluation objective. For instance, the standard deviation of a sample estimate could be selected so that the sample estimate would permit detection, with relative certainty, of a 3 per cent change or more.

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[71] It is also often implicitly assumed that the more precise the results required, the more expensive the evaluation undertaking. This assumption, not discussed here, may often be misleading.

Cost of evaluation

Determining the cost of evaluation is mainly an accounting problem. Evaluation expenditures will, of course, depend upon the type of data-gathering procedure, the data available and data to be collected, geographical circumstances of the area under study, qualification of evaluation personnel, equipment etc. For methods using sample data, once the amount of precision is chosen and the associated probability decided, a sample design can be worked out and its cost assessed. To this cost must be added the additional expenditures for data processing, analyses etc. In brief, information on all costs associated with the application of a particular method must be available or hypothesized.

Cost-precision trade-off

If the cost of applying a given method is acceptable, the evaluation can, of course, be undertaken as planned. If the cost is not acceptable, some balancing of precision against cost must be considered. In this respect, it appears that the basic questions to answer are:

(*a*) What are the advantages of obtaining the precision required?

(*b*) What are the disadvantages of settling for less precision?

(*c*) What is the differential cost of settling for the higher or the lesser degree of precision?

The most important item in considering these questions appears to be the purpose of the evaluation. If the results of the evaluation cannot be utilized as planned because of lack of precision, then the evaluation should not be undertaken unless more funds can be made available. For instance, if programme administrators wish to identify, say, a 5 per cent change in fertility over a given period of time, they might need a very large sample, which might be a very expensive undertaking. Depending upon the purpose of the evaluation study, administrators may consider that some relaxation in precision would not invalidate the results, or that a reduced sample which would identify only an 8 per cent fertility change would still provide useful information. Such decisions can be made in light of the basic questions listed above and can be based on intuitive judgement of the known evaluation conditions.

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APPLICATION OF METHODS OF MEASURING THE IMPACT OF FAMILY PLANNING PROGRAMMES ON FERTILITY: THE CASE OF KARNATAKA STATE, INDIA*

*K. Srinivasan***

Introduction

Methods of measuring the impact of family planning programmes on fertility have been developed only relatively recently, mostly within the past 15 years. This is because family planning programmes, as endeavours organized directly by Governments or with the support of governmental agencies, are of recent origin; nearly all of them have been implemented within the past two decades. India has the distinction of having been the first Government to formulate a demographic goal and to implement a family planning policy, having taken this step as early as 1951 in conjunction with its first five-year developmental plan. The 1960s and early 1970s witnessed the launching of national programmes of family planning by an increasing number of countries; and as of mid-1975, 63 countries of the world had national programmes of family planning run by governmental departments or by voluntary agencies supported by the Governments.[1]

Most of these countries with national programmes of family planning have also stipulated demographic goals in terms of specified reduction in population growth rates or crude birth rates within a given period of time. They have also set targets of family planning acceptors to be recruited by the programme. The acceptor targets are usually selected so as to be consistent with the desired demographic goal, though considerations of operational feasibility are also taken into account. In general, family planning programmes are looked upon as the prime movers in reducing fertility rates and crude birth rates to desired levels. However, in recent years, especially after the World Population Conference held in Bucharest in August 1974, it has been increasingly questioned whether family planning programmes in fact have been the major instruments for altering fertility patterns, though they might have influenced the marital fertility rates. The crude birth rate in any population is the result of the interactions between numerous demographic, social and biological factors. In the context of the modernization process that is currently taking place in many developing countries, these factors are themselves undergoing change. In such circumstances, the problem of determining the extent to which family planning programmes have contributed to fertility change assumes a crucial significance, both as an interesting area of scientific inquiry and because guidelines are needed as to the effectiveness of further investment and support by Governments and international agencies in family planning programmes vis-à-vis other measures which can also be expected to influence fertility.

The methods for measuring the fertility effects of family planning programmes vary widely in their conceptual schemes, complexity, assumptions involved, data requirements and estimation procedures. Consequently, it can be expected that application of different methods to the same situation may yield different results. In cases where the application of different methods to the same population or geographical area gives similar results, faith in the result is reinforced and the validity of the findings increased. On the other hand, when different methods are applied to different populations; or, for example, if the area in question has been affected by large-scale in- or out-migration, considerable caution has to be exercised in interpreting the validity of the results. A detailed analysis of the results obtained from the application of various methods to the same population can be expected to throw light on the strengths and limitations of various methods, the validity of results obtained and the applicability of a method under different levels of data availability and reliability; and to suggest, one hopes, the nature of future research in this direction.

Objectives of the study

The present study was undertaken at the request of the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, as one of three country studies on the application of the methods of measuring the effect on fertility of family planning programmes. The country studies were commissioned with a view to identifying:

(*a*) Problems that arise when an evaluation method is put to use in specified circumstances;

(*b*) Comparison of the results obtained by the different methods and an analysis of the probable reasons for whatever differences are found to exist.

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[1] Dorothy Nortman, *Population and Family Planning Programs: A Factbook*, Reports on Population/Family Planning, No. 2, 7th ed. (New York, The Population Council, 1975).

The emphasis of the country studies is, therefore, primarily on the problem areas of method application and on the comparative validity of the results.

The United Nations Secretariat has categorized the currently available methods as follows, recognizing the fact that they are neither mutually exclusive nor completely comprehensive: (*a*) standardization approach; (*b*) trend analysis (fertility projection approach); (*c*) experimental designs; (*d*) couple-years of protection; (*e*) component projection approach; (*f*) analysis of the reproductive process; (*g*) regression analysis (including path analysis); (*h*) simulation models.

A succinct description of each of the above-mentioned methods is given in the background paper[2] prepared by the United Nations Secretariat and hence is not attempted in this paper. This article presents the problems, results and comparative analysis of the findings obtained from the application of different methods to the population of Karnataka State in India for the period 1961–1971. That period was chosen primarily because the most recent population censuses in India were conducted in March 1961 and April 1971, and data on population structure and demographic characteristics could be obtained from those two censuses. Also, the period 1961–1971 witnessed intensified family planning activity in the state, and the results of the application of different methods would cast considerable light on the effect of the programme of family planning on fertility. Although the period of study was chosen to provide maximum advantage from the point of view of data availability, certain essential information could not be obtained and those data which were available were of poor quality. These were major problems faced at every stage of analysis.

One of the consistent findings observed in this case study was that the current methods of assessing the impact of programmes on fertility call for a wide range of information on the population as a whole, not just the people who come into contact with the programme; and changes in these population characteristics over time impede the effective application of these methods in developing countries. All methods, except experimental designs (in which a programme is introduced into one [the experimental] unit and withheld from a matched [control] unit, and results between the two are compared over time), serious assumptions on the dynamics of the base population appear necessary and unless steps are taken to validate these assumptions on the basis of empirical evidence, results obtained from the application of the methods may be misleading. Before proceeding with actual application of the methods to the evaluation, it appears appropriate to describe briefly the population and the programme taken for analysis in this case study.

[2] "Methods of measuring the impact of family planning programmes on fertility: problems and issues" (ESA/P/AC.7/1). See part one of the present publication.

The study area and the programme

Area and the people

The State of Karnataka was formed in November 1956 by the States Reorganisation Act passed by the Indian Parliament in that year, integrating five subregions, Bombay-Karnataka, Old Mysore, Hyderabad-Karnataka, Madras-Karnataka and Coorg, on the basis of the fact that the language spoken by the majority of the population in each of those subregions was Kannada. After the integration, for administrative purposes, the state was divided into four divisions, Bangalore, Mysore, Belgaum and Gulbarga, which were further subdivided into 19 districts, the first two divisions having five and six districts, respectively, and the last two having four districts each. Though the language of Kannada is a unifying element among all the subregions, there are significant differences in the socio-economic conditions of the population in the five subregions.

The total land area of the state is 190,000 square kilometres and the enumerated population in the 1971 census was 29.3 million. The state ranks sixth among the states in India, in terms of land area, and eighth in terms of population, having 5.4 per cent of the population of the country as a whole. About 7.1 million people, or 24 per cent of the total population of the state, live in urban areas (defined as habitation clusters with more than 5,000 population); and one third of this population lives in the three metropolitan cities of Bangalore, Mysore and Hubli-Dharwar. According to the 1971 census, the crude literacy rates (a literate is defined as a person able to read and write in one language) was 31.5 per cent and only slightly higher than the national average of 29.5 per cent. The proportion of the workers aged 15–59 engaged in non-agricultural activities was 31.2, compared with 24.4 per cent in the country as a whole. A low level of living and income characterize the economy of the state. In 1968–1969, about 95 per cent of the households in the rural areas and 90 per cent of those in urban areas lived on a monthly expenditure of less than Rs 120/– (about $15). For the country as a whole, this figure was around Rs 100/– ($12). Thus from the point of view of extent of urbanization, level of literacy and economic condition, the state is almost at the average level in India, with conditions marginally better than the average.

The population of the area presents a wide diversity of social and cultural patterns within the Indian context. The people in the Bombay-Karnataka subregion, which was part of Bombay presidency before the states were reorganized, follow the traditions and cultural habits of Maharashtrians, and are closer to the northern Indian culture. The people of the subregion of Hyderabad-Karnataka, which was part of the Islamic princely state of Hyderabad before 1956, have been influenced considerably by the Islamic culture and a dominance of northern Indian style of living. The people of Old Mysore and Madras-Karnataka, which constitute about 60 per cent of the population of the state, follow the traditions and cultural values of southern India in dress, eating habits, art and music. The people of the subregion of Coorg, which was centrally administered prior to 1956, had been westernized in their living style owing to their close association with the British over a considerable period of time prior to independence and are more modern in their outlook and habits than the other four subregions. For the state as a whole, 86.5 per cent of the population are Hindus, 10.6 per cent are Moslems, 2.1 per cent are Christians and the other 0.8 per cent adhere to a variety of other religions. However, the religious composition of the population varies slightly from subregion to subregion. The proportion of Moslems in Hyderabad-Karnataka is 15.9 per cent, whereas in Mysore-Karnataka, it is only 8.1 per cent. Similarly, in terms of languages spoken by the population, a significant proportion of the population (22.1 per cent) know, in addition to Kannada, one or more of the languages Tamil, Telugu, Marathi, Urdu and Hindi; but in India as a whole, bilingualism is only 10.1 per cent. Thus, in all aspects, the state is one of the most cosmopolitan in India, with an intermixture of cultural patterns of the south and the north, different religious groups and languages.[3] Summary profiles of the population and the socio-economic characteristics of the state, and of the country as a whole for comparative purposes, are given in table 1.

Population growth

At the censuses of 1971, 1961 and 1951, the inhabitants of the state numbered, respectively, 29.3 million, 23.6 million and 19.4 million (adjusted for the present area). The average annual growth rate during 1951–1961 was 1.96 per cent; during 1961–1971, it was 2.15 per cent. For the country as a whole, the growth rates during the two decades were, respectively, 1.78 and 2.40 per cent. Thus, although Karnataka had a higher growth rate than the national average in 1951–1961, it had a lower than average growth rate in 1961–1971. The reason for this is that the state had achieved a much lower death rate in 1951–1961 than the rest of the country; and although the death rate declined only marginally during the 1960s, the birth rate also began its downward trend. In any year, both the birth and death rates were lower than the national average. The 1950s and 1960s were characterized by marked improvements in medical and public health care for the people through the implementation of national programmes for eradication of malaria, plague and smallpox, and through considerable progress in the organization of primary health centres in rural areas. There was a considerable increase in the number of medical and paramedical personnel employed per thousand population during those two decades. Though these improvements in preventive and curative programmes were executed as a part of the national strategy in all the states of India, Karnataka State had a greater ability to absorb the benefits of the programme even in the 1950s, because of a better developed pre-existing health infrastructure, availability of training institutions for the supply of medical and paramedical personnel and better conditions in terms of communication and over-all development. Consequently, the death rates in the state had always remained lower than the national average. The rate of decline in the death rate during 1951–1961 was also higher than the national decline. In short, the state had always lower birth and death rates than the average figures prevailing in the country; and since 1960, the state growth rates have been less than those for the country as a whole.

Reliable data on fertility, mortality and migration in Karnataka State are not available. The registration of births and deaths is grossly deficient both in coverage and in quality, under-registration amounting to nearly 50 per cent. Consequently, the data from the registration system cannot be used for any analysis of levels and trends in fertility and mortality.

A more reliable source of information on birth and death rates is the Sample Registration System[4] operated by the Government of India throughout the country. A second source for obtaining data on vital rates is the National Sample Survey conducted by the Government of India at periodic intervals. These are multipurpose surveys which include questions on income, expenditure occupation etc. on a sample of households in rural and urban areas; and in a few selected rounds, data on fertility and mortality have also been compiled. The information on birth rates, gross reproduction rates and death rates compiled from available data from the Sample Registration system and the National Sample Survey for rural and urban areas of Karnataka State are provided in table 2.

From table 2, it may be seen that the birth rates in rural Karnataka fell from 40.3 in 1958–1959 to 32.8 in 1972; the death rate dropped from 15.4 to 14.3 during the same period. The figures on birth and death rates computed from the Sample Registration Scheme from 1966 onward show considerable annual fluctuations and it is hard to discern any trends from these rates. This may be due in part to the inherent deficiency in the scheme itself, possibly in matching births obtained from the survey and registration or omission of some events in both the sources, and possibly due also to a real fluctuation in the fertility and mortality levels of the population. This point needs further analysis and is dealt with separately in relevant subsections of this paper.

Family planning programme

As early as 1930, two official family planning clinics were opened in Karnataka by the Government, one at

[3] D. M. Nanjudappa, *Surplus Rural Manpower and Economic Development in Mysore* (Dharwar, Karnataka University, 1968).

[4] India, Registrar General, Vital Statistics Division, *Measures of Fertility and Mortality in India,* Sample Registration System Analytical Series, No. 2 (1972).

TABLE 1. KARNATAKA STATE, A POPULATION PROFILE IN COMPARISON WITH INDIA AS A WHOLE, 1971

Cultural subregion	*Number of districts*	*Population (thousands)*	*Density per square kilometre*	*Literacy rate (literates per 100 population)*			*Percentage urban population*	*Religion*				*Per capita income (rupees)*	*Percentage of population able to speak a language other than their mother tongue*[a]	*Percentage of labour force aged 15-19 engaged in non-agricultural activities*
				Persons	*Male*	*Female*		*Hindu*	*Moslem*	*Christian*	*Other*			
Central Karnataka	1	380	92	44.3	50.2	37.8	15.5	84.6	12.0	3.4	0.0	1 218	32.8	28.8
Madras Karnataka	2	3 060	167	36.7	45.9	27.7	22.8	81.1	12.0	6.4	0.5	636	33.1	36.7
Hyderabad Karnataka	3	3 980	112	19.5	29.9	8.9	16.2	82.3	15.9	1.6	0.2	538	17.8	25.6
Bombay Karnataka	4	7 600	139	33.4	45.4	20.8	23.8	84.9	12.0	1.0	2.1	463	17.7	28.8
Mysore Karnataka	9	14 280	180	32.4	41.7	22.6	27.4	89.7	8.1	1.8	0.4	544	23.1	32.8
All Karnataka	19	29 300	153	31.5	41.6	21.0	24.3	86.5	10.6	2.1	0.8	540	22.1	31.2
All India	356	547 950	167	29.5	39.5	18.7	19.9	82.7	11.2	2.6	3.5	530	10.1	24.4

Source: Unless otherwise noted, data are from the 1971 population census.

[a] Data from 1961 census.

Note:

Geometrical growth rate

Period	*Karnataka State*	*India*
1951-1961	1.96	1.78
1961-1971	2.15	2.40

TABLE 2. FERTILITY AND MORTALITY LEVELS, 1958-1972

	Index year									
	1958-1959[a]	*1960-1961*[b]	*1963-1964*[c]	*1966-1967*[d]	*1967-1968*[d]	*1968*[d]	*1969*[d]	*1970*[e]	*1971*[e]	*1972*[e]
Birth rate *(live births per 1,000 population)*										
Rural	40.3	...	35.59	33.01	34.5	33.7	34.1	35.0	34.6	32.8
Urban	...	33.59	31.81	...	...	29.8	28.9	27.8	25.3	28.0
					(Based on half year)					
Combined	...	...	...	...	...	...	...	33.0	31.7	31.5
Gross reproduction rate										
Rural	2.5	...	...	...	...	2.18[f]	2.27[f]	...	2.2[d]	2.2[d]
Urban	...	2.23	...	...	...	...	...	...	1.48[d]	1.75[d]
Combined	...	...	...	...	...	...	...	...	...	...
Death rate *(per 1,000 population)*										
Rural	15.4	...	10.79	14.3	14.5	13.3	15.4	14.2	14.0	14.3
Urban	...	8.20	7.70	...	...	9.0	9.5	10.3	7.2	8.7
					(Second half)					
Combined	...	...	...	...	...	...	...	13.1	12.1	12.8

[a] A. K. De and R. K. Som, *Fertility and Mortality Rates in India, Fourteenth Round, July 1958-June 1959,* National Sample Survey, Report No. 76 (New Delhi, Cabinet Secretariat, 1963).
[b] India, Cabinet Secretariat, *Tables with Notes on the Fertility and Mortality Rates in Urban Areas of India, Sixteenth Round, August 1960-July 1961,* National Sample Survey, Report No. 180 (New Delhi, 1971).
[c] India, Cabinet Secretariat, *Tables with Notes on Differential Fertility and Mortality Rates in India, Eighteenth Round, February 1963-January 1964,* National Sample Survey, Report No. 175 (New Delhi, 1970).
[d] Karnataka State, Bureau of Economics and Statistics, *A Report on the Sample Registration System in Karnataka, 1971-1972,* Sample Registration System Report Series, No. 1 (1974).
[e] India, Registrar General, Vital Statistics Division, *Sample Registration Bulletin,* vol. 9, Nos. 1 and 2 (January and April 1975).
[f] India, Registrar General, Vital Statistics Division, *Measures of Fertility and Mortality in India,* Sample Registration System Analytical Series, No. 2 (New Delhi, 1972).

Vanivilas hospital at Bangalore and the other at Cheluvamba hospital at Mysore. These clinics were set up with the objective of providing family planning advice to couples for the purposes of spacing. Prior to the 1950s, family planning services were provided as a part of social service to women to enable them to have babies by choice and not by chance, and to reduce the incidence of illegally induced abortion and its consequent ill effects. During the first five-year plan in 1951–1956, the family planning programme was introduced as a part of the government policy to achieve not only social welfare goals but the demographic objectives of reducing the birth rates to certain desired levels. There was a shift from viewing family planning as a purely social welfare measure for the protection of the health and well-being of women to a national demographic policy or fertility control measure.

In Karnataka State, as a part of the First Five-Year Plan, a family planning training centre was set up at Ramanagaram in 1952; and in the subsequent years, a number of family planning clinics were opened. The allotment of national funds to the programme increased dramatically from plan to plan: although only Rs. 580,000 were spent on the programme during the Second Five-Year Plan (1956–1961), the amount increased to Rs. 6,630,000 during the third plan and to Rs. 73,470,000 in the fourth plan (1966–1971). The expenditure in the programme during the year 1974/75 was Rs. 22.0 million. During 1962/63, in the third plan period, there was a change of strategy in the programme from one of clinic approach to extension approach. Under the latter method, the message of family planning was to be carried to every eligible couple, and the contraceptive services were to be provided in a socially and psychologically acceptable manner.

Accordingly, there were increased investments in personnel, and the number of family planning acceptors through programme channels also increased steadily. As of 31 March 1975, there had been approximately 450,000 vasectomies, 295,000 tubectomies, 315,000 insertions of intra-uterine devices (IUDs) and 401,000 users of conventional contraceptives, such as condoms and diaphragms.[5] Data on the annual numbers of acceptors of family planning methods in the state during the period 1956–1974 are given in table 3.

DATA FOR THE STUDY

General data problems

The data needed for the application of the different methods of measuring the impact of family planning programmes on fertility can be categorized under the following four headings:

(1) Population structure, including age, sex, marital status distributions and changes in these distributions over time during the period of analysis;

[5] Karnataka, State Family Planning Bureau, Directorate of Health and Family Planning Services, *Family Planning Programme in Karnataka: Progress at a Glance* (1975). For additional information, see R. N. Bhaskar, *Family Planning in Karnataka* (Bangalore, Institute for Social and Economic Change, 1975).

TABLE 3. FAMILY PLANNING ACCEPTORS THROUGH PROGRAMME SOURCES, BY METHOD, 1956-1974

Year	Number of acceptors of sterilization: Vasectomy	Tubectomy	Total sterilizations	Intra-uterine device insertions	Estimated users of conventional contraceptives
1956	853	725	1 578	...	...
1957	920	996	1 916	...	...
1958	567	765	1 332	...	...
1959	953	791	1 744	...	...
1960	1 434	990	2 424	...	...
1961	2 535	1 143	3 678	...	...
1962	4 282	1 592	5 874	...	...
1963	8 254	1 843	10 097	...	...
1964	17 783	3 267	15 050	...	...
1965	17 695	3 219	20 914	57 079	...
1966	41 355	2 602	43 957	84 750	25 684
1967	89 729	5 666	95 395	52 820	35 523
1968	86 877	9 748	96 625	25 092	39 817
1969	40 459	19 200	59 659	14 718	44 122
1970	17 387	29 873	47 260	10 732	47 901
1971	12 548	41 723	54 271	11 326	46 302
1972	68 947	51 185	120 132	12 898	47 300
1973	35 075	49 941	85 016	11 430	46 947
1974	7 595	52 244	59 839	11 530	49 699

Source: Karnataka, State Family Planning Bureau, Directorate of Health and Family Planning Services, *Family Planning Programme in Karnataka: Progress at a Glance* (1975).

(2) Fertility and mortality levels and trends in age-specific fertility rates and life-table values, annually, for the period under investigation. Information on the fertility levels prevailing prior to the commencement of the programme is also needed for estimation of potential fertility;

(3) Annual numbers and characteristics of family planning acceptors within the programme and outside it, from the beginning of the programme through the period of analysis. The characteristics include method of acceptance, age parity distribution at the time of acceptance, age/method-specific continuation rates, use-effectiveness of methods and fertility rates of the acceptors that would have prevailed in the absence of contraception. Data are also needed on the overlap of periods of post-partum amenorrhoea with contraceptive use, incidence of secondary sterility, extent of substitution of methods and extent of acceptance and use of traditional and non-traditional family planning methods obtained outside of the programme;

(4) Information on the social and economic characteristics of the population is also needed for control in the analysis. Such factors as levels of urbanization, literacy rates; proportion of population, especially women, employed in non-agricultural activities; and income have been found to be strongly associated with fertility differentials among groups; and to the extent to which the analysis of the relationship of programme acceptance to fertility can control for these factors, it governs the extent to which the net effects of the programme can be assessed.

The data available for Karnataka State for the period 1961–1971 in each of the above-listed categories had to be compiled from different sources and were of varying coverage and quality; they posed the problems in the application of any method. The major data sources were the censuses of 1961 and 1971, data collected through the National Sample Survey and Sample Registration Scheme, and the family planning service statistics system. The data from the official records of birth and death registers had to be totally ignored because of gross deficiencies in coverage and quality. The censuses, although they provided a variety of information on the population, were grossly defective in respect of a key set of variables that is essential in the evaluation of the impact of the programme. One of these variables is age distribution. As an illustration of the errors in age reporting in the censuses, a chart of the unsmoothed frequency distribution by individual ages for the state as obtained in the 1971 census is given below. Smoothing procedures have to be resorted to for any meaningful analysis. These procedures in themselves have an effect on the ultimate results of any programme evaluation. For some of the variables, the data needed were just not available; and some procedures had to be devised for estimating these variables through indirect methods from available data, or values of these variables had to be borrowed from other populations similar to that of Karnataka State. An example of this type of adjustment is the age distribution of acceptors and method-specific continuation rates. There are some factors for which no data are available, either for the state or for similar populations, and any study has to accommodate to this gap. Among these factors are the pre-acceptance fertility of acceptors, generally used as an index of their future potential fertility; the extent of non-programme acceptance, the incidence of secondary sterility; and efforts of substitution of traditional methods of contraception by modern methods, which are of greater significance in Indian culture.

Faced with these limitations of data, certain attempts were made to assess the quality of data and to adopt appropriate corrective measures to improve the quality; and wherever necessary and unavoidable, to borrow information from sources outside the State. These efforts are briefly described below.

Population distribution

As may be seen from the figure, the age data from the two censuses reflect severe response errors, especially digital preferences. The proportion of the population reporting their age in multiples of five in the 1971 census was 44 per cent. It is also likely that there was under-enumeration of some section of the population, as well as double counting in a few instances. These latter types of errors are not taken into account in this analysis, under the assumptions that they may be of small magnitude, with the incidence being the same in the two censuses. With regard to the smoothing of the age distribution, two procedures were adopted: the 11-point moving-average method[6] and Coale's method.[7]

Moving-average method

In the 11-point moving-average method, between the ages 8 and 67, the population in each age x was first obtained as an average of the 11 years $x - 5$ to $x + 5$; and these were grouped in five-year age intervals with multiples of five as the central points, such as 8–12, 13–17 and 18–22. These totals in the age groups were again smoothed by a three-point moving-weighted-averaged method; population in age group (L) is corrected as $P_L^1 = 1/4P_{L-1} + 1/2P_L + 1/4P_{L+1}$. These were again redistributed to individual ages using Sprague multipliers and regrouped into conventional five-year age groups. For ages 67 years and over, smoothed distributions were obtained by assuming that the second-order differences above that age remained constant. The numbers in the younger ages, 0–7 years, were estimated using the formula $y = A + Bx + CH^x$ (where x is age and y is the number in that age) and adopting a least-square method. This procedure was adopted independently for males and females.

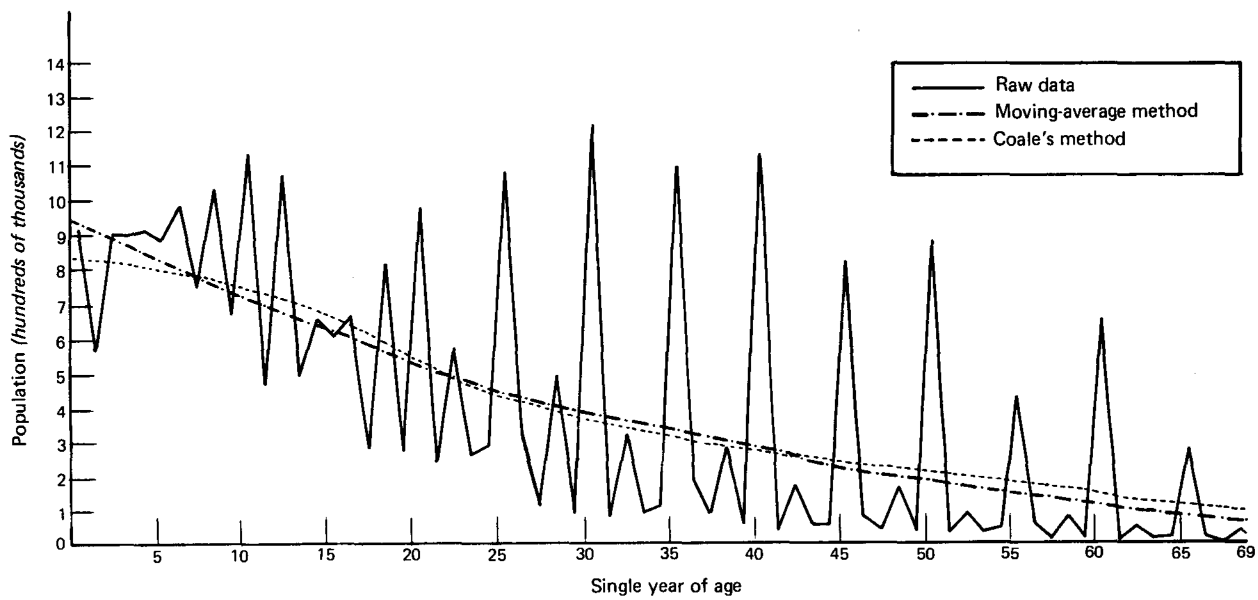
After the smoothed age distribution for each group were obtained, those distributions were allocated to rural and urban areas and to different marital status groups in the same proportions as observed in the unsmoothed data, and adjusted proportionately in such a way that the totals in rural and urban areas and in different marital groups were the same as those enumerated in the census population.

Coale's method

The second procedure that was adopted for smoothing was the one recommended by Coale, using the quasi-stable population theory. In this procedure, the observed age distributions in the censuses are actually ignored and only the totals enumerated are used in conjunction with an approximate idea of the gross reproduction rate (GRR) and the expectation of life (e_0^0) to work out the age distribution of the population on the basis of formulae developed by Coale. In his approach, Coale recommends the use of estimates of GRR and expectation of life (e_0^0) derived by the appli-

[6] *Census of India, 1961,* Paper No. 1 of 1963 (Delhi, 1963). See also S. P. Jain, "Smoothed 1961 census age distribution", *Demography India* (New Delhi), vol. I, No. 1 (October 1972).

[7] Ansley J. Coale, "Constructing the age distribution of a population recently subject to declining mortality", *Population Index*, vol. 37, No. 2 (April-June 1971), pp. 75–82. See also Ansley J. Coale and Paul Demeny, *Regional Model Life Tables and Stable Populations* (Princeton, N.J., Princeton University Press, 1966).



Raw and smoothed population distributions of Karnataka State, based on 1971 census

cation of quasi-stable population theory for the purposes of estimating the correction factors to be applied to model stable age distributions approximating the given population. However, in the present exercise, the values of GRR and e_0^o for 1961 and 1971 used were those assumed by the Bureau of Economics and Statistics for official projection purposes.

The smoothed distributions obtained using the two procedures described above are also charted in the figure, for comparative purposes. The actual population distributions obtained after smoothing for 1961 and 1971 for rural, urban and combined populations by the two smoothing procedures are given in annexed tables 15–18.

It was decided at the outset to adopt two smoothing techniques, because it was considered that the procedures adopted for smoothing could yield different results in the estimation of impact on fertility of the family planning programme. The two smoothing procedures adopted are conceptually very different; in the moving-average method, which is strictly an algebraical exercise, based on the census enumerated age distribution of the population, no assumptions of the fertility and mortality levels and the past trends in those levels are involved; in the second method, Coale's method, the observed age distribution in the census is virtually ignored and resort is had to stable population theory, and age distribution of approximate stable populations are corrected on the basis of estimates of fertility and mortality and trends of those parameters in the past. What is the nature of differences that could arise in the results on the impact on fertility of family planning programmes, if these two age distributions of the population obtained by two different smoothing rules were used in the various calculations? To attempt to answer that question, each of the methods of evaluating the programme impact was applied to the two population age distributions.

To give a comparative idea of the results obtained from the use of the two population age distributions, table 4 shows the average birth rates, gross reproduction rates and death rates estimated for the period 1961–1971 by the application of the forward-survival procedure, the quasi-stable population theory[8] and the reverse-survival method from the 0–9 age group in 1971. It can be seen from table 4 that the estimates of birth rates obtained for 1961–1971 vary widely, depending both upon the smoothing procedure adopted as well as the estimating technique used. Since the application of Coale's procedure presupposes stability over time in the fertility rates of a population and it has been documented from more than one source that the fertility levels in India have been declining since 1966, the validity of any results obtained from the application of a stable or quasi-stable population theory could be questioned. As such, the results based on the moving-average age distributions without any assumptions on the stability of the birth rates over time could be taken as relatively more valid to the context in Karnataka State after 1966.

Fertility and mortality measures

As mentioned earlier, fairly reliable data on levels and trends in fertility and mortality for Karnataka State could be obtained only from the sample surveys conducted at different times by the National Sample Survey and also from the Sample Registration System of the Government of India. The Sample Registration System provides information on the birth and death rates from 1966–1967, generally on the basis of half-yearly figures as well as annual figures. The National Sample Survey provided data on the vital rates for the years 1958–1959, 1960–1961 and 1963–1964. The rates compiled from these two different sources have been provided in table 2. It is interesting to note that even as early as 1958–1959 the birth rate for the rural areas of Karnataka State was 40.3. The Mysore population study conducted in 1951–1952[9] under the joint auspices of the Government of India and the United Nations also provided an estimate of 40.0 for the old Mysore State. Thus, it appears that fertility in Karnataka State even prior to the commencement of any organized large-scale family planning activity was comparatively low, being on the order of 40 per 1,000

[8] *Manual IV. Methods of Estimating Basic Demographic Measures from Incomplete Data* (United Nations publication, Sales No. 67. XIII.2).

[9] *The Mysore Population Study* (United Nations publication, Sales No. 61. XIII.3). See also Mysore State, Bureau of Economics and Statistics, *Population Projections for Mysore, 1972–1986* (1973).

TABLE 4. VITAL RATES FOR 1961-1971, ESTIMATED BY VARIOUS METHODS

Age distribution used	*Estimating method*							
	Forward-survival ratio		*Quasi-stable population theory*			*Reverse-survival ratio*		*Geometrical growth rate*
	Birth rate	*Death rate*	*Birth rate*	*Death rate*	*Gross reproduction rate*	*Birth rate*	*Death rate*[a]	
Raw age distributions	41.87	20.36	42.71	21.20	2.885	42.01	20.50	2.151
Smoothed by moving-average method (S_1)	41.80	20.39	44.48	22.97	3.095	41.94	20.43	2.151
Smoothed by Coale's method (S_2)	35.29	13.78	38.43	16.92	2.687	34.69	13.18	2.151

Source: Method S_2 based on procedure given in Ansley J. Coale, "Constructing the age distribution of a population recently subject to declining mortality", *Population Index*, vol. 37, No. 2 (April-June 1971), pp. 75–82.

[a] Death rates calculated by subtracting growth rate from birth rate.

population. It has been estimated that the biologically maximum level of crude birth rate that can be sustained over any considerable periods of time is on the order of 60–65 per 1,000 population. Thus, the fact that the pre-modern, pre-family planning fertility levels in India were much lower than the biological potential and below the levels prevailing even in 1975 in many of the developing countries indicates the effects of various cultural practices, social norms and traditions in dampening the fertility levels. Cultural practices that had such a lowering effect on fertility were the restrictions on widow remarriage, long periods of abstinence within marriage due to religious reasons or beliefs, the transfer of pregnant women to their mother's home for confinement and the practice whereby the women remained in their maternal home for considerable periods of time even after delivery and long periods of breast-feeding of children. With modernization, these traditional checks are being gradually loosened and the potential fertility of couples is in a state of flux. In the absence of any data for the state at any earlier point of time, the age-specific fertility patterns obtained from the National Sample Surveys in 1958–1959 for rural areas and in 1960–1961 for urban areas were taken as the natural fertility levels prevailing in the population of the state in the absence of any large-scale family planning efforts. These patterns agree quite closely to the patterns observed in the Mysore population study. The age-specific fertility rates and marital fertility rates computed from various sources for the years around 1961 and 1971 are given below in table 5.

The estimates of the birth rates obtained from the sample registration data for the year 1968 indicate moderate annual fluctuations with a general declining trend. These fluctuations may be due in part to errors in the collection of data in the sample registration system, including errors of matching, omission of events in both sources and errors of reference period. They can also include some real fluctuations caused by the interaction of fertility-reducing effects of modern methods of contraception adopted by some couples with the fertility-increasing effects caused by the decline in application of traditional checks due to modernizations, mentioned earlier.

To study the trends in these rates after 1968, linear regressions were fitted to the rural and urban rates over a five-year period, 1968–1972. Separate regressions based on data for the first half-year and the second half-year over these years were also fitted. These rates and regressions are given in table 6.

On the whole, birth rates have been declining at a rate of 0.53 per annum since 1968, 0.52 points in urban areas and 0.43 points in rural areas. When one considers the data separately for the first half-year and the second half-year, different trends are observed. Based on the data for the first half of the year, an increasing trend is observed for the rural areas; but based on the second half year, a steep declining trend is noticed. This indicates the possible presence of some errors of coverage in the sample registration data, wherein events of the first half of the year have been erroneously classified in the second half of the year in the earlier years of the Sample Registration Scheme. The presence of other types of errors, including omissions of vital events, cannot be ruled out and possibly the magnitude of such errors differ from year to year. It is worth-while noting that the beta coefficients are not statistically significant at the 10 per cent level mainly because of the smallness of the sample.

In general, it is believed that the rates based on the Sample Registration System somewhat underestimate the true picture. However, in view of the fact that no precise data are available to quantify the extent of under-registration and also in the light of the fact that the quality of the information in the Sample Registration System has improved over the years, the rates for 1971 are presumed to represent the fertility and mortality picture prevailing among the population of the state. Thus, although the data on the fertility and mortality levels for the year 1961 were obtained from the National Sample Survey, the data for 1971 were obtained from the Sample Registration System. These data, given in table 5, were taken as the basis for further evaluative analysis.

Family planning programme data

The data on the number of acceptors of various methods of family planning are available from the service statistics records published annually by the Directorate of Health and Family Planning. Though exact figures are available on sterilizations and IUD insertions, the data on conventional contraceptives, such as condoms, diaphragms, jellies and foam tablets, are not equally reliable. With regard to conventional contraceptives, the usual procedure adopted by the Government of India is to convert the quantity of the total contraceptives distributed into number of person-years of use, by dividing the number of condoms and foam tablets distributed by 72, which is supposed to represent the average frequency of coitus per couple per year, by 2 for each diaphragm fitted and by 7 for each tube of vaginal jelly distributed. Thus, the conventional contraceptives distributed are directly converted into couple-years of use rather than into the number of acceptors of these methods. Though this method facilitates the estimation of the number of births averted, there are serious assumptions involved with regard to the extent to which the contraceptives distributed have been actually used, the average coital frequency among the users and the effectiveness of these methods during the period of use. Unfortunately, no data are available for empirical verifications of these assumptions.

Although for some years the numbers of acceptors of family planning methods were available on a fiscal-year basis (from 1 April to 31 March), for the rest, the data were available on a calendar-year basis. With some simplistic assumptions of uniform distribution of

TABLE 5. AGE-SPECIFIC FERTILITY RATES FOR ALL WOMEN AND FOR MARRIED WOMEN, SELECTED PERIODS

	1951			*1958-1959*		*1960-1961*		*1961*[a]		*1971*			*1971*[b]		
	MASFR			*ASFR*	*MASFR*[c]	*ASFR*	*MASFR*[d]	*ASFR*	*MASFR*	*ASFR*			*MASFR*		
Age group	*Rural*	*Urban*	*Combined*	*Rural*	*Rural*	*Urban*	*Urban*	*Combined*	*Combined*	*Rural*	*Urban*	*Combined*	*Rural*	*Urban*	*Combined*
15-19	279.8	283.0	280.6	204.6	290.0	129.3	247.9	186.0	281.7	114.6	65.3	101.0	219.5	188.4	213.1
20-24	315.4	261.2	302.3	274.0	294.7	224.5	263.8	262.2	287.8	234.8	149.7	211.1	263.2	194.7	246.1
25-29	309.8	213.0	288.0	257.1	275.5	229.9	250.8	250.9	270.0	232.8	190.7	223.8	247.0	207.2	238.9
30-34	190.5	193.0	191.1	160.5	181.9	184.8	206.3	165.7	187.2	165.5	132.8	157.8	181.4	144.8	172.7
35-39	172.2	107.0	157.6	109.5	133.9	107.3	127.5	109.0	132.5	129.0	82.9	118.0	146.8	93.0	133.9
40-44	59.4	42.1	55.5	32.2	46.6	33.3	46.5	32.4	46.6	49.7	33.8	46.2	63.4	42.7	58.8
45-49	...	...	...	15.8	26.5	10.9	17.9	14.8	24.7	16.7	16.0	16.5	23.8	22.6	23.6
TFR (TMFR).	6.6	5.5	6.4	5.3	6.3	4.6	5.8	5.1	6.2	4.7	3.4	4.4	5.7	4.5	5.4

Sources: For 1951, *The Mysore Population Study* (United Nations publication, Sales No. 61.XIII.3); for 1958-1959, A. K. De and R. K. Som, *Fertility and Mortality Rates in India, Fourteenth Round, July 1958-June 1959,* National Sample Survey, Report No. 76 (New Delhi, Cabinet Secretariat, 1963); for 1960-1961, India, Cabinet Secretariat, *Tables with Notes on the Fertility and Mortality Rates in Urban Areas of India, Sixteenth Round, August 1960-July 1961,* National Sample Survey, Report No. 180 (New Delhi, 1971); for 1971, Karnataka State, Bureau of Economics and Statistics, *A Report on the Sample Registration System in Karnataka,* 1971-1972, Sample Registration System Report Series, No. 1 (1974).

[a] Rural rates for 1958-1959 and urban rates for 1960-1961 were combined to obtain 1961 rates.

[b] Marital age-specific fertility rate calculated using married proportion of 1971 population smoothed by the moving-average method.

[c] Age-specific fertility rate converted into marital age-specific fertility rate using the married population of 1961, smoothed by the moving-average method.

[d] Age-specific fertility rate (MS) calculated using married proportion (urban) of 1961 population smoothed by the moving-average method.

Notes: ASFR = age-specific fertility rate;
MASFR = marital age-specific fertility rate;
TFR = total fertility rate;
TMFR = total marital fertility rate.

TABLE 6. KARNATAKA STATE: TRENDS IN CRUDE BIRTH RATES, BASED ON SAMPLE REGISTRATION DATA, 1968-1972

Birth rates based on:	*1968*	*1969*	*1970*	*1971*	*1972*	*Regression equation*
First half-year						
Rural	29.8	31.6	31.9	33.6	30.8	$y = 30.74 + 0.40x$
Urban	...	27.4	25.9	24.2	27.0	$y = 26.850 - 0.29x$
Second half-year						
Rural	38.1	36.8	38.5	35.2	35.0	$y = 38.28 - 0.78x$
Urban	29.8	30.3	29.4	26.5	29.3	$y = 30.02 - 0.48x$
Combined						
Rural	33.7	34.1	35.0	34.6	32.8	$y = 35.20 - 0.43x$[a]
Urban	...	28.9	27.8	25.3	28.0	$y = 28.8 - 0.52x$
Combined	...	32.84[b]	33.0	31.7	31.5	$y = 33.59 - 0.53x$

[a] Based on only four parts, beginning in 1969.

[b] Estimated figures using the rural/urban proportion at the 1971 census. The origin of all the equations fitted is taken as 1968.

acceptance over the months within a year, all data were converted to calendar-year acceptance figures. These are the figures provided in table 3.

The age distribution of the acceptors was available from the data published by the Directorate of Health and Family Planning Services on the basis of analysis of a sample of the acceptor records from the year 1969 onward. Since no information was available for the earlier years, it was assumed that the age distributions of the acceptors observed for each method for the year 1969 were also applicable to the figures in the earlier years. The age distributions of acceptors of different methods for the different years are given in table 7.

With regard to the continuation rates, no follow-up studies appear to have been conducted in Karnataka State, and it was necessary to apply data from other studies. The rates that have been published[10] on a national basis for IUDs from the survey conducted by the National Institute of Family Planning (NIFP) in 1970–1971 were adopted with minor modifications. A small-scale follow-up study of IUD acceptors in an industrial establishment at Bangalore revealed that the IUD continuation rates were lower than those reported in the study mentioned above. It was also surmised from discussions that in the national study the initial immediate drop-outs, i.e., within one week, or expulsions of the IUDs had not been included in the computation of the continuation rates. Consequently, the a value for the continuation function ae^{-rt} was obtained from the follow-up study done at Gandhigram,[11] and using these a values, the annual discontinuation rate r was recalculated from the NIFP study. The values of a and r thus derived and used in this analysis are also given in table 7.

With regard to sterilizations, the annual discontinuations that were assumed were due to mortality of either the husband or the wife, and the possibility of the woman having completed age 49 (assumed to be the age after which fertility becomes zero). For the conventional contraceptives, as the data provided an estimate of the couples' years of use for different years, these data were directly converted into the births averted assuming that the effectiveness of the method during use is 75 per cent (i.e., one couple-year of protection of conventional contraceptives equals 75 per cent of effective years of use).

Socio-economic data

Data on socio-economic and family planning programme input variables are essential as control factors for any analysis of programme impact on fertility. Since a major consideration in programme planning is population size or areal unit, such an analysis must be macro or areal in nature. The convenient administrative areal unit for such an analysis in the Indian setting is the Primary Health Centre (PHC) in rural areas and the census block in urban areas. Though, with considerable efforts through compilation from various documents, information could be obtained on certain socio-economic factors, such as literacy rate, proportion of population employed in non-agricultural activities and proportion of villages and houses electrified, and on such programme factors as inputs of personnel and money in each area, no data are available from any existing sources on fertility and mortality rates at the PHC level or even at the district level. Without knowledge of the dependent variable, no areal or regression analysis is possible for the state. However, an attempt is being made to relate programme acceptance to other areal variables; and from the special survey being conducted by the Population Centre,[12] regression of fertility or fertility change on other factors would become

[10] P. S. Mohapatra and others, *A Four-Year Follow-up Study of Intra-Uterine Contraceptive Device Acceptors*, Series 19 (New Delhi, National Institute of Family Planning, 1973).

[11] A. Muthaiah, "Termination rates and other contraceptive use of IUD acceptors in Arthoor Block", *Bulletin of the Gandhigram Institute of Rural Health and Family Planning*, vol. 5, No. 2 (December 1970).

[12] P. H. Reddy and others, "Fertility, mortality and demand for family planning: a longitudinal study in progress", *Population Centre Newsletter* (Bangalore, India), vol. 1, No. 4 (May-June 1975).

TABLE 7. ESTIMATED PERCENTAGE DISTRIBUTION [a] OF ACCEPTORS BY AGE AND METHODS USED, AND INTRA-UTERINE DEVICE CONTINUATION RATES BY AGE OF WOMEN

Age group	Up to 1969				1970				1971				Continuation rates for intra-uterine device [c]
	Vasectomy	*Tubectomy*	*Intra-uterine device*	*Conventional contraceptives* [b]	*Vasectomy*	*Tubectomy*	*Intra-uterine device*	*Conventional contraceptives* [b]	*Vasectomy*	*Tubectomy*	*Intra-uterine device*	*Conventional contraceptives* [b]	
15-19	1.99	0.24	2.14	5.43	1.10	0.27	2.88	5.43	1.20	0.30	4.22	5.43	$a = 0.96$
20-24	7.70	6.48	18.84	25.96	9.50	7.99	19.21	25.96	10.01	8.66	22.19	25.96	$r = 0.4158$
25-29	22.40	28.86	34.65	40.53	22.70	31.27	30.42	40.53	24.22	33.13	31.43	40.53	$a = 0.81$ $r = 0.2524$
30-34	31.01	36.24	28.22	19.36	30.70	35.37	27.80	19.36	32.53	34.44	25.70	19.36	$a = 0.81$ $r = 0.2160$
35-39	22.33	22.36	13.08	7.18	23.10	20.54	16.01	7.18	21.02	18.53	12.95	7.18	
40-44	14.57	5.82	3.07	1.06	12.90	4.56	3.88	1.06	11.02	4.94	3.21	1.06	$a = 0.99$ $r = 0.3756$
45-49	0.0	0.0	0.0	0.48	0.0	0.0	0.0	0.48	0.0	0.0	0.0	0.48	

[a] For vasectomies and condoms (among the conventional contraceptives), age data relate to age of the client's wife; for all other methods, the age is that of the client herself.

[b] Data on conventional contraceptives are from the State Family Planning Bureau of Karnataka. For users of conventional contraceptives, it was assumed that 75 per cent drop out immediately and that the data on users are for that year only.

[c] Continuation rates were derived from the studies of the National Institute of Family Planning at Gandhigram.

possible. For the present report, no such analysis could be attempted.

ANALYSIS OF PROGRAMME IMPACT

The data compiled from various sources and adjusted to the extent possible for response errors, as described above, were used in estimating the impact on fertility of family planning programmes in Karnataka State, during the period 1961–1971. The following methods were applied to estimate the impact:

(*a*) Standardization approach;
(*b*) Trend analysis (fertility projection approach);
(*c*) Couple-years of protection;
(*d*) Component projection approach;
(*e*) Experimental designs (matching studies);
(*f*) Simulation models.

The results derived from the application of each of those methods are briefly discussed below.

Standardization approach

The indirect standardization technique was adopted for estimating the effects of changes in the age distribution, marital status, rural-urban composition and marital fertility on the crude birth rates between 1961 and 1971. The age-specific fertility rates of 1971 were applied to the population distributions of 1961, and the estimates of birth rates, standardized separately and jointly for the factors of age, marital status and rural-urban composition, were derived. The results are presented in table 8.

The procedure adopted for separating the effects of various factors is the same as that adopted by Freedman and others[13] in the analysis of the fertility decline in Hong Kong. The age-specific fertility schedules for 1961 and 1971 were those obtained from the National Sample Survey and the Sample Registration Scheme, respectively, as presented in table 5. However, two sets of population distributions were used, the first obtained by application of the moving-average method (S_1) and the second by Coale's method (S_2), mainly in order to study the differences in the smoothing procedures on the results obtained.

It can be seen from the table that when using the population smoothed by the moving-average procedure (S_1), age distribution changes accounted for 4.6 per cent of the change in the crude birth rate, age and marital status changes caused 31.0 per cent and age-marital status and rural-urban composition changes jointly accounted for 32.4 per cent of the crude birth-rate decline. The balance of 67.6 per cent of the change in the crude birth rate can thus be attributed to changes in the marital fertility of the population. On the other hand, if one uses the population figures smoothed by Coale's method (S_2), the changes in marital fertility during 1961–1971 accounted for a lower percentage of change in the crude birth rate, 54.1 per cent.

TABLE 8. RESULTS OF APPLICATION OF INDIRECT STANDARDIZATION PROCEDURES IN ANALYSING FERTILITY CHANGE IN KARNATAKA STATE, 1961-1971

	Population distributions of 1961 and 1971 smoothed by	
	Method S_1 [a]	*Method* S_2 [b]
Crude birth rate; 1961	39.6	38.0
Crude birth rate; 1971	32.0	30.6
Amount of decline, 1961-1971	7.6	7.4
Percentage change in crude birth rate, 1961-1971	19.3	19.4
1971 crude birth rate, standardized for 1961 age distribution	32.3	30.9
1971 crude birth rate, standardized for 1961 age and marital status	34.3	33.8
1971 crude birth rate, standardized for 1961 age, marital status and rural/urban residence	34.4	34.0
Percentage change in crude birth rate, 1961-1971, attributable to:		
Change in age	4.6	4.9
Age and marital status	31.0	43.6
Age, marital status and rural/urban residence	32.4	45.9
Percentage change in marital fertility	67.6	54.1

Source: Method S_2 based on procedure given in Ansley J. Coale, "Constructing the age distribution of a population recently subject to declining mortality", *Population Index*, vol. 37, No. 2 (April-June 1971), pp. 75-82.
[a] Moving-average method.
[b] Coale's method.

Thus, it may be seen that differences in the smoothing procedures could lead to different estimates of birth-rate changes attributable to various factors. For reasons stated above, the application of Coale's method, based on stable population theory, appear to have serious limitations in the analysis of fertility trends in the short run; and, hence, greater validity can be placed in the results obtained on the basis of population smoothed by the moving-average method. This statement is relevant for all the findings in this paper.

Trend analysis

The population of 1961 was projected, year by year, up to 1971, under two sets of fertility assumptions: (1) that the age-specific fertility rates remained at the level noticed in 1961; and (2) that the age-specific fertility rates declined linearly from 1961 to the 1971 levels observed in the Sample Registration Scheme. As in the standardization technique, two sets of results were obtained based on the two sets of population distributions for 1961, smoothed by the moving-average method (S_1) and by Coale's method (S_2). The mortality assumptions for each of the methods were based on

[13] Ronald Freedman and others, "Hong Kong's fertility decline, 1961–68", *Population Index*, vol. 36, No. 1 (January-March 1970), pp. 3–18. See also Ronald Freedman, "A comment on 'Social and Economic Factors in Hong Kong's Fertility Decline' by Sui-ying Wat and R. W. Hodge", *Population Studies* (London), vol. XXVII, No. 3 (November 1973), pp. 589–595.

the expectation of life derived by the reverse-survival procedure, for that particular method by comparing appropriate cohorts between 1961 and 1971, and using the procedure outlined in *Manual IV*.[14] The mortality levels estimated from the two sets of population distributions are given above in table 4. The total number of births estimated to have occurred under different assumptions are provided below in table 9. The total

TABLE 9. ESTIMATES OF TOTAL BIRTHS THAT OCCURRED AND OF BIRTHS AVERTED DURING 1961-1971, OWING TO THE FERTILITY DECLINE

		Population distributions of 1961 and 1971 smoothed by	
		Method S_1 [a]	*Method* S_2 [b]
Estimated births (1961-1971) assuming continuation of 1961 fertility pattern	B_1 ...	11 551 900	11 464 500
Estimated births that occurred during 1961 to 1971 taking into account the observed fertility decline	B_2 ...	10 434 700	10 323 400
Estimated births averted because of fertility decline	B_3 ...	1 117 200	1 141 100
	$\frac{B_3}{B_2} \times 100$ ...	10.7	11.1

Source: Method S_2 based on procedure given in Ansley J. Coale, "Constructing the age distribution of a population recently subject to declining mortality", *Population Index*, vol. 37, No. 2 (April-June 1971), pp. 75-82.

[a] Moving-average method.

[b] Coale's method.

number of births, assuming constant fertility from 1961 to 1971, are estimated at 11,550,000 with the population distribution based on the moving-average method; (S_1) and at 11,460,000 based on Coale's method (S_2). The births that have been averted because of the fertility decline were estimated as 1,120,000 based on the S_1 population distribution and at 1,140,000 on the S_2 distribution. The births averted because of fertility decline as a proportion of the total births that occurred during 1961 and 1971 is found to be 10.7 per cent according to S_1, and 11.1 per cent according to S_2. The latter method of smoothing the population slightly over-estimated the proportion of births averted because of the fertility decline, based on the component projection method; but, on the basis of standardization technique, the opposite effect obtained. Of course, the differences in this case are not significant.

Couple-years of protection[15]

The births that were averted by the number of acceptors of various methods of family planning prior to 1971 were estimated for each year, beginning in 1961. Based on assumptions of continuation rates for each method, as described earlier, the number of couple-years of protection contributing to the saving of births for each calendar year was estimated. This estimate of couple-years of use was made for each age group separately; and assuming that the age-specific fertility rates for 1961 would have continued in the absence of contraception (i.e., potential fertility of acceptors is the same as the average marital fertility rates of all women in that age group), the estimates of births averted in each year because of the family planning programme were derived. For working out the couple-years of protection and births averted, the acceptance data available from 1956 were used. The results obtained for each family planning method, based on the two population distributions, S_1 and S_2, are presented in table 10.

It can be seen that although the total fertility decline between 1961 and 1971 prevented approximately 1,120,000 births according to S_1 distribution (and about 1,140,000 according to S_2 distribution) the proportion of those births averted because of acceptance of family planning methods from within the programme was 37.4 per cent in S_1 (and 36.2 per cent in S_2). Although the estimate of births averted because of the fertility decline has consistently increased over the years, the proportion of those accountable by family planning increased each year up to 1968; thereafter, a declining trend is discerned. Thus, since 1969, the non-programme effects or indirect effects of the programme have begun to play an increasingly significant role in fertility decline in the state. In general, both the estimates of births averted by fertility decline and the proportion accountable to direct programme acceptance are slightly higher by S_1 distribution than by S_2 distribution. During 1971, the total births averted because of fertility decline was 219,800, taking S_1 distribution; and 209,200, taking S_2 distribution, and the proportion of those attributable to family planning practice in the earlier years was 36.4 per cent by S_1 and 37.7 per cent by S_2. It is significant to note that only one third of the decline in marital fertility could be attributable to recorded family planning acceptance within the programme.

Component projection approach

The component projection method first developed by Lee and Isbister[16] in estimating the impact of family planning programmes on fertility is almost similar to

[14] *Manual IV. Methods of Estimating Basic Demographic Measures from Incomplete Data.*

[15] Samuel M. Wishik and K. H. Chen, *The Couple-year of Protection: A Measure of Family Planning Program Output*, Manuals for Evaluation of Family Planning and Population Programs, No. 7 (New York, Columbia University, International Institute for the Study of Human Reproduction, 1973). See also W. Parker Mauldin, "Births averted by family planning programs", *Studies in Family Planning*, vol. 1, No. 33 (August 1968).

[16] B. M. Lee and John Isbister, "The impact of birth control programs on fertility", in Bernard Berelson and others, eds., *Family Planning and Population Programs. A Review of World Development* (Chicago, University of Chicago Press, 1966), pp. 737–758.

TABLE 10. BIRTHS AVERTED BY DIFFERENT FAMILY PLANNING METHODS, 1961-1971, BASED ON CONTINUATION RATES GIVEN IN TABLE 7 AND POTENTIAL FERTILITY REPRESENTED IN TABLE 5

	Method[a]	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*	*Total*
Vasectomy	S_1	907	1 425	2 406	3 954	6 199	10 880	21 530	35 066	42 898	45 563	42 392	213 221
	S_2	897	1 411	2 379	3 908	6 123	10 760	21 310	34 659	42 343	42 877	41 754	208 421
Tubectomy	S_1	907	1 080	1 300	1 660	2 180	2 446	2 992	4 164	6 530	10 680	16 775	50 714
	S_2	894	1 062	1 280	1 635	2 078	2 407	2 947	4 103	6 438	10 531	16 584	49 959
Intra-uterine device	S_1	...	...	...	...	5 165	15 502	21 904	21 535	18 277	14 846	12 218	109 447
	S_2	...	...	...	...	5 143	15 425	21 775	21 382	18 175	14 597	12 067	108 564
Conventional contraceptives	S_1	...	...	...	...	...	4 736	6 550	7 341	8 135	8 832	8 537	44 131
	S_2	...	...	...	...	...	4 736	6 550	7 341	8 135	8 832	8 537	44 131
TOTAL	S_1	1 814	2 505	3 706	5 614	13 544	33 564	53 976	68 106	75 840	79 921	79 922	417 513
	S_2	1 791	2 473	3 659	5 543	13 544	33 328	52 582	67 485	75 091	76 837	78 942	411 175
Estimated births averted because of decline in marital fertility	S_1	...	17 500	35 800	54 900	75 000	95 200	117 900	141 600	166 600	192 900	219 800	1 117 200
	S_2	...	17 100	35 600	55 600	77 300	100 500	123 100	147 200	172 300	198 700	209 200	1 136 600
Percentage decline because of family planning programme	S_1	...	14.3	10.3	10.2	18.1	35.3	44.9	48.1	45.5	41.4	36.4	37.4
	S_2	...	14.5	10.3	10.0	17.3	31.7	42.7	45.8	43.6	38.7	37.7	36.2

Source: Method S_2 based on procedure given in Ansley J. Coale, "Constructing the age distribution of a population recently subject to declining mortality", *Population Index*, vol. 37, No. 2 (April-June 1971), pp. 75-82.

[a] Population distribution in 1961 and 1971 smoothed by: method S_1, moving-average; S_2, Coale's method.

that for couple-years of protection, described above, except for the assumption with respect to potential fertility of acceptors. The number of acceptors of different family planning methods prior to 1971 are survived to mid-1970 by applying the appropriate mortality schedules and the method-specific continuation rates. The number of couples using contraceptives by the middle of 1970 is estimated for each age group separately. This was multiplied by the potential fertility of acceptors obtained from the results of matching of the fertility of acceptors and non-acceptors over a three-year period prior to acceptance. The details of the matching study are given in the next section. It was found that the pre-acceptance fertility of acceptors has been roughly 15 per cent higher than that of the control group, though there was variation among different age groups between the matches and control. Assuming the higher potential fertility for the acceptors, the births averted during 1971 were estimated and found to be on the order of 90,000. The results are provided in table 11. Subtracting the births averted, the estimates of age-specific fertility rates in 1971 were derived, and it is interesting to note that the fertility rates derived by assumptions of the two population-smoothing procedures (S_1 and S_2) are very nearly the same. The percentage reduction in marital fertility because of family planning, during the year 1971, has been estimated to be 41 per cent based on S_1 and 43 per cent based on S_2. The estimate of the total fertility rate in 1971 thus obtained using the component projection method and taking into account the impact of the family planning programme, works out to very nearly the same value with a fertility rate of 4.6 per woman, while the total fertility figures computed from the Sample Registration Scheme data for 1971 was 4.4. Details regarding births averted by each method in each age group in 1971 and the percentage of total births averted attributable to the family planning programme are given in table 11.

Experimental designs

Data for the pre-acceptance and post-acceptance fertility of acceptors of different family planning methods, compared with control groups matched for age, parity and open birth interval, were compiled from the information collected in the Longitudinal Sample Survey of households, currently being conducted by the Population Centre in selected villages of Bangalore city, Bangalore rural districts and Kolar districts. This large-scale sample study envisages collection of data on fertility, mortality, family planning practice and related social and programmatical factors from 5,200 households selected according to scientific sampling procedures from the five districts of the project area. At this writing, the survey had been completed in a sample of 1,200 households (700 in Bangalore city, 250 in Bangalore rural districts and 250 in Kolar districts) and the information collected from these households was available for analysis. From these schedules, data were compiled on the age, parity and open birth interval of family planning acceptors of 1969, 1970 and 1971 at the time of acceptance; their pre-acceptance and post-acceptance fertility over a three-year period and the fertility of non-acceptors over the same duration matched for age (within the same five-year age group); parity (the same parity 0, 1, 2, 3, 4, 5, 6+), and open birth interval (less than 12 months and over 12 months). The total number of acceptors during 1969, 1970 and 1971 as obtained from these samples of 1,200 households was only 35 and the number of matches selected was 105 (three match to one acceptor). The pre-acceptance and post-acceptance fertility rates for the acceptors and for the matches, computed separately for vasectomies, tubectomies and IUD cases, are given in table 12.

The results from this table have to be used with a considerable amount of caution as the data are based on a very small sample. It can be seen that the pre-

TABLE 11. IMPACT OF THE FAMILY PLANNING PROGRAMME AS MEASURED BY THE COMPONENT PROJECTION APPROACH

	Estimated number of couples using respective methods during mid-1970 who entered the conventional age group during 1971					*Number of births averted*					*Estimated age-specific fertility rate in 1971*	
Age group	*Vasectomy*	*Tubectomy*	*Intra-uterine device*	*Conventional contraceptives*	*Total*	*Vasectomy*	*Tubectomy*	*Intra-uterine device*	*Conventional contraceptives*	*Total*	*Method* S_1[a]	*Method* S_2[b]
15-19	2 066	78	497	1 419	4 140	640	31	210	549	1 430	185.0	185.0
20-24	11 335	2 227	4 855	7 547	25 964	3 589	897	2 096	2 824	9 406	254.7	254.2
25-29	36 251	10 727	15 024	12 994	74 996	10 768	4 055	6 085	4 561	25 469	227.4	225.7
30-34	69 447	18 369	25 522	8 148	121 486	14 303	4 815	7 168	1 983	28 269	135.4	134.2
35-39	78 669	17 530	22 251	3 323	121 773	11 469	3 253	4 423	573	19 718	84.0	84.4
40-44	66 218	10 320	9 458	788	86 784	3 391	673	660	48	4 772	25.1	25.7
45-49	32 045	4 203	2 316	207	38 771	870	145	86	7	1 108	12.7	13.0
TOTAL	296 031	63 454	79 923	34 506	473 914	45 030	13 869	20 728	10 545	90 172	4.62[c]	4.60[c]

	Number of births averted in 1971 because of change of marital fertility	*Percentage reduction in marital fertility because of family planning programme*
Method S_1[a]	219 800	41.0
Method S_2[b]	209 200	42.5

Source: Method S_2 based on procedure given in Ansley J. Coale, "Constructing the age distribution of a population recently subject to declining mortality", *Population Index,* vol. 37, No. 2 (April-June 1971), pp. 75-82.

[a] Moving-average method.
[b] Coale's method.
[c] Number of children per woman.

TABLE 12. PRE-ACCEPTANCE AND POST-ACCEPTANCE FERTILITY OVER A THREE-YEAR PERIOD

Family planning method	Pre-acceptance fertility: Acceptors Number	Acceptors Average	Matches Number	Matches Average	Ratio of acceptor's fertility to that of the matches	Post-acceptance fertility: Acceptors Number	Acceptors Average	Matches Number	Matches Average	Ratio of acceptor's fertility to that of the matches	Percentage decline in fertility: Acceptors	Matches
Vasectomy	6	500.00	18	388.89	1.29	6	0	18	277.78	0	100	28.57
Tubectomy	7	523.81	21	333.33	1.57	7	0	21	269.84	0	100	19.05
Intra-uterine device	6	444.44	18	277.78	1.60	6	111.19	18	203.70	0.55	75	26.67
Nirodh (condom)	16	458.33	48	368.06	1.25	16	187.50	48	263.89	0.71	39.09	28.30
TOTAL	35	476.18	105	349.20	1.36	35	104.78	105	257.14	0.41	63.30	26.36

Source: Partial data from the Longitudinal Sample Survey being conducted by the Population Centre, Bangalore, India.

acceptance fertility of acceptors, for all the methods combined, was 36 per cent higher than the non-acceptors; and the post-acceptance fertility of the same group over a three-year period following the acceptance was 59 per cent lower than that of the matches. It is also interesting to note that the fertility of matches, that is, those who reported not to have used any family planning method, has itself declined by 26 per cent over a three-year period. This may be partially because of the selection of cases, both acceptors and matches, on the basis of a recent birth within the last one or two years; as a consequence, the probability of their giving birth to a child in the next two- to three-year period can be expected to be lower even without any contraception. However, in the absence of any data based on a larger sample for the state, these figures were used in the computation of births averted by the component projection method described in the earlier sections. It is also to be noted that the post-acceptance fertility of acceptors and matches given in the table refer mostly to a period after 1971 and, consequently, it can be surmised that the fertility decline after 1971 has been greater than that estimated before 1971.

Simulation models

On assumptions concerning fertility, mortality, foetal loss and post-partum amenorrhoea that are very similar to the conditions prevailing in Karnataka State, Venkatacharya[17] has computed, using a micro-simulation model, the annual birth probabilities of an acceptor of a family planning method in successive years after acceptance for vasectomy, tubectomy and IUD, specified by the age group at acceptance. These birth probabilities have been computed taking into account specifically the susceptible state of the wife at the time of acceptance. For example, all the tubectomies in the state have been performed on post-partum women immediately after delivery; and with a long period (about a year) of amenorrhoea following a live birth, practically no birth would be prevented in the next one-year period. On the other hand, since the IUDs are inserted after making sure that the woman had resumed menstruation after the last childbirth, the fecundability of the woman is higher and the births prevented in the next one-year period for an IUD are much higher. Since the state of the woman at the time of the vasectomy of her husband is not known from the records, it was assumed that the birth prevention probabilities of a vasectomy case is an average of that of an IUD and a tubectomy case. The probabilities for IUD and tubectomy as worked out by Venkatacharya are given in table 13.

Using the birth probabilities and the number of acceptors of tubectomy, IUD and vasectomy reported in Karnataka State from 1961 onward, and the age distributions of these acceptors as given in table 7, the births averted per annum by each of these methods during 1961–1971 are given in table 14.

It is interesting to compare the results obtained by the application of simulation procedures with those obtained by the couple-years of protection given in table 10. The births averted by IUDs by applying the simulation birth probabilities from 1965–1971 work out to 116,179, while by couple-years-of-protection concept given in table 10 they work out to 109,447 (S_1 distribution). For tubectomies, the figures are 22,783 and 50,714, respectively. The reason that the simulation procedure has underestimated the births averted in this case is that it takes into account the post-partum amenorrhoea after tubectomy. For vasectomy, the figures for the two methods are again close, being 195,396 according to simulation procedure and 213,221 according to couple-years of protection.

SUMMARY AND CONCLUSIONS

This report presents the results of application of six methods of measuring the impact of family planning programmes on fertility in Karnataka State, India. The methods applied were standardization approach; trend analysis (fertility projection approach); couple-years of protection; component projection approach; experimental designs (matching studies); and simulation models. The methods developed by Potter[18] and Wol-

[17] K. Venkatacharya, "A computer model to estimate births averted due to IUCD and sterilizations", Bombay, International Institute of Population Studies, 1970 (mimeographed).

[18] Robert G. Potter, "Estimating births averted in a family planning program", in S. J. Behrman, Leslie Corsa, Jr., and Ronald

TABLE 13. PROBABILITY OF A WOMAN'S GIVING BIRTH (NOT USING ANY FAMILY PLANNING METHOD) WITH INITIAL SUSCEPTIBLE STATUS OF AN INTRA-UTERINE DEVICE USER OR SALPINGECTOMIZED FEMALE IN EACH CALENDAR YEAR SINCE THE INITIAL POINT OF TIME

	Birth probabilities by matrix										
		Intra-uterine device					Salpingectomy				
Age group	Age-specific marital fertility rate	1	2	3	4	5	1	2	3	4	5
15-19	0.184	0.026	0.299	0.278	0.238	0.268	0.000	0.019	0.171	0.324	0.274
20-24	0.302	0.049	0.471	0.314	0.247	0.301	0.000	0.033	0.259	0.400	0.278
25-29	0.323	0.057	0.544	0.289	0.243	0.360	0.000	0.038	0.298	0.421	0.261
30-34	0.257	0.032	0.390	0.265	0.198	0.277	0.000	0.024	0.206	0.332	0.226
35-39	0.155	0.012	0.182	0.181	0.143	0.152	0.000	0.010	0.095	0.186	0.160
40-44	0.075	0.004	0.070	0.059	0.054	0.053	0.000	0.004	0.036	0.078	0.077

Source: K. Venkatacharya, "A computer model to estimate births averted due to IUCD and Sterilization", Bombay, International Institute of Population Studies, 1970 (mimeographed).

fers[19] for estimating births averted, which relate the extent to which the fecundable state of a woman is lengthened because of contraception to the birth intervals, could not be applied because of paucity of necessary data. Also, it was not possible to apply any regression analysis on the basis of areal data in the state, in view of the fact that information on fertility levels and trends for administrative units within the state, necessary for such analysis, was not available.

The results derived from the application of the six methods relate to the period 1961–1971 in Karnataka State. This period was chosen because the two most recent censuses were conducted in 1961 and 1971, and could provide the necessary basic demographic and socio-economic data for the population of the state, and also because the official family planning programme in the state had received a considerable impetus in terms of increased financial and organizational inputs during that period. The data necessary for the application of the various evaluation methods were derived from these two censuses, from National Sample Surveys conducted in 1958–1959 and 1960–1961, from the Sample Registration Scheme figures on fertility and mortality available from 1968 onward; and from the family planning service statistics system, which provided data on the number of acceptors of various family planning methods and the age distribution of the acceptors. In addition, data on certain essential parameters, such as continuation rates of methods, were borrowed from a few special studies conducted in other states in India.

Though the censuses did provide data on various aspects of the population of the state in 1961 and 1971, certain essential particulars, such as the age distribution recorded, were of poor quality and revealed considerable response errors. Smoothing of the age distribution of the population was a prerequisite of any further analysis. It was assumed, *a priori,* that the procedures adopted for smoothing might, in themselves, have effects on the results of programme impact; and, consequently, two different smoothing procedures were adopted in order to determine the extent of variation caused by such procedure on the final results. The two smoothing procedures were the moving-average method (S_1) and Coale's method (S_2). Analysis of the results obtained by the application of various methods of programme impact revealed that the smoothing procedure does have a significant effect on the results of the impact of the programme, especially at the first stage where the total birth-rate change has to be partitioned into two parts: one due to the structural changes in the population, such as changes in age-sex-marital status; and the second part due to changes in marital fertility.

On the other hand, smoothing procedures do not appear to influence to the same extent the results with regard to the proportion of changes in marital fertility attributable to the family planning programme. The other important observations that emanate from a comparative analysis of the results obtained from the

Freedman, eds., *Fertility and Family Planning: A World View* (Ann Arbor, Mich., University of Michigan Press, 1969), pp. 413–434.

[19] David Wolfers, "The demographic effects of a contraceptive programme", *Population Studies,* vol. XXIII, No. 1 (March 1969), pp. 111–141.

TABLE 14. APPLICATION OF THE RESULTS OF COMPUTER SIMULATION

Family planning method	Births averted											
	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	Total
Vasectomy	38	476	1 248	2 688	4 699	7 832	14 972	29 045	42 002	46 999	45 397	195 396
Tubectomy	0	25	221	571	929	1 417	1 914	2 227	2 925	4 623	7 931	22 783
Intra-uterine device.....	...	...	...	...	851	14 646	26 827	25 332	20 192	16 062	12 269	116 179
TOTAL	38	501	1 469	3 259	6 479	23 895	43 713	56 604	65 119	67 684	65 597	334 358

Note: The number of births averted has been calculated from the data on acceptors in 1961 and thereafter, whereas in table 10, acceptor data for 1956 and subsequent years have been used.

application of the various methods are as follows. Unless otherwise specified, the findings given below are generally based on populations smoothed by the moving-average method (S_1):

1. The birth rate in the state has declined by about 7.6 points during the 10-year period 1961–1971; about two thirds of this decline can be attributed to changes in marital fertility;

2. The births averted because of the fertility decline during 1961–1971 constituted 11 per cent of the total births that occurred during the same period;

3. About 37 per cent of the births that were averted during 1961–1971 because of the fertility decline can be attributed to the acceptance and use of various methods of family planning from within the programme in the state prior to 1971;

4. Forty-one per cent of the reduction in marital fertility in the year 1971 can be attributed to family planning acceptors from within the programme prior to that year;

5. There is a considerable decline in the post-acceptance fertility of acceptors of different methods of family planning compared with their pre-acceptance fertility levels. On the other hand, even among the control group, there is a significant decline in fertility over the same period of time;

6. The analysis reveals that both programme factors and non-programme factors have played a significant role in the decline of fertility in the state during 1961–1971, the indirect effects of the programme and non-programme effects accounting for almost two thirds of the decline in marital fertility.

7. The application of stable population theory to smooth the age distribution or for estimation of fertility and mortality levels has serious limitations in the Indian situation after 1961. Further research in this aspect appears very necessary.

Annex

KARNATAKA STATE: SMOOTHED POPULATION DISTRIBUTIONS, 1961 AND 1971

TABLE 15. POPULATION DISTRIBUTION SMOOTHED BY MOVING-AVERAGE METHOD, 1961

(Hundreds)

Age group	Male: Single	Male: Married	Male: Widowed	Male: Divorced or separated	Male: Total	Female: Single	Female: Married	Female: Widowed	Female: Divorced or separated	Female: Total	Total: Single	Total: Married	Total: Widowed	Total: Divorced or separated	Total: Total
Rural population															
0-9	27 541				27 541	27 419				27 419	54 960				54 960
10-14	9 920	157	4	1	10 082	9 301	1 348	15	5	10 669	19 221	1 505	19	6	20 751
15-19	7 875	735	12	2	8 624	2 547	6 391	76	43	9 057	10 422	7 126	88	45	17 681
20-24	4 616	2 944	45	15	7 620	331	7 331	157	66	7 885	4 947	10 275	202	81	15 505
25-29	1 651	5 377	88	33	7 149	95	6 410	295	70	6 870	1 746	11 787	383	103	14 019
30-34	454	5 741	135	39	6 369	62	5 205	563	70	5 900	516	10 946	698	109	12 269
35-39	202	5 250	170	37	5 659	42	4 015	797	58	4 912	244	9 265	967	95	10 571
40-44	132	4 449	271	36	4 888	41	2 834	1 180	48	4 103	173	7 283	1 451	84	8 991
45-49	92	3 700	323	29	4 144	27	2 025	1 323	30	3 405	119	5 725	1 646	59	7 549
50-54	69	2 823	401	24	3 317	23	1 214	1 565	18	2 820	92	4 037	1 966	42	6 137
55-59	54	2 121	394	16	2 585	18	804	1 459	12	2 293	72	2 925	1 853	28	4 878
60-64	32	1 456	411	11	1 910	12	398	1 466	7	1 883	44	1 854	1 877	18	3 793
65-69	27	924	324	8	1 283	10	240	1 162	4	1 416	37	1 164	1 486	12	2 699
70+	29	1 083	584	10	1 706	12	154	1 524	3	1 693	41	1 237	2 108	13	3 399
TOTAL	52 694	36 760	3 162	261	92 877	39 940	38 369	11 582	434	90 325	92 634	75 129	14 744	695	183 202
Urban population															
0-9	7 532				7 532	7 365				7 365	14 897				14 897
10-14	2 989	15	–	–	3 004	2 806	154	2	1	2 963	5 795	169	2	1	5 967
15-19	2 974	101	2	1	3 078	1 402	1 554	13	9	2 978	4 376	1 655	15	10	6 056
20-24	2 110	696	8	3	2 817	317	2 100	36	15	2 468	2 427	2 796	44	18	5 285
25-29	726	1 493	19	5	2 243	89	1 835	63	15	2 002	815	3 328	82	20	4 245
30-34	195	1 751	31	6	1 983	33	1 460	121	16	1 630	228	3 211	152	22	3 613
35-39	69	1 585	35	5	1 694	22	1 106	173	12	1 313	91	2 691	208	17	3 007
40-44	39	1 343	57	5	1 444	15	752	272	9	1 048	54	2 095	329	14	2 492
45-49	25	1 028	61	3	1 117	11	533	326	7	877	36	1 561	387	10	1 994
50-54	17	766	80	4	867	8	312	375	5	700	25	1 078	455	9	1 567
55-59	12	539	75	2	628	6	210	354	2	572	18	749	429	4	1 200
60-64	7	358	87	1	453	10	104	350	2	466	17	462	437	3	919
65-69	5	218	62	1	286	8	65	255	2	330	13	283	317	3	616
70+	7	254	125	1	387	10	39	370	1	420	17	293	495	2	807
TOTAL	16 707	10 147	642	37	27 533	12 102	10 224	2 710	96	25 132	28 809	20 371	3 352	133	52 665

TABLE 15. (*continued*)

Age group	Combined population														
	Male					Female					Total				
	Single	Married	Wid-owed	Divorced or sepa-rated	Total	Single	Married	Wid-owed	Divorced or sepa-rated	Total	Single	Married	Wid-owed	Divorced or sepa-rated	Total
0-9	35 073				35 073	34 784				34 784	69 857				69 857
10-14	12 909	172	4	1	13 086	12 107	1 502	17	6	13 632	25 016	1 674	21	7	26 718
15-19	10 849	836	14	3	11 702	3 949	7 945	89	52	12 035	14 798	8 781	103	55	23 737
20-24	6 726	3 640	53	18	10 437	648	9 431	193	81	10 353	7 374	13 071	246	99	20 790
25-29	2 377	6 870	107	38	9 392	184	8 245	358	85	8 872	2 561	15 115	465	123	18 264
30-34	649	7 492	166	45	8 352	95	6 665	684	86	7 530	744	14 157	850	131	15 882
35-39	271	6 835	205	42	7 353	64	5 121	970	70	6 225	335	11 956	1 175	112	13 578
40-44	171	5 792	328	41	6 332	56	3 586	1 452	57	5 151	227	9 378	1 780	98	11 483
45-49	117	4 728	384	32	5 261	38	2 558	1 649	37	4 282	155	7 286	2 033	69	9 543
50-54	86	3 589	481	28	4 184	31	1 526	1 940	23	3 520	117	5 115	2 421	51	7 704
55-59	66	2 660	469	18	3 213	24	1 014	1 813	14	2 865	90	3 674	2 282	32	6 078
60-64	39	1 814	498	12	2 363	22	502	1 816	9	2 349	61	2 316	2 314	21	4 712
65-69	32	1 142	386	9	1 569	18	305	1 417	6	1 746	50	1 447	1 803	15	3 315
70+	36	1 337	709	11	2 093	22	193	1 894	4	2 113	58	1 530	2 603	15	4 206
TOTAL	69 401	46 907	3 804	298	120 410	52 042	48 593	14 292	530	115 457	121 443	95 500	18 096	828	235 867

TABLE 16. POPULATION DISTRIBUTION SMOOTHED BY COALE'S METHOD, 1961
(*Hundreds*)

Age group	Rural Population														
	Male					Female					Total				
	Single	Married	Wid-owed	Divorced or sepa-rated	Total	Single	Married	Wid-owed	Divorced or sepa-rated	Total	Single	Married	Wid-owed	Divorced or sepa-rated	Total
0-9	27 259				27 259	25 957				25 957	53 216				53 216
10-14	10 171	163	4	1	10 339	10 433	1 288	12	4	11 737	20 604	1 451	16	5	22 076
15-19	7 948	755	12	2	8 717	2 757	5 895	58	39	8 749	10 705	6 650	70	41	17 466
20-24	4 624	3 003	45	15	7 687	361	6 822	122	60	7 365	4 985	9 825	167	75	15 052
25-29	1 632	5 410	86	33	7 161	106	6 102	234	65	6 507	1 738	11 512	320	98	13 668
30-34	439	5 664	129	39	6 271	72	5 095	459	67	5 693	511	10 759	588	106	11 964
35-39	191	5 059	158	36	5 444	51	4 134	684	58	4 927	242	9 193	842	94	10 371
40-44	124	4 246	250	34	4 654	52	3 101	1 076	51	4 280	176	7 347	1 326	85	8 934
45-49	87	3 583	301	28	3 999	37	2 361	1 285	35	3 718	124	5 944	1 586	63	7 717
50-54	69	2 831	388	24	3 312	34	1 512	1 624	23	3 193	103	4 343	2 012	47	6 505
55-59	56	2 223	398	17	2 694	27	1 041	1 575	15	2 658	83	3 264	1 973	32	5 352
60-64	35	1 603	436	12	2 086	19	512	1 571	9	2 111	54	2 115	2 007	21	4 197
65-69	30	1 093	369	9	1 501	16	307	1 239	5	1 567	46	1 400	1 608	14	3 068
70+	29	1 127	586	11	1 753	18	199	1 643	3	1 863	47	1 326	2 229	14	3 616
TOTAL	52 694	36 760	3 162	261	92 877	39 940	38 369	11 582	434	90 325	92 634	75 129	14 744	695	183 202
	Urban population														
0-9	7 456				7 456	6 972				6 972	14 428				14 428
10-14	3 062	16	—	—	3 078	3 063	147	1	1	3 212	6 125	163	1	1	6 290
15-19	2 998	104	2	1	3 105	1 477	1 434	10	8	2 929	4 475	1 538	12	9	6 034
20-24	2 112	713	8	3	2 836	337	1 955	28	14	2 334	2 449	2 668	36	17	5 170
25-29	716	1 507	19	5	2 247	96	1 748	50	14	1 908	812	3 255	69	19	4 155
30-34	188	1 733	29	6	1 956	36	1 429	99	15	1 579	224	3 162	128	21	3 535
35-39	64	1 533	33	5	1 635	26	1 139	148	12	1 325	90	2 672	181	17	2 960
40-44	37	1 285	52	5	1 379	18	824	247	10	1 099	55	2 109	299	15	2 478
45-49	24	998	57	3	1 082	15	621	316	8	960	39	1 619	373	11	2 042
50-54	17	771	77	4	869	11	388	389	6	794	28	1 159	466	10	1 663
55-59	12	567	75	2	656	10	272	380	3	665	22	839	455	5	1 321
60-64	8	396	93	1	498	14	133	374	2	523	22	529	467	3	1 021
65-69	6	259	71	1	337	12	84	271	2	369	18	343	342	3	706
70+	7	265	126	1	399	15	50	397	1	463	22	315	523	2	862
TOTAL	16 707	10 147	642	37	27 533	12 102	10 224	2 710	96	25 132	28 809	20 371	3 352	133	52 665

TABLE 16. (*continued*)

Age group	Combined population														
	Male					Female					Total				
	Single	Married	Widowed	Divorced or separated	Total	Single	Married	Widowed	Divorced or separated	Total	Single	Married	Widowed	Divorced or separated	Total
0-9	34 715				34 715	32 929				32 929	67 644				67 644
10-14	13 233	179	4	1	13 417	13 496	1 435	13	5	14 949	26 729	1 614	17	6	28 366
15-19	10 946	859	14	3	11 822	4 234	7 329	68	47	11 678	15 180	8 188	82	50	23 500
20-24	6 736	3 716	53	18	10 523	698	8 777	150	74	9 699	7 434	12 493	203	92	20 222
25-29	2 348	6 917	105	38	9 408	202	7 850	284	79	8 415	2 550	14 767	389	117	17 823
30-34	627	7 397	158	45	8 227	108	6 524	558	82	7 272	735	13 921	716	127	15 499
35-39	255	6 592	191	41	7 079	77	5 273	832	70	6 252	332	11 865	1 023	111	13 331
40-44	161	5 531	302	39	6 033	70	3 925	1 323	61	5 379	231	9 456	1 625	100	11 412
45-49	111	4 581	358	31	5 081	52	2 982	1 601	43	4 678	163	7 563	1 959	74	9 759
50-54	86	3 602	465	28	4 181	45	1 900	2 013	29	3 987	131	5 502	2 478	57	8 168
55-59	68	2 790	473	19	3 350	37	1 313	1 955	18	3 323	105	4 103	2 428	37	6 673
60-64	43	1 999	529	13	2 584	33	645	1 945	11	2 634	76	2 644	2 474	24	5 218
65-69	36	1 352	440	10	1 838	28	391	1 510	7	1 936	64	1 743	1 950	17	3 774
70+	36	1 392	712	12	2 152	33	249	2 040	4	2 326	69	1 641	2 752	16	4 478
TOTAL	69 401	46 907	3 804	298	120 410	52 042	48 593	14 292	530	115 457	121 443	95 500	18 096	828	235 867

Source: Smoothing method based on procedure given in Ansley J. Coale, "Constructing the age distribution of a population recently subject to declining mortality", *Population Index*, vol. 37, No. 2 (April-June 1971), pp. 75-82.

Note: for the purpose of smoothing, male e_o^o was assumed to be 47.5; female e_o^o, 45.0; gross reproduction rate, 2.8; and sex ratio at birth, 107.

TABLE 17. POPULATION DISTRIBUTION SMOOTHED BY MOVING-AVERAGE METHOD, 1971

(*Hundreds*)

Age group	Male					Female					Total				
	Single	Married	Widowed	Divorced or separated	Total	Single	Married	Widowed	Divorced or separated	Total	Single	Married	Widowed	Divorced or separated	Total
	Rural population														
0-9	32 809				32 809	32 511				32 511	65 320				65 320
10-14	13 872	125	3	—	14 000	13 001	984	11	3	13 999	26 873	1 109	14	3	27 999
15-19	10 292	613	10	1	10 916	5 016	5 611	89	28	10 744	15 308	6 224	99	29	21 660
20-24	5 795	2 867	29	10	8 701	755	8 071	163	58	9 047	6 550	10 938	192	68	17 748
25-29	1 889	5 935	64	29	7 917	151	7 607	245	69	8 072	2 040	13 542	309	98	15 989
30-34	495	6 458	99	35	7 087	74	6 497	480	70	7 121	569	12 955	579	105	14 208
35-39	192	6 166	132	36	6 526	47	5 270	620	62	5 999	239	11 436	752	98	12 525
40-44	147	5 413	199	32	5 791	36	4 015	1 023	50	5 124	183	9 428	1 222	82	10 915
45-49	87	4 558	247	31	4 923	26	2 940	1 195	32	4 193	113	7 498	1 442	63	9 116
50-54	61	3 647	337	27	4 072	20	1 830	1 594	24	3 468	81	5 477	1 931	51	7 540
55-59	37	2 846	326	22	3 231	25	1 241	1 490	22	2 778	62	4 087	1 816	44	6 009
60-64	30	2 047	372	13	2 462	11	632	1 586	10	2 239	41	2 679	1 958	23	4 701
65-69	19	1 378	310	8	1 715	8	372	1 214	6	1 600	27	1 750	1 524	14	3 315
70+	28	1 639	661	14	2 342	12	297	2 068	5	2 382	40	1 936	2 729	19	4 724
TOTAL	65 753	43 692	2 789	258	112 492	51 693	45 367	11 778	439	109 277	117 446	89 059	14 567	697	221 769
	Urban population														
0-9	9 683				9 683	9 507				9 507	19 190				19 190
10-14	4 329	14	—	—	4 343	3 950	113	1	—	4 064	8 279	127	1	—	8 407
15-19	4 254	97	1	1	4 353	2 657	1 419	9	6	4 091	6 911	1 516	10	7	8 444
20-24	3 231	714	6	2	3 953	760	2 683	32	14	3 489	3 991	3 397	38	16	7 442
25-29	1 136	1 851	14	5	3 006	146	2 525	59	14	2 744	1 282	4 376	73	19	5 750
30-34	282	2 296	27	5	2 610	58	2 030	111	14	2 213	340	4 326	138	19	4 823
35-39	95	2 085	30	5	2 215	30	1 675	162	13	1 880	125	3 760	192	18	4 095
40-44	55	1 783	47	5	1 890	19	1 146	271	13	1 449	74	2 929	318	18	3 339
45-49	35	1 458	54	3	1 550	13	851	330	10	1 204	48	2 309	384	13	2 754
50-54	23	1 066	72	3	1 164	10	515	420	6	951	33	1 581	492	9	2 115
55-59	16	778	71	2	867	7	360	416	3	786	23	1 138	487	5	1 653
60-64	10	531	81	2	624	5	167	410	2	584	15	698	491	4	1 208
65-69	8	340	68	1	417	3	102	314	1	420	11	442	382	2	837
70+	9	397	145	1	552	4	81	526	1	612	13	478	671	2	1 164
TOTAL	23 166	13 410	616	35	37 227	17 169	13 667	3 061	97	33 994	40 335	27 077	3 677	132	71 221

TABLE 17. (*continued*)

Age group	Combined population														
	Male					Female					Total				
	Single	Married	Widowed	Divorced or separated	Total	Single	Married	Widowed	Divorced or separated	Total	Single	Married	Widowed	Divorced or separated	Total
0-9	42 492				42 492	42 018				42 018	84 510				84 510
10-14	18 201	139	3	—	18 343	16 951	1 097	12	3	18 063	35 152	1 236	15	3	36 406
15-19	14 546	710	11	2	15 269	7 673	7 030	98	34	14 835	22 219	7 740	109	36	30 104
20-24	9 026	3 581	35	12	12 654	1 515	10 754	195	72	12 536	10 541	14 335	230	84	25 190
25-29	3 025	7 786	78	34	10 923	297	10 132	304	83	10 816	3 322	17 918	382	117	21 739
30-34	777	8 754	126	40	9 697	132	8 527	591	84	9 334	909	17 281	717	124	19 031
35-39	287	8 251	162	41	8 741	77	6 945	782	75	7 879	364	15 196	944	116	16 620
40-44	202	7 196	246	37	7 681	55	5 161	1 294	63	6 573	257	12 357	1 540	100	14 254
45-49	122	6 016	301	34	6 473	39	3 791	1 525	42	5 397	161	9 807	1 826	76	11 870
50-54	84	4 713	409	30	5 236	30	2 345	2 014	30	4 419	114	7 058	2 423	60	9 655
55-59	53	3 624	397	24	4 098	32	1 601	1 906	25	3 564	85	5 225	2 303	49	7 662
60-64	40	2 578	453	15	3 086	16	799	1 996	12	2 823	56	3 377	2 449	27	5 909
65-69	27	1 718	378	9	2 132	11	474	1 528	7	2 020	38	2 192	1 906	16	4 152
70+	37	2 036	806	15	2 894	16	378	2 594	6	2 994	53	2 414	3 400	21	5 888
TOTAL	88 919	57 102	3 405	293	149 719	68 862	59 034	14 839	536	143 271	157 781	116 136	18 244	829	292 990

TABLE 18. POPULATION DISTRIBUTION SMOOTHED BY COALE'S METHOD, 1971
(*Hundreds*)

Age group	Rural population														
	Male					Female					Total				
	Single	Married	Widowed	Divorced or separated	Total	Single	Married	Widowed	Divorced or separated	Total	Single	Married	Widowed	Divorced or separated	Total
0-9	30 346				30 346	29 565				29 565	59 911				59 911
10-14	13 967	97	2	—	14 066	14 770	850	8	2	15 630	28 737	947	10	2	29 696
15-19	11 060	508	7	1	11 576	5 889	5 012	62	25	10 988	16 949	5 520	69	26	22 564
20-24	6 703	2 554	23	9	9 289	898	7 307	115	51	8 371	7 601	9 861	138	60	17 660
25-29	2 285	5 529	52	27	7 893	185	7 049	177	62	7 473	2 470	12 578	229	89	15 366
30-34	606	6 093	82	33	6 814	93	6 216	358	65	6 732	699	12 309	440	98	13 546
35-39	233	5 781	109	33	6 156	63	5 326	489	60	5 938	296	11 107	598	93	12 094
40-44	179	5 100	164	29	5 472	52	4 324	860	52	5 288	231	9 424	1 024	81	10 760
45-49	110	4 466	212	30	4 818	40	3 409	1 081	36	4 566	150	7 875	1 293	66	9 384
50-54	83	3 828	311	28	4 250	32	2 292	1 559	29	3 912	115	6 120	1 870	57	8 162
55-59	55	3 260	327	24	3 666	45	1 679	1 574	28	3 326	100	4 939	1 901	52	6 992
60-64	48	2 550	406	15	3 019	22	910	1 782	14	2 728	70	3 460	2 188	29	5 747
65-69	33	1 874	369	11	2 287	16	583	1 485	9	2 093	49	2 457	1 854	20	4 380
70+	45	2 052	725	18	2 840	23	410	2 228	6	2 667	68	2 462	2 953	24	5 507
TOTAL	65 753	43 692	2 789	258	112 492	51 693	45 367	11 778	439	109 277	117 446	89 059	14 567	697	221 769
	Urban population														
0-9	8 956				8 956	8 646				8 646	17 602				17 602
10-14	4 208	11	—	—	4 219	4 295	98	1	—	4 394	8 503	109	1	—	8 613
15-19	4 414	81	1	—	4 496	2 987	1 271	7	5	4 270	7 401	1 352	8	5	8 766
20-24	3 608	641	4	2	4 255	866	2 435	22	12	3 335	4 474	3 076	26	14	7 590
25-29	1 327	1 737	12	4	3 080	170	2 345	43	13	2 571	1 497	4 082	55	17	5 651
30-34	334	2 182	22	5	2 543	69	1 947	83	13	2 112	403	4 129	105	18	4 655
35-39	112	1 969	25	5	2 111	39	1 696	127	13	1 875	151	3 665	152	18	3 986
40-44	66	1 692	39	4	1 801	26	1 237	227	13	1 503	92	2 929	266	17	3 304
45-49	45	1 439	47	3	1 534	19	989	298	11	1 317	64	2 428	345	14	2 851
50-54	30	1 127	66	3	1 226	16	647	409	7	1 079	46	1 774	475	10	2 305
55-59	23	897	72	3	995	12	489	438	4	943	35	1 386	510	7	1 938
60-64	16	666	88	2	772	9	241	459	3	712	25	907	547	5	1 484
65-69	13	467	81	2	563	7	160	382	2	551	20	627	463	4	1 114
70+	14	501	159	2	676	8	112	565	1	686	22	613	724	3	1 362
TOTAL	23 166	13 410	616	35	37 227	17 169	13 667	3 061	97	33 994	40 335	27 077	3 677	132	71 221

TABLE 18. (*continued*)

Age group	Combined population														
	Male					*Female*					*Total*				
	Single	*Married*	*Wid-owed*	*Divorced or sepa-rated*	*Total*	*Single*	*Married*	*Wid-owed*	*Divorced or sepa-rated*	*Total*	*Single*	*Married*	*Wid-owed*	*Divorced or sepa-rated*	*Total*
0-9	39 302				39 302	38 211				38 211	77 513				77 513
10-14	18 175	108	2	—	18 285	19 065	948	9	2	20 024	37 240	1 056	11	2	38 309
15-19	15 474	589	8	1	16 072	8 876	6 283	69	30	15 258	24 350	6 872	77	31	31 330
20-24	10 311	3 195	27	11	13 544	1 764	9 742	137	63	11 706	12 075	12 937	164	74	25 250
25-29	3 612	7 266	64	31	10 973	355	9 394	220	75	10 044	3 967	16 660	284	106	21 017
30-34	940	8 275	104	38	9 357	162	8 163	441	78	8 844	1 102	16 438	545	116	18 201
35-39	345	7 750	134	38	8 267	102	7 022	616	73	7 813	447	14 772	750	111	16 080
40-44	245	6 792	203	33	7 273	78	5 561	1 087	65	6 791	323	12 353	1 290	98	14 064
45-49	155	5 905	259	33	6 352	59	4 398	1 379	47	5 883	214	10 303	1 638	80	12 235
50-54	113	4 955	377	31	5 476	48	2 939	1 968	36	4 991	161	7 894	2 345	67	10 467
55-59	78	4 157	399	27	4 661	57	2 168	2 012	32	4 269	135	6 325	2 411	59	8 930
60-64	64	3 216	494	17	3 791	31	1 151	2 241	17	3 440	95	4 367	2 735	34	7 231
65-69	46	2 341	450	13	2 850	23	743	1 867	11	2 644	69	3 084	2 317	24	5 494
70+	59	2 553	884	20	3 516	31	522	2 793	7	3 353	90	3 075	3 677	27	6 869
TOTAL	88 919	57 102	3 405	293	149 719	68 862	59 034	14 839	536	143 271	157 781	116 136	18 244	829	292 990

Source: Smoothing method based on procedure given in Ansley J. Coale, "Constructing the age distribution of a population recently subject to declining mortality", *Population Index*, vol. 37, No. 2 (April-June 1971), pp. 75-82.

Note: For the purpose of smoothing, male $\mathring{e}_0$ was assumed to be 50.0; female $\mathring{e}_0$, 48.0; gross reproduction rate, 2.5; and sex ratio at birth, 107.

APPLICATION OF METHODS OF MEASURING THE IMPACT OF FAMILY PLANNING PROGRAMMES ON FERTILITY: THE CASE OF TUNISIA*

*Yolande Jemai*** and *Hedi Jemai****

The trend towards a decline in fertility among Tunisian women appears to have been confirmed during the past 10 years and therefore to indicate a definite change in the reproductive behaviour of couples, but it is still difficult to isolate the economic and social factors that have resulted in the replacement in the Moslem Arab society of the traditional attitude that favoured large families by a voluntary joint choice of family planning by both spouses.

In order to make a useful contribution to a knowledge of the mechanics of this transition, an effort must be made to identify the relative impact of spontaneous factors and deliberately induced factors on the fall in fertility, if one is to assess the impact of the policy adopted by the Tunisian authorities within the framework of the over-all economic and social development policy of the country.

A number of methods have been proposed for measuring the impact of a family planning programme on fertility, and the purpose here is to test them in the specific case of Tunisia and to try to identify their defects and the methodological difficulties involved in applying them.

In view of the need for uniformity in making any comparison of methods, this assessment has been made for the period 1966–1971 and for Tunisia as a whole. It should be pointed out, however, that this period has been selected for reasons of availability of demographic data, but that it is not the most favourable period for an assessment of the success of the Tunisian programme, as all evidence indicates that awareness of the family planning programme among the population in general has occurred chiefly since 1973, when the National Family Planning and Population Office (ONPFP) was established.

This analysis, which is guided largely by the methodological aspects of the question, essentially takes the form of applying simultaneously over space and time five methods of measuring the impact of family planning programmes on fertility: standardization approach; trend analysis (fertility projection approach); experimental designs; couple-years of protection (CYP); component projection approach. The present report does not cover analysis of the reproductive process and regression analysis.

Before describing the results of the application of these methods and the criticisms suggested by them, however, a brief summary is given of past and recent trends in fertility in Tunisia (some characteristic indicators for Tunisia are also given in annex I).

Past and recent fertility trends in Tunisia

Past trends

Prior to introduction of the national family planning programme in 1964

According to a number of estimates,[1] the population of Tunisia was rising slightly prior to 1921, after which date the first censuses of the native population were carried out. It is generally believed that from 1860 to 1921, the average annual rate of growth was no more than 1 per cent because of high mortality, due to epidemics and deplorable economic and social conditions, which masked the effects of the high birth rate which is traditional among Moslem Arab societies.

From 1921 to 1946, that trend continued; and it was not until after the Second World War that the annual rate of growth approached 2 per cent and continued to rise steadily until 1966, when it reached 2.8 per cent, the highest level ever recorded (see table1).

The progress achieved in the health field since independence is the main cause of the sudden fall in general mortality (27–28 per 1,000 in 1945; 9.5 per 1,000 in 1974),[2] which thus revealed the effects of natality. The high fertility level was, and still is, closely connected with a social and cultural context which requires, in Arab countries, that matrimonial customs conform to a number of rules codified by Islam: very young age at marriage; stability of unions; the prizing of male progeny; and natural behaviour which excludes con-

* The original version of this paper appeared as document ESA/P/AC.7/3.

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[1] See, in particular, Mahmoud Seklani, *La population de la Tunisie* (Paris, Comité international de coordination des recherches nationales de démographie, 1974). See also Mahmoud Seklani, "La population de la Tunisie, situation actuelle et évolution probable jusqu'en 1986", *Population* (Paris), vol. 16, No. 3 (July-September 1961), pp. 473–504.

[2] Office national du planning familial et de la population, *Statistiques de planning familial; indicateurs démographiques,* No. 6, second quarter (Tunis, 1975).

TABLE 1. POPULATION GROWTH IN TUNISIA, CENSUS YEARS, 1921-1975

Census year	*Crude data as of date of census*	*Corrected data*	*Average annual rate of growth (percentage)*
1921	2 093 939	2 000 000	1.2
1926	2 159 708	2 120 000	1.32
1931	2 410 692	2 260 000	1.46
1936	2 608 313	2 426 000	1.79
1946	3 230 952	2 891 000	2.0
1956	3 783 169	3 519 000	3.7
1966	4 533 351	4 589 000	2.8
1975	5 572 229	...	...

Sources: Tunisia, Institut national de la statistique; and for average annual rate of growth, Hedi Jemai, "Tunisie–Madagascar: démographie comparée", *Revue tunisienne de sciences sociales* (forthcoming).

traceptive practices. All these factors have contributed to causing the Tunisian birth rate, which was never among the highest in the world, to reach a dangerous level from the point of view of the requirements of balanced economic and social development.

According to official figures,[3] in 1960, the corrected crude birth rate was 45.7 per 1,000 (191,810 births); in 1964, just before the introduction of the official family planning programme, the crude birth rate reached its highest level, 46.2 per 1,000 (206,046 births) and the general fertility rate (for women aged 15–54 years) was about 207 per 1,000.

From the introduction of family planning until 1970

During the period from the introduction of family planning in 1964 up to 1970, the responsible authorities changed their position from an attitude favouring birth control to state direction in population matters.

Ever since independence, they had been aware of the problem and had taken a number of measures to alleviate it, either directly or indirectly:

(*a*) The Code of Personal Status, promulgated on 13 August 1956, granted women equality of civil status (regulations governing marriage and divorce);

(*b*) In 1961, the French Act of 1920, which prohibited the sale and distribution of contraceptives, was abrogated;

(*c*) In 1964, the minimum age for marriage was raised to 17 years for girls and 20 years for boys;

(*d*) In 1965, the first measure liberalizing abortion authorized the practice of social abortion on certain conditions (minimum of five children).

The decisive step in favour of population policy, however, was taken in 1964, with the initiation of the pilot family planning experiment following the encouraging results of a Knowledge/Attitude/Practice (KAP) survey of the population, which was found to be predominantly in favour of birth control. After two years of work and an analysis of the results, the success of the experiment opened the way for the national family planning programme.

The method that had been most prevalent until then was the intra-uterine device (IUD); however, following a speech by President Bourguiba in favour of population growth and propaganda against that method, there was a falling-off in the activities of the programme. This situation led in 1968 to organizational reforms: resumption of the work of the mobile teams; implementation of a post-partum and post-abortum programme; establishment of a Family Planning Department within the Ministry of Public Health; and most important, wide distribution of pills and condoms. Following these improvements, activities made progress until 1971. At the statistical level, the separate phases described above are illustrated by the data in table 2.

The official figures indicate that during the same period, the general fertility rate (15–54 years) fell from approximately 207 per 1,000 in 1964 to 193 per 1,000 in 1966 and 164 per 1,000 in 1970. According to the fourth economic and social development plan (1973–1976), this fall corresponds to an average annual decline of 5.1 births per 1,000 women of reproductive age, made up of: 1.8 births per 1,000 women of reproductive age averted by the effect of the age structure; and 3.3 births per 1,000 women of reproductive age averted by the specific effect of family planning.

A number of demographers have analysed the impact of various factors on the observed fertility decline between 1966 and 1970;[4] all reached the conclusion that, at most, one third of the decline was caused by family planning, and that age structure and matrimonial status together had an effect of the same magnitude. Accordingly, approximately one third of the fall is thought to have been due to the effect of eco-

[3] Data referred to in this paper as "official figures" were obtained, unless otherwise indicated, from Institut national de la statistique, Tunis.

[4] See, for example, Jacques Vallin, "Limitation des naissances en Tunisie: efforts et résultats", *Population* (Paris), vol. 26, special number (March 1971), pp. 181–204.

TABLE 2. RESULTS OF THE ACTIVITIES OF THE FAMILY PLANNING PROGRAMME, 1964-1970

Year	*Primary insertion of intra-uterine devices*	*New acceptors of the pill*	*Tubal ligation*	*Social abortion*	*New consultations*	*Total consultations*
1964	1 154	—	293	—	6 160	12 620
1966	12 077	350	766	1 396	16 176	41 517
1968	9 304	4 780	1 627	2 246	20 432	67 986
1970	9 638	9 959	2 531	2 705	35 362	184 419

Source: Tunisia, Office national du planning familial et de la population.

nomic and social development, the growth of internal and external migration after 1966, increased school attendance of girls (58.49 per cent in 1971/72) and awareness that the risk of infant mortality had fallen.

Recent trends in fertility: 1970–1975

The trend that had emerged in the preceding period was strengthened, although the decline in fertility might well have been considered a purely circumstantial phenomenon, given the characteristics of the age structure of the population and the reduced impact of the 1964 Act on the age of marriage.

For the period 1964–1974 as a whole, that is to say, after 10 years of the family planning programme, the estimated birth rates and fertility rates were as shown in table 3.

TABLE 3. CRUDE BIRTH RATES AND GENERAL FERTILITY RATES, 1964-1974

Year	*Corrected crude birth rate (live births per 1 000 population)*	*General fertility rate (per 1 000 women aged 15-54 years)*
1960	45.7	195
1961	45.4	...
1962	44.2	...
1963	44.6	...
1964	46.2	207
1965	43.5	190
1966	43.8	193
1967	40.8	178
1968	40.3	175
1969	40.7	177
1970	38.2	164
1971	36.8	157
1972	39.3	165
1973	37.5	156
1974	35.7	149

Sources: For corrected crude birth rate in 1960, A. Marcoux, "Evolution générale et mouvements saisonniers des naissances en Tunisie de 1956 à 1968", *Revue tunisienne de sciences sociales,* vol. 7, No. 20 (March 1970), pp. 173-214; for general fertility rate in 1960, 1964 and 1965, Jacques Vallin and R. J. Lapham, "Place du planning familial dans l'évolution récente de la natalité en Tunisie", *Revue tunisienne de sciences sociales,* vol. 6, Nos. 17-18 (1966), pp. 379-414; for 1974 data, Tunisia, Office national du planning familial et de la population, *Statistiaues de planning familial,* No. 5, second quarter (Tunis. 1975). All other data obtained from Institut national de la statistique, Tunis.

Accordingly, from 1970 onward, the crude birth rate fell below 40 per 1,000 and the general fertility rate (women aged 15–54 years) below 170 per 1,000.

At the regional level, .there are still disparities between the northern governorates and the coastal regions, in which contraception is already widely practised, and the central and southern governorates, whose population still strongly favours large families. In 1970, the official extreme figures for regional crude birth rates were as follows:

	Live births per 1 000 population
Gafsa	41
Kairouan	39
Medenine	41
Bejá	34
Jendouba	33
Le Kef	34
Sfax	33
Tunis	33

These differences are also attributable to the relative impact of the rural environment and the level of economic and social development. Thus far, the population of rural areas has been little affected by new modes of thinking, and their economic and social conditions are very close to the traditional model.

Three models of fertility behaviour have been identified[5] in contemporary society:

(a) *Primal fertility in rural areas:* families are large (from seven to eight children), and age at last birth is high (40–41.5 years), whereas age at marriage is low (18–19 years);

(b) *Advanced fertility pattern found in urban areas among the more affluent social categories:* final family size is no more than three children and contraception is widely practised;

(c) *Transitional fertility pattern of rural population having recently migrated to Tunis:* age at marriage and size of family approach those of rural areas, but age at last birth has fallen by one or two years. Women appear to adopt family planning in the last years of reproductive life.

Having analysed the results of this recent research, the authorities of the family planning programme currently have as their objective the further development of information and education, but with more specific emphasis on agricultural and working-class groups and on integrating population matters into secondary education. Since 1971, new structures have been set up. After the failure of the National Institute for Family Planning and Maternal and Child Welfare, an Act of 1973 created the National Family Planning and Population Office, which has carried out a complete reorganization of services and activities. Quantitative targets have been set for each method and in terms of births to be averted with a view to achieving in 2001 age-specific fertility rates equal to those of Italy in 1970 (see tables 4–7). Tables 6 and 7 provide evidence of the growth of these activities since 1973, which is confirmed by such encouraging results as: rate of protection per 100 women of reproductive age; 8.47 per 100 at the end of 1973 and 10.06 per 100 at the end of 1974;[6] rate of coverage of objectives, 103 per cent in 1974 and 113 per cent in 1975; and 392 family planning centres in operation in 1974.[7]

Another factor in this success was the complete liberalization of social abortion after 26 September 1973, and the extension of the practice of tubal liga-

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[5] M. B'Chir and others, "L'influence sur le taux de fécondité du statut et du rôle de la femme dans la société tunisienne", *Revue tunisienne de sciences sociales*, vol. 10, No. 32-35 (1973), pp. 103-159.

[6] L. Behar, "Taux de protection par le planning familial en 1974 et 1975", *Bulletin de documentation de l'ONPFP* (Tunis, Office national du planning familial et de la population, 1975).

[7] Yolande Jemai, "L'évolution du nombre de centres de planning familial en activité de 1970 au 30 juin 1974", Tunis, Office national du planning familial et de la population, 1974 (mimeographed).

TABLE 4. TARGET FERTILITY RATES FOR TUNISIA IN 2001, BY AGE GROUP

(*Rates per 1,000*)

Age group	*Tunisia, 1971*	*Target 2001 = Italy 1970*
15-19	46	22
20-24	273	104
25-29	321	156
30-34	287	108
35-39	214	58
40-44	102	18
45-49	30	2
50-54	9	—
Crude reproduction rate	3.11	1.14

Source: Tunisia, Institut national de la statistique, *Perspectives d'évolution de la population, 1971-2001* (Tunis, 1972).

tion, but the most popular contraceptive method remains the IUD.[8]

In 1973, a survey of the continuation of contraceptive methods (IUD and pill)[9] gave the following results:

(*a*) Contraception begins late, since the average age

[8] See, for example, M. Ayad, "Les caractéristiques des acceptantes de DIU de 1970 à 1974", April 1975 (mimeographed); and A. Marcoux, "Les utilisatrices du programme de planning familial à la fin de l'année 1973", Tunis, Population Council, February 1974 (mimeographed).

[9] Tunisia, Office national du planning familial et de la population, *Enquête nationale sur la continuation des méthodes contraceptives, 1973:* vol. I. *Présentation et méthodologie;* vol. II. *Exploitation et résultats* (Tunis, 1974–1975).

TABLE 5. TARGETS AND ACTIVITIES OF FAMILY PLANNING PROGRAMMES, 1971-1981

(a) *Number of births to be averted per annum by the family planning programme, 1971-1981*

Year	*Births to be averted*	*Year*	*Births to be averted*
1971	12 000	1977	33 750
1972	15 500	1978	37 500
1973	19 000	1979	41 500
1974	22 500	1980	45 500
1975	26 250	1981	49 500
1976	30 000		

(b) *Former and revised targets for births to be averted, 1976 and 1977*

Births to be averted	*1976*	*1977*
Former target	30 000	33 750
New target	34 300	45 200
Difference	+ 4 300	+ 11 450

(c) *Family planning operations to be carried out, 1975-1976*

Year	*Tubal ligation*	*Social abortion*	*Intra-uterine device*	*Pill*	*Secondary method*
1975	12 000	12 500	25 200	17 800	3 400
1976	12 000	17 350	32 600	24 700	3 700

Source: Tunisia, Office national du planning familial et de la population, *Programme d'activités de l'ONPFP de 1974 à 1977* (Tunis, 1974).

TABLE 6. RESULTS OF ACTIVITIES OF THE NATIONAL FAMILY PLANNING PROGRAMME, 1971-1975

Year	*Primary insertion of intra-uterine device*	*New acceptors of the pill*	*Tubal ligation*	*Social abortion*	*New consultations*	*Total consultations*
1971	12 381	11 778	2 280	3 197	40 360	239 916
1972	13 250	12 026	2 453	4 621	43 665	246 675
1973	16 790	11 194	4 964	6 547	43 840	241 355
1974	19 084	10 795	10 757	12 427	50 901	256 984
1975[a]	(9 917)	(7 709)	(6 503)	(7 833)	(30 927)	(151 714)

Source: Tunisia, Office national du planning familial et de la population, *Statistiques des activités du programme de planning familial de 1971 à 1973* (Tunis, 1974).

[a] Result of the first quarter.

TABLE 7. BIRTHS AVERTED COMPARED WITH TARGET FOR 1971-1975

	1971	1972	1973	1974	1975
Target	12 000	15 500	19 000	22 500	26 250
Achieved	13 330	15 515	17 288	23 117	29 720
$R = \frac{\text{Achieved}}{\text{Target}}$	1.11	1.00	0.91	1.03	1.13

Source: Tunisia, Office national du planning familial et de la population, *Statistiques de planning familial; indicateurs de planning familial,* No. 6, second quarter (Tunis, 1975).

of acceptors is over 30 years (pill, 31 years; IUD, 32 years);

(*b*) Parity among female contraceptive users is higher than that observed elsewhere in the world (pill, 4.4; IUD, 4.75);

(*c*) The educational level of acceptors is very low: 75 per cent are illiterate;

(*d*) Continuation rates are about the average observed elsewhere in the world: pill, 56 per cent after six months, 42 per cent after one year; IUD, 84 per cent after six months, 75 per cent after one year;

(*e*) Protection is less effective for acceptors of the pill than for acceptors of IUD. The pregnancy rate of pill acceptors is not very different from that of the female population as a whole and 25 per cent of acceptors of IUD are pregnant within two years of acceptance, as against 50 per cent of acceptors of the pill.

It has been claimed that the decline in fertility could not continue unless very ambitious family planning targets were achieved. It looks as if they have indeed been achieved: the percentage of births averted by family planning compared with births registered (5 per cent correction) was 4.9 per cent in 1970, but appears to have been 11.5 per cent in 1974. Is there any justification for stating that the decline in the birth rate is largely due to the impact of the national family planning programme in 1974–1975, while the existing age structure is in itself an impediment to the continuation of past trends? It is hoped that the application of the methods proposed for this study will answer that question.

APPLICATION OF THE METHODS TO TUNISIA[10]

Standardization approach

The estimates

In order to determine the relative impact of all the factors involved, the base year selected was 1966, a census year and a year in which fertility was very close to natural fertility.

The official data of the National Statistical Institute (INS) at Tunis were used to show the number of females in the 15–54 age groups from 1966 to 1971; the corrected figures for births registered in 1966 and 1971; and the general fertility rates (for women aged 15–54 years) and age-specific rates for 1966 and 1971.

The application to all women aged 15–54 years in 1971 of the general fertility rate of 1966 gives the number of births which would have occurred among those women if fertility conditions had remained unchanged. Thus, by applying to the female population aged 15–54 in 1971 (whose numbers are estimated at 1,229,300) the 1966 general fertility rate of 193 per 1,000, one obtains 237,255 theoretical births. In fact, births registered by the civil registry authorities, with a 5 per cent correction,[11] numbered 192,959 (see table 8). It is therefore considered that 44,296

[10] This report does not discuss in detail the characteristics of these methods, which are described in the background paper entitled "Methods of measuring the impact of family planning programmes on fertility: problems and issues" (ESA/P/AC.7/1); see part one of the present publication.

[11] The statistics of the civil registry authorities since 1960 are very valuable, as it is generally believed that the rate of registry coverage is 95 per cent for births and 75 per cent for deaths. Such gaps as exist are largely due to non-declaration of the birth of a girl or of the death of a very young child in rural areas. For 1966, the birth figures have not been corrected, because Institut national de la statistique believes the rate of coverage to be 100 per cent for that year.

TABLE 8. DATA USED IN CALCULATING HYPOTHETICAL BIRTHS IN 1971 ON BASIS OF GENERAL FERTILITY RATE IN 1966

	1966	1971
Births registered	206 730	183 311
Corrected number of births	206 730	192 959
Women aged 15-54 (mid-year)	1 071 300	1 229 300
Proportion of married women aged 15-54, per 100	71.8	66.7
Married women aged 15-54 (mid-year)	769 460	818 752
General fertility rate *(per 1,000 women aged 15-45)*	193	157
General legitimate fertility rate *(per 1,000 women aged 15-45)*	268.6	234

Sources: For number of women aged 15-54 years in 1971, Tunisia, Institut national de la statistique, *Perspectives d'évolution de la population, 1971-2001* (Tunis, 1972); proportion of married women in 1971, estimate of A. Marcoux, "Sur les facteurs de l'évolution passée et future des naissances en Tunisie", Tunis, Population Council, 1972 (mineographed). Other data taken from Tunisia, Civil Register; and Institut national de la statistique, *Recensement général de la population et des logements du 3 mai 1966,* new ed. (Tunis, 1973).

Note:

Hypothetical births in 1971 on basis of general fertility rate in 1966: 1 299 300 × 193	237 255
Births registered (corrected) in 1971	192 959
Births averted in 1971 *(standardized on the basis of 1966)*	44 296

(237,255–192, 959) births were averted by all the factors, i.e., 23 per cent of the corrected registered births in 1971, standardized on the basis of 1966.

This decline in births can be attributed to the three effects described below.

Effect of change in age structure of the female population

Had the general age-specific fertility rate remained constant between 1966 and 1971, there would have been 225,410 hypothetical births on the basis of the size of the female population in 1971 (table 9). Thus, the changes in the age structure of the female population aged 15–54 have in themselves had the effect of lowering the number of births by 11,845, or 26.74 per cent of the total births averted.

Effect of changes in legitimate age-specific fertility rates

It has been estimated that there would have been 214,789 hypothetical births in 1971 if the age-specific legitimate fertility rates had remained at the 1966 level; however, there were 192,959 births in 1971, or 21,830 fewer births, which represents 49.28 per cent of the total of births averted (see tables 10 and 11).

Effect of variations in structure by marital status

Had the proportions of married women remained constant in each age group between 1966 and 1971, the number of births estimated on the basis of constant general fertility and constant legitimate fertility rates would have been identical (illegitimate births, amounting to approximately 3 per cent in Tunisia, are not taken into account here). Thus, the difference between these figures is due solely to the effect of changes in these proportions between 1966 and 1971.

It is accordingly necessary to estimate the hypothetical births which would have taken place among married women in 1971 if legitimate age-specific fertility had remained at the 1966 level.

The difference between the total of hypothetical births in 1971 on the basis of general age-specific fertility in 1966 and the total of hypothetical births in 1971 on the basis of legitimate age-specific fertility in 1966 gives the births averted as the result of changes in structure by marital status, as follows:

$$225{,}410 - 214{,}789 = 10{,}621 \text{ births}$$

or $\dfrac{10{,}621}{44{,}296} = 23.98$ per cent of total births averted:

Hypothetical births in 1971 on basis of 1966 general age-specific fertility rate	225,410
Hypothetical births in 1971 on basis of 1966 legitimate age-specific fertility rate	214,789
Births averted by changes of structure by marital status	10,621

The results

The estimates given above can be summarized as follows:

Corrected figures for births registered in 1971	192,959
Total births averted in 1971 (by comparison with the base year 1966)	44,296

TABLE 9. ESTIMATE OF HYPOTHETICAL BIRTHS IN 1971, BASED ON GENERAL FERTILITY RATES IN 1966

Age group	1966: Women aged 15-54 (thousands, at mid-year) (1)	1966: General fertility rate (per 1 000 women aged 15-54) (2)	1971: Women age 15-54 (thousands, at mid-year) (3)	1971: General fertility rate (per 1 000 women aged 15-54) (4)	Hypothetical births based on 1966 age-specific rates (2) × (3)=(5)
15-19	198.8	73	291.8	41	21 300
20-24	153.3	296	190.3	255	56 330
25-29	152.3	350	143.8	309	50 330
30-34	147.1	316	144.8	283	45 760
35-39	131.3	236	141.0	210	33 280
40-44	105.4	114	126.1	102	14 380
45-49	95.6	31	101.1	26	3 130
50-54	87.5	10	90.4	9	900
TOTAL	1 071.3	193	1 229.3	157	225 410

Sources: Tunisia, Institut national de la statistique, *Recensement général de la population et des logements du 3 mai 1966*, new ed. (Tunis, 1973); for forecast of number of women aged 15-54 years in 1971, *idem, Perspectives d'évolution de la population, 1971-2001* (Tunis, 1972).

Note:

Hypothetical births in 1971 on the basis of the general fertility rate for 1966	= 237 255
Hypothetical births in 1971 on the basis of the age-specific general fertility rates in 1966	= 225 410
Births averted in 1971 by the change in the age structure of the female population (by comparison with 1966)	= 11 845

TABLE 10. DATA USED IN ESTIMATING HYPOTHETICAL BIRTHS IN 1971 ON BASIS OF LEGITIMATE FERTILITY RATES IN 1966

Age group	1966				1971			
	Women aged 15-54 (thousands, at mid-year)	*Proportion of married women (percentage)*	*Married women aged 15-54*	*Legitimate fertility rate (per 1 000)*	*Women aged 15-54 (thousands, at mid-year)*	*Proportion of married women[a] (percentage)*	*Married women aged 15-54*	*Legitimate fertility rate (per 1 000)*
15-19	198.8	18.5	36 778	400	291.8	12.0	35 016	342
20-24	153.3	71.1	108 996	410	190.3	68.7	130 736	371
25-29	152.3	88.5	134 785	398	143.8	85.5	122 949	362
30-34	147.1	92.4	135 920	342	144.8	92.1	133 361	307
35-39	131.3	91.8	120 533	260	141.0	92.7	130 707	226
40-44	105.4	87.9	92 647	129	126.1	89.8	113 238	113
45-49	95.6	81.8	78 201	38	101.1	84.2	85 126	32
50-54	87.5	70.4	61 600	12	90.4	74.8	67 619	13
TOTAL	1 071.3	71.8	769 460	268.6	1 229.3	66.7	818 752	234

Source: Tunisia, Institut national de la statistique.

[a] Proportions estimated by extrapolating the data for 1956 and 1966 and taking into account the raising of the age of marriage by a law of 1964. See A. Marcoux, "Sur les facteurs de l'évolution passée et future des naissances en Tunisie", Tunis, Population Council, 1972 (mimeographed).

Broken down as follows:

	Number	*Percentage*
Effect of age structure	11,845	27
Effect of structure by marital status	10,621	24
Effect of variations in legitimate fertility	21,830	49
	44,296	100

The diminished birth cohorts caused by epidemics and food shortages during the Second World War (1939–1945) largely explain the births averted by the effect of structure. Without these losses, the number of women aged 25–29 in 1971 would have been higher by 20,000; and they would have given birth to 6,180 children if their general fertility rate had been the same as that observed in the group aged 25–29 in 1970, or 309 per 1,000.

It should be noted that the effect of the diminished cohorts reaching their maximum fertility between 1969 and 1973 is due to the circumstances prevailing at the time. Beginning with 1975, the 25–29 year age group will be composed of the larger cohorts born after the war; furthermore, estimates have shown that the number of births averted by the effect of age structure after 1971 was declining.[12]

Nearly one fourth of the births averted have been due to the change in structure by marital status and are concentrated in the 15–19 age group. This situation results from the application of the law of 1964 raising the age of marriage for women to 17 complete years, but also from a number of factors tending to modify traditional structures as they affect marriage (school attendance of girls, growing urbanization, advancement of women in society in general).[13] Lastly, almost half the births averted are attributable to factors specifically affecting fertility as such, including the impact of the national family planning programme.

If the estimates of the Population Division of ONPFP are accepted as satisfactory, it will be seen that the activities of the official programme have in themselves had the effect of averting 13,330 births, or 30.09 per cent of the total of births averted, which coincides with the percentage generally acknowledged by various researchers. This estimate depends upon the validity of the method used in estimating the number of women protected and of births averted; however, account has not been taken of contraception practised by individuals independently of the government programme or of the indirect effects produced by official education and information programmes.

As to the other factors (social and economic), it is recognized that they must have helped to determine the new behaviour adopted by many couples, but any measurement of them is still a very rough estimate. The most important among them are the spread of education and particularly school attendance of girls (however, the increased attendance resulting from the raising of the minimum age of marriage for girls to 17

TABLE 11. ESTIMATE OF HYPOTHETICAL BIRTHS IN 1971, BASED ON LEGITIMATE FERTILITY RATES IN 1966

Age group	*Married women aged 15-54 years, 1971*	*Legitimate age-specific fertility rate, 1966 (per 1 000)*	*Hypthetical births in 1971 based on legitimate age-specific fertility rates for 1966*
15-19	35 016	400	14 006
20-24	130 736	410	53 602
25-29	122 949	398	48 934
30-34	133 361	342	45 609
35-39	130 707	260	33 984
40-44	113 238	129	14 608
45-49	85 126	38	3 235
50-54	67 619	12	811
TOTAL	818 752	268.6	214 789

Note:

Hypothetical births in 1971 based on legitimate age-specific fertility rates for 1966	214 789
Registered births (corrected figures) in 1971	192 959
Births averted in 1971 by changes in legitimate fertility (by comparison with 1966)	21 830

[12] M. Ayad, "La fécondité des Tunisiennes en mutation", Tunis, Office national du planning familial et de la population, 1975.

[13] L. Behar, "Evolution récente de la nuptialité en Tunisie", Tunis, Office du planning familial et de la population, 1975.

has not reduced appreciably the reproductive period of the lives of women in general); and migrations. Workers in foreign countries, who have been numerous since 1966, often live alone in the receiving country and the absence of the husband from Tunisia reduces the reproductive life to a corresponding extent; but in the majority of cases the husband returns each year and the total progeny of the couple is not reduced. However, internal migration has definitely had an important impact on the decline in fertility because the migrants leaving their villages for the towns often adopt urban behaviour, as has been verified by INS.[14]

As concerns the decline in mortality, the general death rate, as officially reported by INS with a correction of 30 per cent, dropped from 14.0 per 1,000 in 1966 to 95 in 1974. The decline in infant mortality has been much smaller, but the progress made in the field of health has increased the chances of a couple seeing their children reach adulthood. The other economic and social development factors have had an impact only in their combined action, which is all the more difficult to measure; individually, they have not been determinative. Nevertheless, through their influence on fertility they have accounted for about 20 per cent of the total of births averted, which is by no means negligible; and it would be worth while to determine more explicitly how this effect has been achieved, provided an appropriate method of doing so could be applied.

Appraisal of the method

The standardization approach has the advantage of being easy to apply and of showing clearly the impact of the different factors analysed in lowering fertility. It leads to results that are consistent with findings actually made, and it can thus be usefully taken into consideration by the authority in assessing the proportion of the decline in fertility which will take place spontaneously, thus relieving the burden on the family planning programme.

Nevertheless, it is this very simplicity which also constitutes the weakness of the method, for the three reasons discussed below.

First, it is assumed that the factors are additive and independent of one another, and some are favoured because they are easier to measure.

The fact is, however, that in Tunisia, the family planning programme is part of an over-all development model which favours small families and penalizes those which deviate from the model. All the economic and social measures on which the planning undertaken since 1962 is based are directed to a type of society where the traditional family cannot continue to exist and where the couple is obliged to change its behaviour and, in particular, its attitude towards procreation, exercising more control in this sphere if it wishes to share in and benefit from the advantages the model offers (education for the couple's children, home ownership, a motorcar, medical care etc.).

The family planning policy cannot be reduced to the activities of the programme properly so called, for all the legislative measures referred to earlier, including the law of 1964 raising the age of marriage, contribute to the possibility of making a controlling choice, at all levels, with regard to fertility.

Secondly, in addition to acknowledging the rigidity of this technique of analysis, one must also realize the fragility of the conclusions reached, depending upon the degree of reliability of the data used. Thus, for the present estimates, it was considered that under-registration of births amounted to 5 per cent (according to INS), whereas some sources maintain that under-registration in 1971 amounted to 6.9 per cent, which would mean that the number of births would be higher by 3,938 (196,897 instead of 192,959).

Furthermore, the figure for the female population in 1971 is the result of forecasts and of an estimate of the proportions of married women by extrapolation, the quality of which cannot be assessed until after publication of the results of the 1975 census. Lastly, the formula that has made it possible to relate hypothetical births to constant legitimate and general fertility is based on the assumption that the number of illegitimate births is negligible (2.5 per cent in 1971 and 3.3 per cent in 1966).

Thirdly, in taking 1966 as the base year, the primary considerations were the use of census data and the beginning of the official family planning activities, but where structure by age and by marital status is concerned, it is not certain that that choice was ideal. The fact is that by 1966 the effects of the law of 1964 were already being felt; and, in addition, a distortion occurred in nuptiality for the period 1964–1966, due to circumstances prevailing at that time.

Moreover, the present estimate assumes that the women who did not marry or were not born would have had the same fertility as the women who were actually married in 1971. The effects of structure by age and by marital status are undoubtedly overestimated.

Trend analysis

The estimates

On the basis of the series of birth rates (corrected figures) for the period from 1956 to 1973,[15] the level and trend of fertility before the introduction of the programme were determined. Dealing in the same manner with the period after 1964, it was possible to

[14] Tunisia, Institut national de la statistique, *Enquête migration et emploi à Tunis, 1972–1973. Résultats*, Demographie Series, No. 4 (Tunis, 1974).

[15] For the period 1956–1959, the figures are those given in A. Marcoux, "La croissance de la population de la Tunisie: passé récent et perspectives", *Population* (Paris), vol. 26, special issue (March 1971), pp. 105–123; for 1960–1973, official figures published by Institut national de le statistique have been used.

measure the extent of the decline which, according to this method, is attributable to the family planning programme (see table 12).

The figures given below show first the estimates on the basis of which the trend of fertility from 1956 to 1963 was determined, and then the estimates from 1965 to 1971 (see also figure I):

CRUDE BIRTH RATE, 1956–1963; ESTIMATE OF TREND

x	y	x^2	y^2	xy
1	46.4	1	2,152.9	46.4
2	46.5	4	2,162.2	93.0
3	46.3	9	2,143.6	138.9
4	46.2	16	2,134.4	184.8
5	45.7	25	2,088.4	228.5
6	45.4	36	2,061.1	272.4
7	44.2	49	1,953.6	309.4
8	44.6	64	1,989.1	356.8
36	365.3	204	16,685.3	1,630.2

$n = 8$
$\bar{x} = 4.5$
$\bar{y} = 45.7$

$$a = \frac{\Sigma\, xiyi - n\,\bar{x}\,\bar{y}}{\Sigma\,(xi)^2\, n\,\bar{x}^2}$$

$$a = \frac{1{,}630.2 - 1{,}643.8}{240 - 162} = -\,13.6/42 = \boxed{-\,0.32}$$

$$b = \bar{y} - a\bar{x} = 45.7 - [(-\,0.32)\,(4.5)] = 47.14$$

$$\boxed{Y_1 = -\,0.32\;X_1 + 47.14}$$

CRUDE BIRTH RATE, 1965–1971; ESTIMATE OF TREND

x	y	x^2	y^2	xy
10	43.5	100	1,892.25	435.0
11	43.8	121	1,918.44	481.8
12	40.8	144	1,664.64	489.6
13	40.3	169	1,624.09	523.9
14	40.7	196	1,656.49	569.8
15	38.2	225	1,459.24	573.0
16	36.8	256	1,354.24	588.8
91	284.1	1,211	11,569.39	3,661.9

$n = 7$
$\bar{x} = 13$
$\bar{y} = 40.6$

$$a = \frac{3{,}661.9 - [(7)(13)(40.6)]}{1{,}211 - 7(13)^2} = \frac{[3{,}6619 - 3{,}694.6]}{1{,}211 - 1{,}183}$$

$$= \frac{-\,32.7}{28} = \boxed{-1.17}$$

$$b = \bar{y} - a\bar{x} = 40.6 - [-\,1.17(13)] = [55.81]$$

$$\boxed{Y_2 = -\,1.17\,X_2 + 55.81}$$

The results

With reference to the birth rate, the estimates and figure I show the following results:

(*a*) From 1956 to 1963, a slow decline of 0.32 point per annum;

(*b*) After the 1964 peak, resulting from the rush of marriages in 1963, a more rapid decline of 1.17 points per annum.

TABLE 12. CRUDE BIRTH RATES AND PERCENTAGE OF DECLINE IN SUCCESSIVE YEARS, 1956-1971

Year	Rate	Decline	Year	Rate	Decline
1956	46.4		1964	46.2	+3.6
1957	46.5	+0.2	1965	43.5	−5.8
1958	46.3	−0.4	1966	43.8	+0.7
1959	46.2	−0.2	1967	40.8	−6.8
1960	45.7	−1.0	1968	40.3	−1.2
1961	45.4	−0.7	1969	40.7	+1.0
1962	44.2	−2.6	1970	38.2	−6.1
1963	44.6	+0.9	1971	36.8	−3.7

Sources: For 1956-1959, A. Marcoux, "La croissance de la population de la Tunisie: passé récent et perspectives", *Population* (Paris), vol. 26, special issue (March 1971), pp. 105-123; for 1960-1971, official figures of Institut national de la statistique, Tunis.

Note: The year 1964 was exceptional: the peak in the birth rate registered that year (46.2 per 1 000) was actually a consequence of the rush of marriages in 1963, the year preceding that in which the age of marriage for women was fixed at 17 years. In estimates for measuring the percentage of the annual decline in the birth rate for the period 1956-1971, the rate for 1964 has been eliminated, because it distorted the general trend of the curve.

This method thus assumes that before the introduction of the family planning programme in 1964–1965, the decline was 0.32 point per annum; and the birth rate was influenced by urbanization, industrialization and all the other factors of economic and social development in general. It might have been expected that the trend would continue to be slow and linear in the following years; however, after family planning activities had begun and the circumstantial effects of the law of 1964 raising the age of marriage began to be felt, the decline accelerated, reaching 1.17 points per annum. Consequently, the increase in the decline of the crude birth rate must be attributed to the family planning programme.

Appraisal of the method

While noting that the interruption in the trend of the crude birth rate between 1956 and 1971 is very marked and that it can confidently be deduced that this change is due to the introduction of the family planning programme, it is nevertheless necessary, for a number of reasons, to be very cautious in making a quantified estimate of the impact of the programme.

First, the method of estimating the trend is very approximate and is based on a mathematical technique which is often challenged in its application to economic and social phenomena.

Secondly, the downward trend of the crude birth rate must be viewed in the light of trends in the general fertility rate, shown in table 13 and figure II.[16]

Until 1961, the rate of increase in fertility appears to have been steady because the female population of

[16] This comment is based on the analysis of A. Marcoux, "La croissance de la population de la Tunisie: passé récent et perspectives".

TABLE 13. TRENDS IN THE GENERAL FERTILITY RATE, 1958-1974
(Rate per 1 000 women aged 15-54 years)

Year	General fertility rate	Year	General fertility rate
1958	186.6	1966	193
1959	188.7	1967	178
1960	189.5	1968	175
1961	190.6	1969	177
1962	187.0	1970	164
1963	188.6	1971	157
1964	198.1	1972	165
1965	187.2	1973	156
		1974	149

Sources: For 1958-1965, rates estimated by A. Marcoux, "La croissance de la population de la Tunisie: passé récent et perspectives", *Population* (Paris), vol. 26, special issue (March 1971), pp. 105-123; for 1966-1971, official rates; see Tunisia, Institut national de la statistique, *Naissances, décès, marriages, divorces, 1970; statistiques détaillées,* Demographic Series, No. 5 (Tunis, 1974).

reproductive age was growing at a rate markedly lower than that of the population as a whole, owing to emigration and the arrival at reproductive age of the "diminished birth cohorts"; however, that factor had only a very slight effect on fertility, because women in the 15–19 age group have a low fertility rate. Thus, those two phenomena did not appreciably decrease the birth potential, which explains the rise in general fertility rates (15–54 years).

In a second phase, 1964–1966, there was a circumstantial fluctuation due to the rush of marriages in 1963 in anticipation of the law of 1964, leading to an exceptional increase in births and hence to particularly high fertility rates. The general trend in the period 1966–1971 was unquestionably downward for both fertility rates and birth rates. But to the effect of the family planning programme, which has certainly been considerable, must be added the "braking" effect on fertility exercised by the "diminished birth cohorts" upon reaching the age of high fertility (in 1970, they formed the 25–29 age group). Thus, trend analysis (the fertility projection method) provides a very crude means of determining trends in the period in question.

Lastly, unlike the standardization approach applied above, trend analysis does not permit estimation of the relative impact of the various factors contributing to the decline in fertility and attributes to the programme an impact considerably greater than it has had in reality. If one considers, as has already been stated, not only family planning activities *per se* but the aggregate of the indirect effects of the programme, and then the demographic policy of Tunisia, it can be seen that this method enables one to measure in a much more significant way the results of the policy implemented by the authorities.

As in the case of the standardization method, here too it is necessary to be able to judge the reliability of the data used. As concerns births, this aspect has already been commented upon. With respect to total population (see table 14), the INS estimates were used by interpolation of the censuses between 1956 and 1966 and by extrapolation for the period 1966–1971.[17]

[17] The forecasts of Institut national de la statistiques for the period 1971–2001 (drawn up in 1972) are based on several hypotheses:

(a) *Mortality:* according to United Nations studies made in countries at a level of development similar to that of Tunisia, life expectancy at birth is increasing by about 6 months per year;

(b) *Fertility:* it should drop steadily, reaching in 2001 the rates per age prevailing in Italy in 1970 (cited in table 4);

(c) *External migration:* it should gradually become negligible.

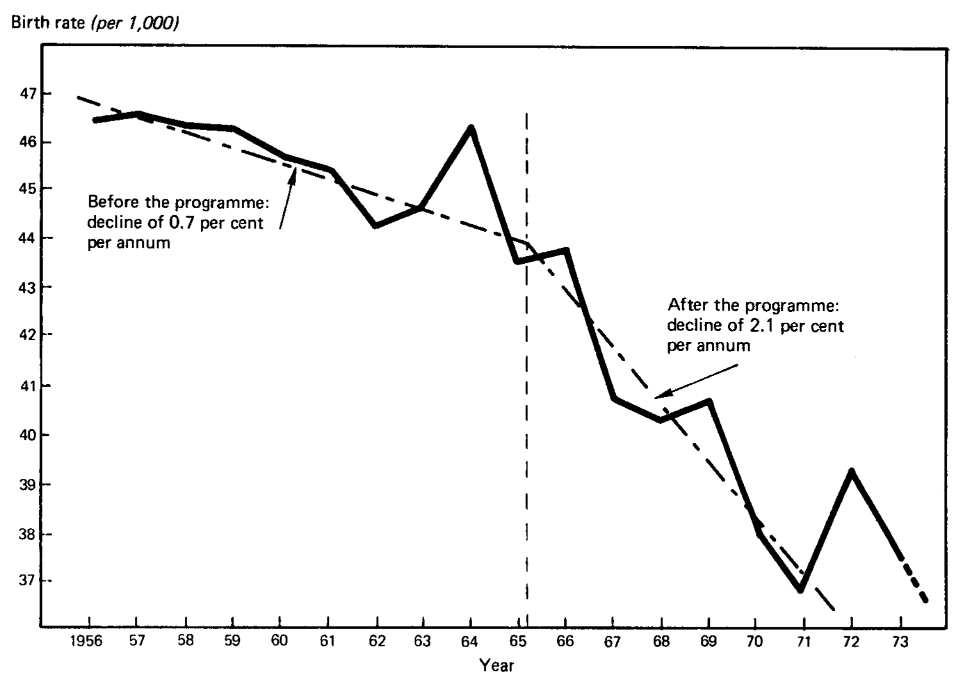


Figure I. Tunisia: trends in the crude birth rate, 1950–1973

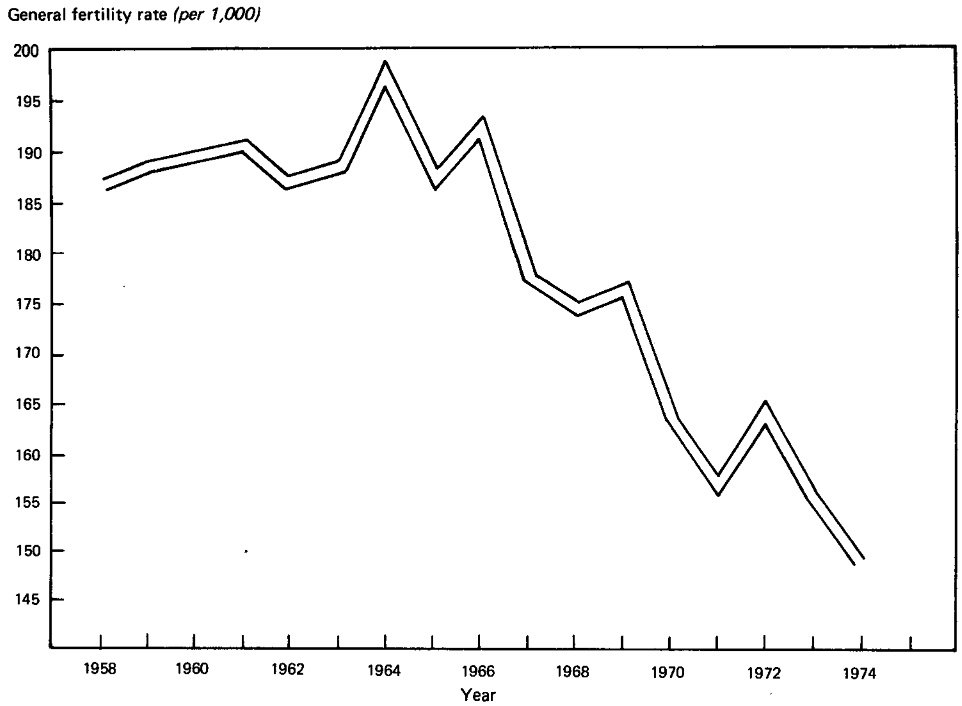


Figure II. Tunisia: trend in the general fertility rate, 1958-1974

Experimental designs

Experimental group A

The experimental group (A) selected for the application of the experimental-design method consists of the women who were interviewed for a survey on "continuation of the principal contraceptive methods under the Tunisian Family Planning Programme" conducted by ONPFP in 1973.[18]

The purpose of the survey was to provide scientific answers to the questions that arise concerning the effectiveness and demographic impact of the programme and concerning some aspects of the actual operation of the programme.

[18] Tunisia, Office national du planning familial et de la population, *Enquête nationale sur la continuation des méthodes contraceptives, 1973;* vol. I. *Présentation et méthodologie;* vol. II. *Exploitation et résultats.*

TABLE 14. TRENDS IN PROPORTION OF TOTAL POPULATION REPRESENTED BY FEMALE POPULATION, 1958-1971

Year	*Total population at 1 July (thousands)* (1)	*Female population aged 15-54 years (thousands)* (2)	*Proportion of women aged 15-54 years (percentage)* (2)/(1)
1958	4 040.0	1 002.0	24.8
1959	4 117.0	1 007.0	24.4
1960	4 198.5	1 013.0	24.1
1961	4 268.5	1 018.0	23.8
1962	4 335.0	1 027.0	23.7
1963	4 422.0	1 039.0	23.5
1964	4 523.0	1 050.0	23.2
1965	4 619.5	1 063.0	23.0
1966	4 717.5	1 071.3	22.7
1967	4 825.0	1 103.7	22.9
1968	4 928.0	1 135.2	23.0
1969	5 027.5	1 165.1	23.2
1970	5 126.5	1 194.3	23.3
1971	5 228.4	1 229.3	23.5

Source: Tunisia, Institut national de la statistique.

Characteristics of the sampling procedure

The choices that governed the preparation of the sampling scheme were as follows:

(*a*) The persons about whom information was sought were women who had accepted the IUD or the pill at family planning programme centres;

(*b*) Of those women, the population to be interviewed would be restricted to those who had accepted after 1 January 1969 and at least a year before the survey, so that for all the respondents there would be data relating to a one-year continuation.

(*c*) The sample would be nation-wide, meaning that every acceptor, whatever centre she belonged to, would have the same probability of being included in the sample;

(*d*) The statistical results that the survey would attempt to obtain would be nation-wide;

(*e*) In order to be able to detect any disparities between the continuation rates for the two methods at a satisfactory level of significance, the sample to be surveyed would consist of 2,000 persons, comprising 1,000 IUD acceptors and 1,000 pill acceptors. The sampling rate would thus be 1/35.

When it came to drawing the sample, the question was what procedure should be chosen for making the selection from among the population of 69,906 acceptors registered, between January 1969 and April 1972, at 350 centres whose volume of activity for that period varied from 1 to 4,868 acceptors. The following choices were made:

(*a*) The sample would be drawn in two stages: first a sample of centres; and then a sample of acceptors at each selected centre;

(*b*) The distribution of the 2,000 expected respondents would be 40 women per centre at 50 centres;

(*c*) Centres would be drawn with a probability proportionate to their "size" (number of acceptors during the reference period), and the same number of women (40) would be drawn at each selected centre, thus giving every acceptor an equal probability of being included in the sample;

(*d*) The method of drawing centres would allow for geographical stratification, with the aim of improving accuracy and obtaining some data by major geographical divisions.

Thus, the theoretical sample—the number of acceptors multiplied by the sampling fraction—would number 2,227. In fact, the actual sample comprised only 2,060 acceptors, or 92.5 per cent of the 2,227 expected.

However, it is important to mention that this sample, which forms the experimental group A, includes only acceptors of two principal methods, namely, the pill and IUD, the results for which are dealt with separately. This restriction on the composition of the group was necessitated by the lack of any statistical data concerning acceptors of other contraceptive methods (another survey is in progress on the characteristics of women who have undergone an abortion or tubal ligation).

Control groups

It was impossible to find in Tunisia a group of women who had not been affected by the national family planning programme and had socio-demographic characteristics similar to those of acceptors. In order to be able to apply the experimental method in spite of this problem, two alternative solutions were found.

First, the fertility of IUD and pill acceptors, as determined by the survey described above, was compared with the age-specific fertility rates for all married women for 1966 and 1971. Acceptors are, of course, included in this population, a fact which tends to over-represent the effects of the programme for the purpose of comparison with 1966 fertility and to under-represent its effects in the comparison with 1971 fertility.

The comparability of the two groups is difficult to analyse because for 1971 the socio-demographic characteristics of the married female population are not known and reference had to be made to the 1966 census figures. It may, however, be assumed that the changes were not very great. This control group is hereafter referred to as group B.

Secondly, the fertility of acceptors before and after acceptance also was compared, assuming that the control group, referred to as group C, consists of women who are not yet acceptors and comparing the fertility of the two groups at the same age.

Comparability of the groups

Comparison with control group B

On the basis of the data available both for experimental group A and for control group B, it was possible to select five comparison factors, which are discussed separately below.

Age distribution. For the purpose of comparing the age distribution of group A with that of group B, it was decided to match acceptors with married women—and not all women—according to the census figure for 1966 and an estimated figure for 1971 determined by application of the standardization approach (table 15). This decision was facilitated, first, by the fact that in Tunisia, acceptors are often, if not always, married; and, secondly, by the availability of this datum for both 1966 and 1971.

Before comparing these age distributions, it is important to bear in mind some data yielded by the "continuation" survey. According to the results of that survey,[19] the mean age at the time of acceptance is 30.8 years for IUD acceptors and 30.0 years for pill acceptors; the median age is 31.5 years for the former and 30.5 years for the latter.

These figures, when compared with observed behaviour in other countries, show that acceptance of contraception occurs rather late in Tunisia. Only Hong Kong (32.4 years in 1968), Morocco (33 in 1972) and the Republic of Korea (33.2 in 1966) have higher median ages than Tunisia for IUD. In the case of the pill, the only example of the same order is that of the Republic of Korea (34 years in 1969).

It must be said that it is quite common for the population of pill acceptors to be younger than that of women practising intra-uterine contraception. This situation is often due to the fact that oral contraceptives are more convenient for women who want to space births rather than prevent them altogether, and that the lower mean age of pill acceptors is associated, as is shown below, with lesser parity.

If one now compares the two distributions (see figure IV) for the experimental group with those for the control group in both 1966 and 1971, it can be seen that the former group differs from the latter in having a relative concentration of acceptances around the 30–34 age group. In any event, these distributions are seldom similar, which would indicate a comparable degree of acceptance of contraception at all ages.

Geographical distribution. For the purpose of comparing the geographical origin of experimental group A with that of control group B, lower and upper age limits of 20 and 44 years were set for women in the

[19] *Ibid.*, vol. II, p. 3.

TABLE 15. DISTRIBUTION, BY AGE GROUP, OF EXPERIMENTAL GROUP A, ACCORDING TO METHOD; AND CONTROL GROUP B, ACCORDING TO 1966 CENSUS AND 1971 ESTIMATE

(*Percentage*)

Age group	*Experimental group A according to method*		*Control group B according to:*	
	Intra-uterine device	*Pill*	*1966 census*	*1971 estimate*
15-19	1.9	2.7	5.0	4.7
20-24	18.0	19.3	15.5	17.4
25-29	21.5	24.0	19.8	16.4
30-34	25.2	25.6	19.8	17.8
35-39	21.6	17.5	17.3	17.4
40-44	7.4	6.5	12.7	15.0
45-49	1.9	1.3	9.9	11.3
Not stated	2.5	3.1	...	...
TOTAL	100.00 (1 136)	100.0 (924)	100.0 (690 453)	100.0 (751 133)

latter group (see table 16). The reason for this limitation was to avoid distorting the results, which would have vitiated the comparison, precisely because of the high percentage of underestimation (see table 15) of acceptors in group A in both the youngest (15–19) and the oldest (45–49) age groups.

Thus, the figures in table 16 show that there is a sizable over-representation of group-A women residing in the capital and its suburbs (29 per cent), compared with group-B women (17 per cent). This over-representation is greater (nearly double) in other urban areas (40 per cent in group A as against 21 per cent in group B). In the interior (rural) stratum, on the other hand, there is about a 50 per cent under-representation of women in the experimental group (31 per cent), compared with the control group, in which the proportion of women of rural origin is 62 per cent.

Parity by age group. The survey on the continuation of contraceptive methods showed a mean family size of 4.6 children still living at the time of acceptance in the case of IUD acceptors, compared with a mean of 4.3 for pill acceptors; the median figures were 4.5 and 4.2, respectively.

Compared with the 1966 census data (table 17), the mean parity of acceptors by age at the time of acceptance shows (see figure V) that such women (the experimental group) are distinctly more fertile—at the same age—than the average, this being particularly true after the age of 30.[20]

In order to corroborate these findings, a comparison was made of the distribution of women by number of children still living in the experimental group and the control group (table 18).

[20] A comparison between the two groups according to the number of live-born children was not possible owing to a lack of data for group A. However, it should be pointed out that deviations in mortality certainly could not cause such differences in the number of surviving children.

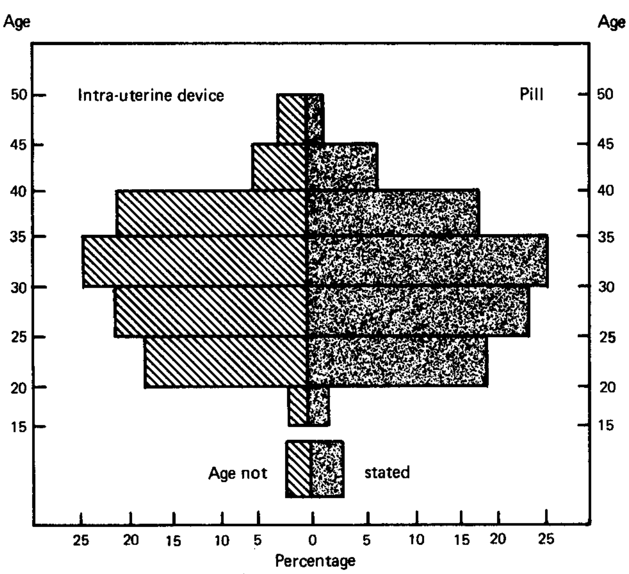


Figure III. Population pyramid of experimental group A, by contraceptive method

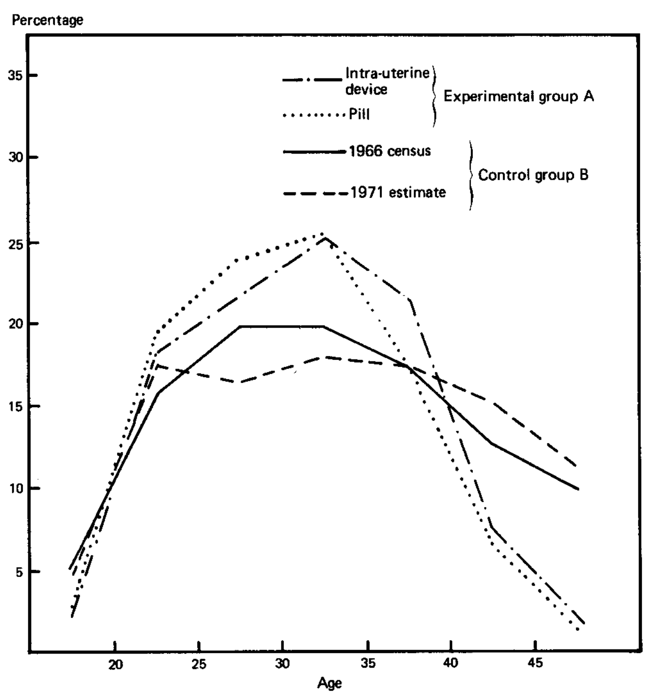


Figure IV. Distribution by age group of acceptors in experimental group A, according to method; and of married women in control group B under age 50 in 1966 (census) and 1971 (estimated)

TABLE 16. GEOGRAPHICAL DISTRIBUTION OF EXPERIMENTAL GROUP A AND CONTROL GROUP B (MARRIED WOMEN BETWEEN THE AGES OF 20 AND 44 IN 1966)

	Experimental group A		*Control group B*	
Geographical origin	*Number*	*Percentage*	*Number*	*Percentage*
Tunis and suburbs	600	29.0	95 394	17.0
Interior (urban)	826	40.0	124 876	21.0
Interior (rural)	634	31.0	366 113	62.0
TOTAL	2 060	100.0	586 383	100.0

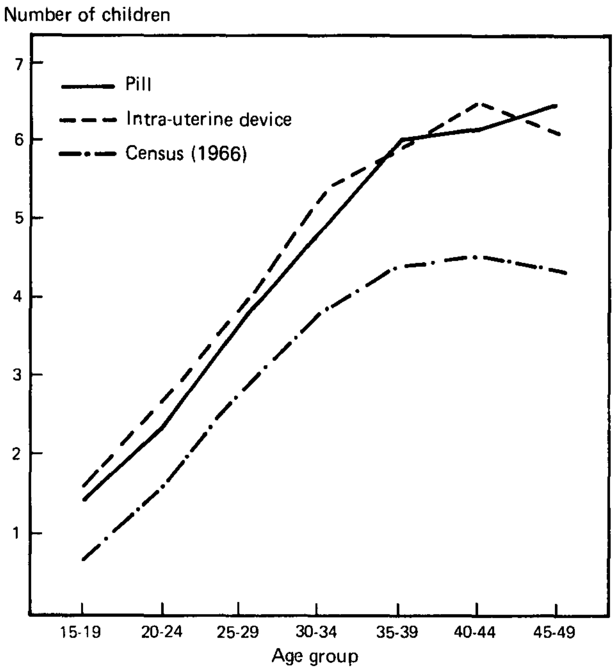


Figure V. Number of children still living, by age group of woman: comparison of experimental group A (by method) and control group B (1966 census)

TABLE 17. NUMBER OF CHILDREN STILL LIVING, BY AGE GROUP OF WOMEN, EXPERIMENTAL GROUP A AND CONTROL GROUP B

	Experimental group A		*Control group B*
Age group	*Intra-uterine device*	*Pill*	*1966 census*
15-19	1.60	1.40	0.66
20-24	2.47	2.30	1.60
25-29	3.88	3.67	2.78
30-34	5.30	4.88	3.80
35-39	5.88	6.0	4.40
40-44	6.48	6.18	4.57
45-49	6.08	6.40	4.48

Thus, tables 17 and 18 show that fertility is higher among contracepting women. It is especially after the fourth child that women decide to limit their offspring; and their fertility then exceeds—as a relative percentage—that of Tunisian women as a whole. This finding leads one to conclude that acceptance of contraception comes late in Tunisia, as previously noted in connexion with age distribution.

Level of education. For the purpose of analysing educational status in the two groups, four categories or levels of education were established. The first comprises women who have had no education and are therefore unable to read or write. The second category consists of women who received a minimal education either from the Koranic schools (*kuttabs*) or from the literacy campaign schools known as "schools of social education". The third category relates to women who completed all or part of the primary cycle of public education. The fourth category comprises all those who went beyond primary school. This classification permitted the comparison shown in table 19.

Within the experimental group itself, a slight difference can be seen, in that pill acceptors are, on average, a little better educated, one fourth of them having had at least some primary education, compared with one fifth of the IUD acceptors.

A comparison between women in the experimental group as a whole and those in the control group, on the other hand, shows that the former group is, on average, much better educated than those in the latter group, 25 per cent of contraceptors having had some formal education as against only 8 per cent of non-contraceptors. This is added evidence of the often-observed relationship between educational status and family planning practice.

Economic activity. The same observation applies to the economic activity of women, as shown in table 20.

In comparison with the control group, the acceptors in the experimental group have a higher proportion of economically active women (11.8 per cent, compared with 5.5 per cent in the control group). However, and contrary to the finding with respect to the level of

TABLE 18. DISTRIBUTION OF WOMEN IN EXPERIMENTAL GROUP A AND CONTROL GROUP B BY NUMBER OF SURVIVING CHILDREN

	Number of surviving children											
Percentage of women ...	0	1	2	3	4	5	6	7	8	9	10+	Not stated
Experimental group	0.4	6.7	12.9	14.4	16.9	16.1	13.7	8.5	5.0	2.1	1.5	1.8
Control group	9.7	12.6	14.3	14.6	16.0	12.5	8.0	5.4	3.0	1.4	0.8	1.1

TABLE 19. COMPARATIVE LEVELS OF EDUCATION OF EXPERIMENTAL GROUP A AND CONTROL GROUP B
(Percentage)

Level of education	Experimental group A			Control group B
	Intra-uterine device	Pill	Aggregate	1966 census
Illiterate	77.1	71.6	74.6	92.1
Kuttab or social education	1.8	3.4	2.6	0.4
Primary	15.7	19.1	17.3	4.3
Secondary, technical or higher	5.1	5.5	5.2	2.6
Other or not stated	0.3	0.4	0.3	0.6
TOTAL	100.0	100.0	100.0	100.0

TABLE 20. COMPARISON OF ECONOMIC ACTIVITY OF WOMEN IN EXPERIMENTAL GROUP A AND WOMEN IN CONTROL GROUP B
(Percentage)

Occupation	Experimental group A			Control group B
	Intra-uterine device	Pill	Total	1966 census
No occupation or housewife	86.9	89.4	88.0	94.0
Women economically active in the home or outside	12.8	10.4	11.8	5.5
Not stated	0.3	0.2	0.2	0.5
TOTAL	100.0	100.0	100.0	100.0

education within the experimental group, fewer acceptors of the pill (10.4 per cent) than acceptors of IUD (12.8 per cent) work.

Comparison with control group C

As mentioned above, control group C comprises the same women as experimental group A. The essential difference between them is that those in group C had never practised any method of contraception whereas group A comprises women who are acceptors of contraceptives.

In order to make this comparison between two fundamentally different states of the same group of women, it was assumed that women in, for example, the 25–29 age group agreed to practise contraception at an average age of 27.5, so that one can describe their fertility at "about age 25" (actually age 24.5) as "before acceptance". This result could then be set against that obtained for acceptors in the 20–24 age group, which would represent the fertility of this group at "about age 25" but "after acceptance".[21]

By using this five-year differential, one is able to compare two different states of the same group. The advantage of this method is, of course, that the socio-economic, cultural and demographic characteristics are identical because the same women are involved.

[21] The method of estimating fertility rates both before and after acceptance is set forth in the section on application and results of the method.

Fertility levels

Having defined the characteristics of each group, one may proceed to a comparison of the series of legitimate fertility rates by age group for experimental group A and control groups B and C.

Differences in fertility between experimental group A and control group B

Before a comparison is made of the fertility rates of the two groups, some comments are called for:

(a) *Regarding experimental group A:* only the series of rates after the second year of acceptance have been used. The reason for this choice is that a woman is not pregnant at the time of acceptance of contraception, which implies a selection process that is reflected in abnormally low fertility rates in the year following acceptance. Therefore, an average of each rate by age group was computed on the basis of the second, third and fourth years after acceptance. In table 21, this series of rates is compared to that obtained for group B;

(b) *Regarding control group B:* two series of age-specific rates were used. The first is that for married women in 1966, and the second is specific to married women in 1971. In order to make the subjects of the comparison homogeneous, the series of rates begin with that for the 20–24 age group, which therefore corresponds, in group A, to that for the group under 25 years. Furthermore and for the same purpose, an average rate was computed for the 40–44 and 45–49 age

TABLE 21. LEGITIMATE FERTILITY RATES FOR ACCEPTORS (*n* YEARS AFTER ACCEPTANCE) IN EXPERIMENTAL GROUP A AND FOR WOMEN IN GENERAL IN CONTROL GROUP B
(Rates per 1 000 women)

	Experimental group A									
	Intra-uterine device acceptors				*Pill acceptors*				*Control group B*	
Age group	*Second year*	*Third year*	*Fourth year*	*Average rate*	*Second year*	*Third year*	*Fourth year*	*Average rate*	*1966 census*	*1971 estimate*
Under 25	177	203	220	200	373	303	272	318	410	371
25-29	81	226	261	189	365	369	362	365	398	362
30-34	105	61	196	120	213	105	281	199	342	307
35-39	30	168	194	130	249	221	171	214	260	226
40 and over	66	45	52	54	41	45	[a]	...	83	72
All ages	95	145	193	144	276	235	253	255	269	234

[a] Insufficient data.

groups which corresponds to that for the 40+ members of group A.

Two comparisons can be made from the data in table 21: the first can be made at the level of the experimental group itself; and the second between group A and group B. Leaving aside for the time being the first level, which is discussed below, the series affecting the groups A and B can be considered.

General fertility rate. Comparing the general fertility rates, all ages combined, in 1966 for the experimental group and the control group gives the following results:

Group B, 1966	*Group A*	*Difference*
269	− 144 (IUD) =	−125
269	− 255 (Pill) =	− 14

The differences between the rates for experimental group A and the results obtained for control group B in 1971 are:

Group B, 1971	*Group A*	*Difference*
234	− 144 (IUD) =	−90
234	− 255 (Pill) =	+21

It is in relation to the 1966 results for group B, therefore, that the fertility of acceptors, regardless of the method of contraception used, has recorded a fairly significant decline. The decline was roughly 46.5 per cent for acceptors of IUD, as against only 5.2 per cent for acceptors of the pill.

On the other hand, the comparison of the observed rates for the experimental group with those of the control group in 1971 still yields a negative difference, though one smaller than that of 1966 for acceptors of IUD, inasmuch as the difference drops from −46.5 per cent to −38.5 per cent; and likewise in the case of pill acceptors, the difference becomes markedly positive (about +9 per cent) precisely because of a higher level of fertility (253) than that recorded for women in general in group B in 1971 (234).

Before commenting on this situation, which may seem anomalous and illogical, some consideration must be given to the distribution of the rates by age.

Figure VI shows the general profile of these rates by age groups. For control group B, there was a fairly substantial decline in fertility between 1966 and 1971, particularly among the youngest age groups. The distance between the two curves is reduced as the age rises, but the downward trend in fertility is systematic regardless of age group. For experimental group A, on the other hand, the curve tends to fluctuate according to the method of contraception. The curve for the IUD acceptors falls steadily as far as the 30–34 age group, rises to reflect the rate for women between the ages of 35 and 39 (130) to a higher level than that of the immediately preceding age group (120), and then resumes its downward slope. Another feature demonstrated by figure VI is that IUD acceptors owe their fall in fertility primarily to those among them in the 25–29 and 30–34 age groups. For acceptors of the pill, the curve follows a zigzag course. The negative difference that it shows in relation to the 1966 curve is, as can be clearly seen from the graph, almost entirely due to the very low fertility rate of the 30–34 age group. In

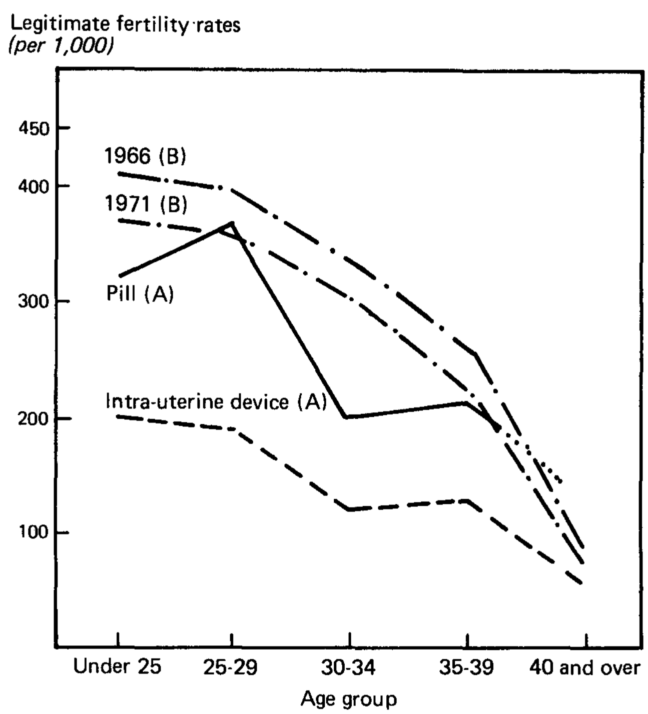


Figure VI. Experimental group A and control group B: legitimate fertility rates by age group

1971, pill acceptors between the ages of 25 and 29 have a slightly higher fertility level than women of the same age in the control group.

Lastly, the evidence shows that it is generally acceptors, whether of the pill or IUD, between the ages of 30 and 34 who contribute most to the general fall in the fertility level of their group, (A), compared with the level of women not practising contraception.

However, as has been shown, the distribution of the rates by age does not explain the situation in 1971, which has been described as anomalous.

The present authors hold that there are two main reasons for this finding. The first concerns the control population B itself. Although it can be regarded as genuinely constituting the total number of women experiencing natural fertility in 1966 (the official family planning programme was not launched until June 1965), it cannot be so regarded in 1971 (after five years of official and national practice of contraception in Tunisia) without underestimating the disparity between it and experimental group A, since it will inevitably contain a fairly large number of women using contraception.

It is therefore believed that the disparity found for 1971 in fact underestimates the true situation, which partially explains why the fertility level of acceptors of the pill is higher than that of group B.

The second reason concerns the experimental group itself and, more precisely, the continuation rate for each of the contraceptive methods used. As is demonstrated below, the continuation rate for IUD is much higher than that for the pill, which after only one year falls from unity to about 40 per cent. Because it is a birth-spacing contraceptive chiefly used by women who are young in the absolute sense and are of a younger average age than IUD acceptors, the fluctuating behaviour of the curve and the high level of fertility are both understandable.

The third reason, which is examined in greater detail in the following section, is associated with one exceptional characteristic of contraceptive users in general and of the experimental group in particular, namely, their very high fertility level.

Differences in fertility between experimental group A and control group C

This method is applied to the same group of women "before and after" acceptance of a method of contraception; its obvious merit is that the socio-economic, cultural and demographic characteristics are identical. Its drawback is, naturally, a chronological one, since it compares two situations, each of which relates to a different time-frame.

In this method, fertility rates before and after acceptance are compared at equal ages, using, for a given age group (e.g., 30–34) the average of "pre-acceptance" rates (see table 22). The result obtained characterizes the fertility of the group at "about age 30" and can be compared with the average of the "post-acceptance" fertility rates of women in the 25–29 age group, which likewise characterizes their fertility at "about age 30".

Estimates computed on the basis of the data in table 22 yield the average rates given in table 23.

Figure VII illustrates these estimates. Average fertility rates before and after acceptance are shown in figure VII (*a*); it reveals the decline in fertility among acceptors over an average interval of five and a half years. Figure VII (*b*) illustrates the difference, at comparable ages, between the pre- and post-acceptance fertility of the women.

A review of the results provided by this method suggests two important observations. First, the decline in fertility is definitely greater for acceptors of IUD than for acceptors of the pill, in the case of whom the

TABLE 22. FERTILITY RATES, BY AGE GROUP, OF WOMEN IN EXPERIMENTAL GROUP A BEFORE AND AFTER ACCEPTANCE OF CONTRACEPTION
(Rates per 1 000 women)

	Before acceptance				*After acceptance*		
Method and age group	*Fifth year*	*Fourth year*	*Third year*	*Second year*	*Second year*	*Third year*	*Fourth year*
Intra-uterine device							
Under 25	452	498	438	563	177	203	220
25-29	383	425	380	389	81	226	261
30-34	309	326	365	381	105	61	196
35-39	342	243	305	332	30	168	194
40 and over	210	167	131	292	66	45	52
Pill							
Under 25	445	524	380	552	373	303	272
25-29	326	394	371	434	365	369	362
30-34	369	342	419	370	213	105	281
35-39	307	244	270	303	249	221	171
40 and over	350	254	157	278	41	45	[a]

Source: Tunisia, Office national du planning familial et de la population, *Enquête nationale sur la continuation des methodes contraceeptives, 1973;* vol. II, *Exploitation et résultats* (Tunis, 1975).

[a] Insufficient data.

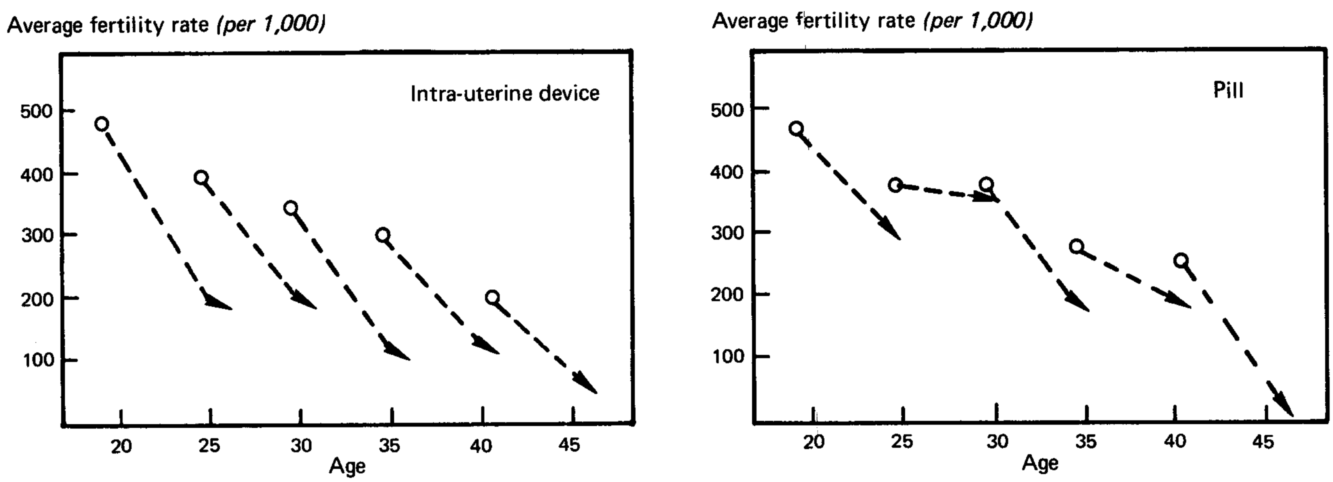
TABLE 23. AVERAGE FERTILITY RATES BEFORE AND AFTER ACCEPTANCE, BY AGE GROUP
(Rates per 1 000 women)

Method and age group	*Average rates* — *Before acceptance*	*Average rates* — *After acceptance*	*Difference* — *Value*	*Difference* — *Corresponding age*
Intra-uterine device				*About*
Under 25	488	200	194	25
25-29	394	189	156	30
30-34	345	121	185	35
35-39	306	131	69	40
45 and over	200	54	—	45
Pill				*About*
Under 25	475	316	65	25
25-29	381	365	10	30
30-34	375	200	81	35
35-39	281	213	47	40
40 and over	260	43	...	45

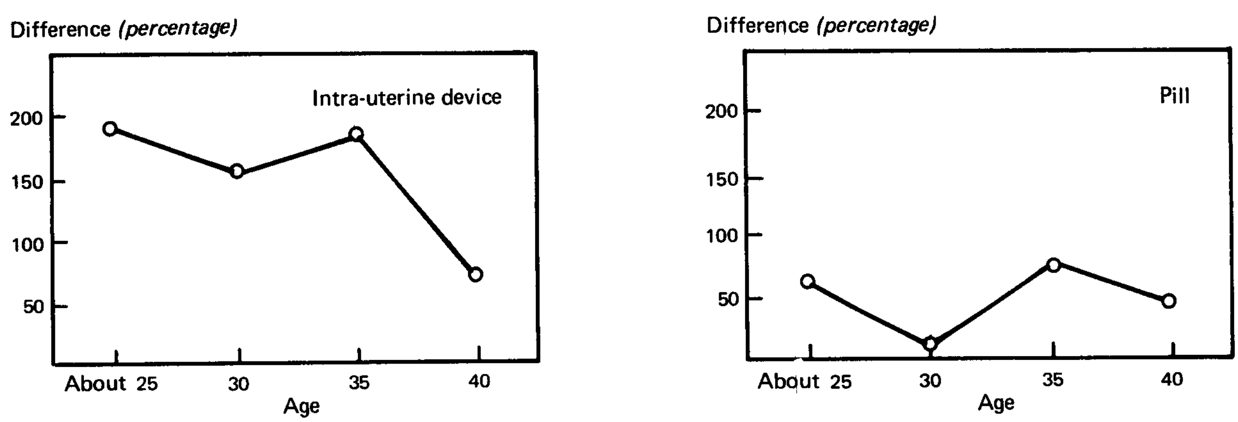
decline is very small at the level of the 25–29 (10) and 35–39 (47) age groups; secondly, the differences in fertility at comparable ages between contraceptive users (after acceptance) and non-users (before acceptance) are much smaller for pill acceptors (from 10 to 80 points) than for IUD acceptors (from 69 to 194 points).

Generally speaking, however—and contrary to the conclusion emerged from the comparison of group A with group B—the two groups of acceptors (pill and IUD) did show a real decline in fertility, compared with their pre-contraception status. Indeed, although acceptors of the pill had a higher general fertility rate than the control group in 1971, that was because the pill acceptors were women who were much more fertile than the average of women in general.

That such is the case provides further confirmation of the slight impact of oral contraception on fertility in Tunisia, as already indicated by the low rate of continuation for this form. Many plausible explanations could be advanced, and the situation could be the subject of valuable research.



(*a*) Average fertility rates before and after acceptance, by age group at time of acceptance



(*b*) Differences in fertility, at comparable ages, between acceptors and those who are not yet acceptors

Figure VII. Pre-acceptance and post-acceptance fertility rate and differences in fertility

Appraisal of the method

The experimental-design method has one indisputable advantage—it is simple to apply. It is, however, very inadequate because it is too crude in the way in which it measures the impact of family planning on fertility. Its inadequacy derives basically from two factors.

Selection of the experimental and control groups. The method is based on the full comparability of the two groups. However, it is extremely difficult, if not impossible, to find two population groups having identical socio-economic, cultural and demographic characteristics and differing only in the practice or non-practice of contraception.

In the example used, it was found that in the first case (groups A and B) there were significant social and economic differences between the populations compared; and although they differed in the fundamental characteristic of being acceptors or non-acceptors, illogical results were produced. On the other hand, the second case (groups A and C) appeared to have solved the problem of identical characteristics. In the authors' view, however, this was only apparently so, and the effect was due to the procedure of displacement over time that had to be applied in order to make the comparison.

In comparing the fertility of women of, say, ages 30–34 before acceptance with that of the 25–29 age group after acceptance, one is no longer comparing the same women even though this may appear to be the case, but two groups of women who are completely different (according to age group) and who consequently have different socio-economic, cultural and demographic characteristics.

Furthermore, in order to be significant, the average rates must be estimated over a long period (an average of five years). The contention here is that the behaviour of a woman at the beginning of this period necessarily differs from that of another woman, even if she has the same characteristics, at the end of the period, because such behaviour is linked to the social and—more importantly—the economic evolution of the country.

Exceptional nature of the experimental group

The second defect of the method is that it ignores the exceptionally fertile nature of women contraceptive users as compared to all non-users. It has been shown, after all, that acceptors of both IUD and the pill are both young (average ages of 30.8 and 30, respectively) and very fertile, especially during the year preceding acceptance (555 per 1,000 for acceptors of IUD and 485 per 1,000 for acceptors of the pill one year before acceptance, and 390 per 1,000 and 386 per 1,000, respectively, on average, for the five years preceding acceptance, as against a general fertility rate at the national level of 269 per 1,000 in 1966 and 234 per 1,000 in 1971). The method makes no adjustment or correction of this extra-high fertility level among acceptors and this factor, obviously, distorts the results and the conclusions.

Couple-years of protection index

The estimates

In applying the couple-years of protection method, use was made of the formula applied to Pakistan; but vasectomies, which are not performed under the Tunisian programme, were excluded, and two other methods, the pill and social abortion, were added.

Secondary methods

Data are available in Tunisia, not for the number of condoms or tubes of cream and jelly distributed, but for the average number of users per month. In the case of condoms and jelly, each acceptor is usually given the quantity considered necessary for one cycle, in other words, 12 condoms and one tube of jelly. This judgement is largely empirical, and there has been no study to verify its validity.

Family planning centres consider these methods to be temporary (either for a client who comes in half the way through her cycle or in the expectation of persuading the woman at her next visit to adopt a more effective method (IUD or pill)).

It is also assumed that, in order to provide protection for one year, each woman must be supplied with contraceptives for 13 cycles.

In 1971, there were, on average, 2,237 users of condoms and 401 users of jelly and cream per month; the corresponding number of couple-years of protection is:

$$\text{CYP}_{1971} \text{ (condoms + jelly)} = \frac{(2{,}237 + 401) \times 12}{13}$$
$$= 2{,}435 \text{ couple-years of protection.}$$

Pill

The reasoning given above applies also to pill users. In 1971, there were, on average, 7,612 pill users per month and 96,570 packs were distributed during the year, which gives:

$$\text{CYP}_{1971} \text{ (pill)} = \frac{96{,}570}{13}$$
$$= 7{,}427 \text{ couple-years of protection.}$$

In some centres, multicycle packs are issued, which accounts for the difference between the total number of packs and the number of users (7,612 × 12 = 91,344 users).

Tubal ligation

In the formula used for Pakistan, the total number of ligations is calculated from the start of the programme to year *n* which, in Tunisia, corresponds to 11,144 couple-years of protection in 1971 (see tables 24 and 25).

TABLE 24. WOMEN REMAINING *n* YEARS FOLLOWING LIGATION PER 1 000 WOMEN HAVING UNDERGONE LIGATION, ALL AGES COMBINED

n	*Women remaining*	*n*	*Women remaining*
1	933	15	101
2	867	16	75
3	793	17	50
4	718	18	34
5	645	19	27
6	572	20	20
7	498	21	14
8	429	22	7
9	372	23	4
10	313	24	3
11	253	25	2
12	196	26	1
13	150	27	0
14	126	28	0

It was deemed preferable to use the results of one demographer's estimate based on Tunisian data[22] and to allow for the following events which might have occurred in the absence of tubal ligation: (*a*) death between the ages of 25 and 50; (*b*) being widowed between the ages of 25 and 50; (*c*) divorce; (*d*) becoming sterile; (*e*) resort to other methods of contraception.

From table 24 and figure VIII, an estimate was made of the number of women having undergone ligation who remained in 1971, on the basis of the number of women having undergone the procedure since 1964 (see table 25).

Table 25 gives the number of women in 1971 who had undergone the procedure and hence the value of CYP:

CYP_{1971} (tubal ligation)
= 8,722 couple-years of protection.

Intra-uterine device

The Pakistan formula was adopted, but the coefficients were replaced with Tunisian estimates of the

[22] See annex II, "Naissances évitées par les ligatures de trompes en Tunisie", prepared by L. Behar.

TABLE 25. RESIDUE IN 1971 OF WOMEN HAVING UNDERGONE LIGATION

Year	*Number of women having undergone ligation*	*Residue in 1971 of women having undergone ligation* — *Per 1 000*	*Total*
1964	293	429	126
1965	384	498	191
1966	766	572	438
1967	742	645	478
1968	1 627	718	1 168
1969	2 513	793	1 993
1970	2 539	867	2 201
1971	2 280	933	2 127
TOTAL	11 144		8 722

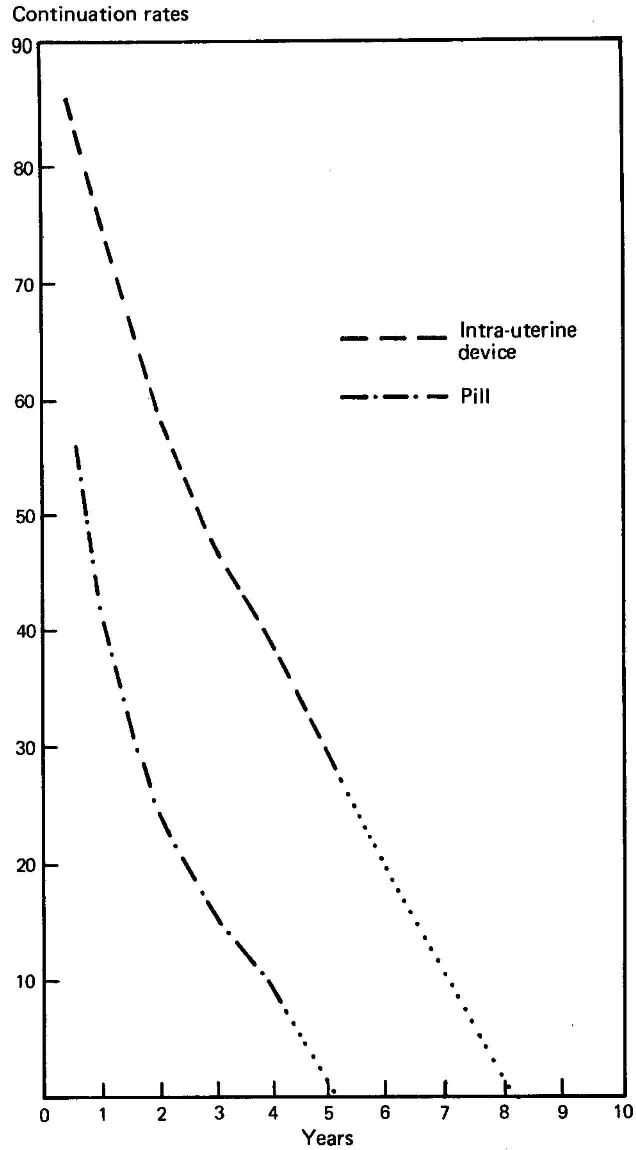


Figure VIII. Trend of continuation rates, first method, for acceptors of the pill and the intra-uterine device

proportion of IUD acceptors who were still protected after one year, two years etc., following initial acceptance, as estimated by the 1973 continuation survey (table 26).

Rates for periods exceeding 48 months were determined by trend extrapolation (figure VIII). A figure for women remaining who continued to be protected by an IUD in 1971 was thus obtained (see table 27).

The value of CYP, therefore, is:

CYP_{1971} (IUD)
= 28,659 couple-years of protection.

The results

The sum of the number of couple-years of protection obtained by the various methods gives the value of the CYP index for 1971:

TABLE 26. RATES OF CONTINUATION FOR ACCEPTORS OF AN INTRA-UTERINE DEVICE, AT 6, 12, 24, . . . 96 MONTHS

	Average period (months)								
	6	*12*	*24*	*36*	*48*	*60*	*72*	*84*	*96*
Rate given by the survey	84.9	74.6	58.5	46.7	38.3	28	18	10	0

$$\text{CYP}_{1971} = 2{,}435 + 7{,}427 + 8{,}722 + 28{,}659$$
$$= 47{,}243 \text{ couple-years of protection.}$$

In order to express this value as births averted, it was assumed that in Tunisia 1 CYP = 0.25 birth averted, which would correspond to a legitimate fertility rate of 250 per 1,000, which is close to but about 10 per cent higher than that for all married women (15–54 years) in 1971 (234 per 1,000) and is the rate used by ONPFP for its evaluations.

On the basis of that formula, the number of births averted would be 11,810, not including births averted by the 3,197 abortions performed in 1971.

Appraisal of the method

The CYP method was found by the authors to be very crude and open to criticism at every level. Although is might be of some use to the authorities when comparing the results of programme activities, it is particularly misleading if it is assumed to represent the number of births genuinely averted and is therefore used to measure the impact of the family planning programme on fertility.

Estimating protection by the various methods

With respect to secondary methods, it was not possible to gather data as detailed as the reference material recommended. The number of units distributed, the number of units needed to protect a couple during one cycle and the percentage of contraceptives efficiently used were all unknown. The number of years of protection secured by these methods are certainly over-estimated. As stated above, clients are advised to use them only as temporary measures and they are only a marginal activity of the family planning centres.

For the pill, the present estimate of protection, which is based on the number of packs distributed, is also optimistic. The survey on the continuation of the IUD and the pill has demonstrated how little impact oral contraceptives have had on fertility in Tunisia: after one year, 60 per cent of the acceptors had abandoned that method. The level of protection is poor, since half of the acceptors become pregnant within two years and their pregnancy rate does not appear to be much lower than the rate for the population as a whole. It seems that for these women contraception provides little motivation or that they use it for spacing purposes, in order to defer further pregnancy for a few months or a year.

TABLE 27. WOMEN STILL PROTECTED BY AN INTRA-UTERINE DEVICE IN 1971, BY YEAR OF INSERTION

		Women remaining in 1971 and still protected by IUD	
Year	*Primary insertions*	*Rate per 1 000*	*Total*
1964	1 154	0	
1965	12 832	10	1 283
1966	12 077	18	2 174
1967	9 657	28	2 704
1968	9 304	38.3	3 563
1969	8 696	46.7	4 061
1970	9 638	58.5	5 638
1971	12 381	74.6	9 236
TOTAL	75 739		28 659

Tubal ligation

The CYP method can be considered satisfactory with respect to tubal ligations, even though protection for 1971 was over-estimated since ligations performed in January or December were assumed to provide the same protection over the year. Moreover, that assumption is equally applicable to preceding years. The method, in fact, is as good as the assumptions with regard to mortality, divorce, widowhood, sterility and use of contraception in the absence of ligation (see annex II).

These comments on ligation are also applicable to IUDs; the method of estimation adopted is similar. Moreover, the protection provided by the IUD also involves other variables—fertility, mortality, dissolution of unions, amenorrhoea—about which no accurate information is available.

The reasons for discontinuation which were taken into account in estimating continuation rates are as follows: (*a*) pregnancy; (*b*) expulsion; (*c*) withdrawal on medical grounds; (*d*) withdrawal for other reasons. The data in table 28 show that withdrawal because of "pain" or "bleeding" (i.e., medical grounds) is the most frequent reason for discontinuation.

Abortions For the 3,197 abortions, it would be better to use the method of births averted described below in the subsection on the ONPFP method, in order to estimate directly the number of births averted in 1971, taking into account the fact that the interruption of a pregnancy causes a woman to become fertile earlier, thereby diminishing the apparent demographic effectiveness of the operation.

This method of evaluating the impact of the family planning programme presupposes that the years of protection are additive and that the contraceptive methods are independent of one another. It ignores the indirect effects of the programme and takes no account of non-programme contraception through private doctors and pharmacies.

TABLE 28. CUMULATIVE RATE OF DISCONTINUATION BY ACCEPTORS OF AN INTRA-UTERINE DEVICE, BY CAUSE, AT 6, 12, 24, 36 AND 48 MONTHS [a]

Reason for discontinuation	*Number of months* 6	12	24	36	48
Pregnancy	2.3	3.2	4.0	4.4	4.8
Expulsion	4.5	6.6	10.5	10.9	12.4
Withdrawal on medical grounds	6.9	14.0	22.5	30.9	34.6
Withdrawal for other reasons	2.3	3.9	6.5	8.2	10.2
Rate of discontinuation	16.0	27.8	43.4	54.3	62.1

Source: See table 22.
[a] Only those acceptors were surveyed.

Abandoning the first method used does not mean that a couple ceases to practise contraception in general and, in the continuation survey, consideration was also given to the continuation of "all contraception" (see figure IX).

Table 29 shows what proportion of the women who have ceased using the IUD or the pill have adopted other methods, indicating which method.

Over all, only one third of the women who stop using the IUD continue to practise contraception, and half of those who continue use the pill; the other methods practised are, in order of use, the "natural methods" and condoms, jelly and cream. Among acceptors of the pill, three quarters of those who discontinue using it give up all contraception (at least until the next pregnancy). Those who continue use natural methods or condoms, jelly and cream in preference to the IUD.

Lastly, the conversion of the CYP index into number of births averted is very questionable since the

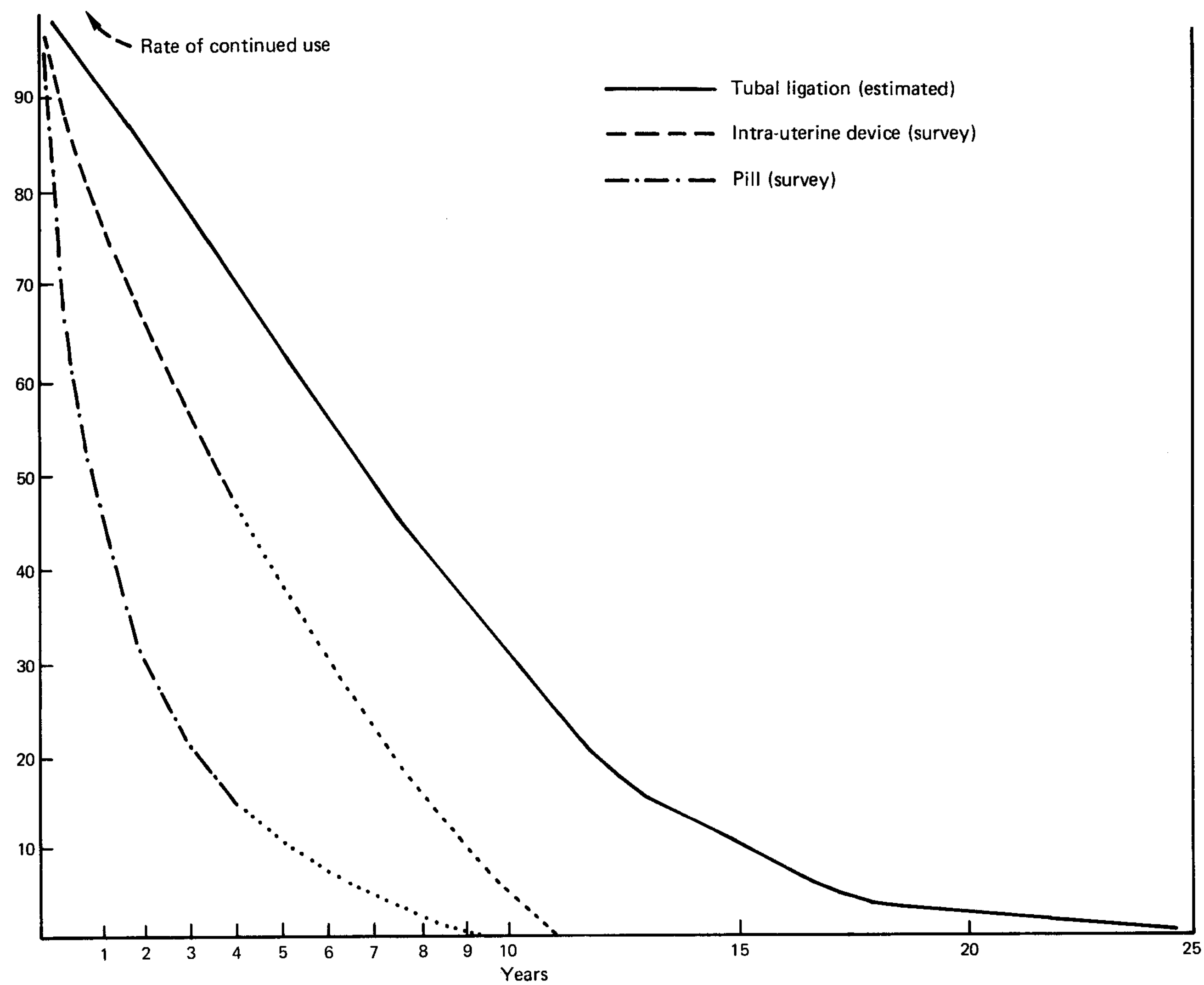


Figure IX. Evolution of rates of continued use of the intra-uterine device and the pill (all contraception) and tubal ligation.

potential fertility of acceptors appears, in fact, to be significantly higher than that of married women in general. This argument is set forth in detail in the next section of this report.

TABLE 29. WOMEN HAVING CEASED TO USE THE FIRST METHOD, BY METHOD ADOPTED, IF ANY, PRIOR TO PREGNANCY, IF ANY
(Percentage)

Method adopted	*Intra-uterine device acceptors*	*Pill acceptors*
No method	66.5	76.0
Intra-uterine device	—	5.5
Pill	15.3	—
Condom, jelly, cream	5.1	5.9
Tubal ligation	2.9	1.4
Natural method	6.4	7.3
Traditional method	2.9	2.5
Another method	1.0	1.1
Not stated	—	0.2
TOTAL	100.0	100.0
NUMBER	(313)	(438)

Source: See table 21.

Component projection approach

The estimates

It is assumed for the purposes of this discussion of the component projection approach that in order to avert births in 1971, a couple must have been protected by a contraceptive method from June 1970 to May 1971. The following calculations therefore relate to each age group efficiently practising contraception during that period.

Intra-uterine device

An attempt is made to estimate the number of couples still living in the same union and remaining fertile in which the wife is using an IUD. This estimate was made by wife's age group at the end of 1970, which was taken to be the mid-point of the period (June 1970-May 1971).

For each earlier year (from 1964, when the programme began, to 1970), data are available on primary insertions of IUDs, broken down by wife's age group at the time of acceptance. This distribution, by percentage and in absolute figures, is given in table 30.

In addition, the 1973 continuation survey provides data on the rate of continuation by age group (table 31). It was assumed in the survey that continuation is uniform within age groups; that IUDs inserted in 1970 had been in use an average of six months as of the end of 1970; and that the same applies to earlier years.

Overall, continuation improves with age, as might be expected. Although the rise is steady up to age 30–34, the pattern is less clear thereafter: women in the 35–39 age group show a lower rate of continuation than those in the 30–34 age group, and women aged 40 years and over show a higher rate of continuation only after 18 months. By applying these rates to all women who have had an IUD inserted between 1964 and 1970, it is possible to determine by age group the number of women who at the time of insertion will continue to use the IUD in the absence of any other disruptive factor in their married life.

No data were available for continuation after 42 months and as extrapolation proved to be a very risky process, it appeared to be appropriate to make the following hypotheses.

The continuation rate for all ages combined is applied to all women who have had an IUD insertion (i.e., 32.5 per cent after 54 months for 1966, 25 per cent after 66 months for 1965 and 14.5 per cent after 78 months for 1964). See table 24. It was assumed that for 1965 and 1966, women continuing to use an IUD were distributed as follows: 25–29 years, one fifth; 30–34 years, two fifths; and 35–39 years, two fifths. For 1964, the following distribution was assumed: 30–34 years, three quarters; and 35–39 years, one quarter. This produces the results given in table 32.

In order to take account of the risks to which the women in question may have been exposed between 1964 and 1970, data on tubal ligations were obtained from the study by L. Behar (see annex II), in which the following events are considered: deaths occurring between the ages of 25 and 50; widowhood between the ages of 25 and 50; divorce; becoming sterile; and resorting to another method of contraception. It will be noted, however, that the probability of resorting to another method of contraception would certainly be lower for women who have accepted IUDs than for women who have undergone tubal ligation. That hypothesis would therefore lead to slightly underestimating the number of women remaining. Each age group is represented by its mean age, and it is assumed that the average age at time of insertion is 23 for the age group under 24 and 42.5 for the age group 40 and over.

With the assistance of table 37, which gives the data for remaining women n months after a tubal ligation, expressed as a percentage, the number of women remaining who used an IUD at the end of 1970, distributed by age group at the time of insertion, was estimated (see table 33).

In determining the distribution of these persons by age group at the end of 1970, it was assumed that the distribution was uniform within age groups and that the total number of IUDs actually in use at the end of 1970 among women who were assumed to be in the same age group in 1971 would therefore be given by:

$$\begin{aligned} Q_i,\ 1971 = {} & 0.90\, q_i,\ 1970 + 0.10\, q_i-1,\ 1970 \\ & + 0.70\, q_i,\ 1969 + 0.30\, q_i-1,\ 1969 \\ & + 0.50\, q_i,\ 1968 + 0.50\, q_i-1,\ 1968 \\ & + 0.30\, q_i,\ 1967 + 0.70\, q_i-1,\ 1967 \\ & + 0.10\, q_i,\ 1966 + 0.90\, q_i-1,\ 1966 \\ & + 0.90\, q_i-1,\ 1965 + 0.10\, q_i-2,\ 1965 \\ & + 0.70\, q_i-1,\ 1964 + 0.30\, q_i-2,\ 1964 \end{aligned}$$

This method was used to derive the number of

TABLE 30. DISTRIBUTION OF WOMEN WHO HAVE HAD A PRIMARY INTRA-UTERINE DEVICE INSERTION, BY AGE GROUP AND DATE OF INSERTION

Age group	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*
			(a) *Rate per 1 000 women*				
Under 24	120.6	142.0	96.4	95.7	150.3	163.0	176.3
25-29	223.1	272.9	204.0	195.5	243.6	246.5	239.9
30-34	305.8	281.2	296.6	294.4	284.6	280.2	275.4
35-39	218.2	204.9	290.6	314.1	240.0	242.8	233.4
40 and over	132.3	99.0	112.4	100.3	81.5	67.5	75.0
TOTAL	1 000.0	1 000.0	1 000.0	1 000.0	1 000.0	1 000.0	1 000.0
			(b) *Absolute number*				
Under 24	139	1 822	1 164	924	1 398	1 417	1 699
25-29	257	3 502	2 464	1 888	2 267	2 144	2 312
30-34	353	3 608	3 582	2 843	2 648	2 437	2 654
35-39	252	2 630	3 510	3 033	2 233	2 111	2 250
40 and over	153	1 270	1 357	969	758	587	723
TOTAL	1 154	12 832	12 077	9 657	9 304	8 696	9 638

Source: Tunisia, Office du planning familial et de la population, *Caracteristiques des acceptrices de DIU de 1964 à 1969* (Tunis, 1972).

women who were efficiently practising contraception at the end of 1970, by age group at the end of 1970, as an average over the period June 1970-May 1971, and who would therefore prevent births in 1971. Table 34 gives the final results of those calculations.

TABLE 31. RATES OF CONTINUATION, FIRST METHOD, OF WOMEN ACCEPTING AN INTRA-UTERINE DEVICE, BY AGE GROUP

Age group	*Six months*	*Eighteen months*	*Thirty months*	*Forty-two months*
15-24	79.7	54.3	38.5	29.2
25-29	82.2	64.3	50.1	39.7
30-34	90.2	74.4	61.4	50.0
35-39	87.0	69.7	54.1	44.8
40+	84.8	72.4	64.6	56.9
TOTAL	84.9	66.5	52.6	42.5

Tubal ligation

The same estimating principles were applied to tubal ligations. However, since the distributions of women by age at the time of ligation was not known for all years, the 1974 distribution (see table 35) was applied to all women who underwent tubal ligation between 1964 and 1970. The distribution of those women by age group would therefore be as shown in table 36.

Assuming that the necessary conditions obtained for applying the method of estimating the number of women remaining in the sample n months after a ligation (see annex II), an estimate was made, on the basis of the data in table 37, of the number of women still protected by ligation at the end of 1970; women in the group aged 45 years and over were presumed to have an average age of 47 at the time of ligation (see table 38).

Using the same assumption for distribution by age group as in the case of IUDs, it is possible to estimate, by age group at the end of 1970, the number of women who were protected by tubal ligation at the end of 1970 and who thus prevented births in 1971 (table 39).

Condoms and jelly

An estimate was made of the average numbers of users per month of condoms and jelly, during the period June 1970-May 1971 (table 40). It was assumed that 80 per cent of them were practising contraception efficiently. These contraceptives are, as a rule, supplied for one cycle at a time. For the distribution of users (table 41), the distribution IUD insertions by age group in 1970 was used (see table 30(*a*)).

These couples were assumed to be living in the same union and to be fertile throughout the period.

The pill

The method used to estimate the number of users efficiently practising this form of contraception between June 1970 and May 1971 is very similar to the

TABLE 32. WOMEN CONTINUING TO USE AN INTRA-UTERINE DEVICE AT END-1970 (IN THE ABSENCE OF OTHER DISRUPTIVE FACTORS), BY AGE GROUP AT TIME OF INSERTION

Age group	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*
24 and under	–	–	–	270	538	769	1 354
25-29	–	642	785	749	1 136	1 379	1 900
30-34	125	1 283	1 570	1 421	1 626	1 813	2 394
35-39	42	1 283	1 570	1 359	1 208	1 471	1 957
40 and over	–	–	–	551	490	425	613
TOTAL	167	3 208	3 925	4 350	4 998	5 857	8 218

TABLE 33. WOMEN REMAINING IN SAMPLE AND STILL USING AN INTRA-UTERINE DEVICE AS OF END-1970, BY AGE GROUP

Age group	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*
24 and under	–	–	–	245	505	742	1 338
25-29	–	530	669	658	1 033	1 302	1 864
30-34	92	1 002	1 297	1 236	1 483	1 719	2 353
35-39	23	797	1 100	1 061	1 033	1 347	1 902
40 and over	–	–	–	307	339	348	576
TOTAL	115	2 329	3 066	3 507	4 393	5 458	8 033

previous method, but a number of remarks need to be made since it takes into account the continued use of the pill.

A recent study[23] of the period 1970–1973 shows that data obtained by applying an adjusted continuation table to the number of acceptors correspond, with very minor disparities, to the number of former registered users. Statistics are available on the average number of users per month, the number of new acceptors per month and the number of packs distributed. Because, in some centres, users are given a supply for several cycles (usually three), a distinction was made between users and packs; then, for each month, women protected by a one-cycle supply of pills were regarded as users for that month, and to them were added users for the previous two months who still had one cycle's supply but had not visited the centre. For December 1970, for example, the figures would be determined as follows:

Users for December 1970 7,342
Difference between number of packs
and number of users:
November 1970 199
October 1970 201
Women protected by a one-cycle supply of pills in
December 1970:

$$7{,}342 + \left(\frac{199 + 201}{2}\right) = 7{,}542$$

This calculation was made for each month from June 1970 to May 1971 in order to estimate the average number of women who were protected by the pill during that period (see table 42).

As was done with respect to condoms and jelly, it was assumed that 80 per cent of those women actually used their supply for the cycle (no information was available on the subject, but it does appear from some surveys that many women do not use their pack of pills or use them incorrectly): 7,003 × 80 per cent = 6,443. On the basis of this calculation, 6,443 women were actually protected by the pill during the period June 1970-May 1971.

It was assumed that 50 per cent of the women were one-year users, that 40 per cent has been users for from one to two years and that 10 per cent had been users for over two years. The age distribution at the time of acceptance (table 43) is that given by the continuation survey sample.

On the basis of these assumptions as to the distribution of women actually protected by the pill over time and by age group at time of acceptance, the method used for IUDs was again utilized to estimate by age group the number of women protected by the pill between June 1970 and May 1971. The results are given in table 44.

Since the age group distribution of women actually protected by the pill was derived *a posteriori,* women leaving the sample by reason of age were replaced, in the estimation process used, in the group aged 40 years and over (see table 45).

For social abortions, the number of births averted was estimated by a specific method described in the next section of this paper.

The results

Data are thus available for women effectively protected by IUD, tubal ligation, condoms and jelly, and pills by average age groups for the period from June

[23] A. Marcoux, "Continuation de la pillule d'après les statistiques de service," Tunis, Population Council, 1974 (mimeographed).

TABLE 34. DISTRIBUTION OF WOMEN REMAINING IN SAMPLE AND USING AN INTRA-UTERINE DEVICE BY AGE GROUP AT END-1970

Age group	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*	*Total number of women remaining, end-1970*
Under 25	–	–	–	73	252	519	1 205	2 049
25-29	–	–	66	369	769	1 134	1 811	4 149
30-34	–	477	733	832	1 258	1 594	2 304	7 198
35-39	64	955	1 277	1 183	1 258	1 459	1 947	8 143
40 and over	44	817	990	835	686	648	709	4 729
TOTAL	108	2 249	3 066	3 292	4 223	5 354	7 976	26 268
Women leaving the sample as a result of age	7	80	–	215	170	104	57	
TOTAL	115	2 329	3 066	3 507	4 393	5 458	8 033	

TABLE 35. NUMBER OF WOMEN WHO UNDERWENT TUBAL LIGATION IN 1974, BY AGE GROUP

Age group	Women who underwent tubal ligation in 1974	
	Number	Percentage
Under 25	108	1.5
25-29	701	10.0
30-34	1 931	27.5
35-39	2 733	38.9
40-44	1 361	19.3
45 and over	197	2.8
Not stated	403	
TOTAL	7 434	100.0
Average age	35.13	

Source: Tunisia, Office du planning familial et de la population.

1970 to May 1971, who would therefore avert births during 1971 (table 46).

In order to estimate the number of births averted by these women, it was decided to apply as potential fertility the fertility of IUD and pill acceptors in the five years preceding acceptance as assessed on the basis of the 1973 continuation survey.[24] The year preceding acceptance was excluded, as it was clear that acceptance of contraception often occurred in the year following a birth (or an abortion), so that fertility rates were particularly high in the year preceding acceptance. Therefore it was assumed that on average, acceptors in the 30–34 age group accepted at the mean age of 32.5 and that the average of the four pre-acceptance fertility rates would represent their fertility at "about age 30" (see table 47).

In those estimates, that fertility rate was applied to women aged 30–35 at the end of 1970, thereby avoiding an over-estimation of births (see table 48).

For women protected by tubal ligation, the potential fertility of pill acceptors, who are assumed to be very fertile, was used. For women protected by condoms and jelly, the potential fertility rates of IUD acceptors were used.

To the total given in table 48 must be added the number of births (1,817) averted by social abortion, as estimated by the method described in the following section. The total number of births averted in 1971 is thus: 13,876 + 1,817 = 15,693.

[24] These rates are given above in the subsection on experimental designs.

Social abortions

Marcoux argues that although an abortion prevents a birth, the woman concerned becomes fertile again at an earlier date, thereby reducing the demographic effectiveness of the operation. The only information available on the distribution by duration of terminated pregnancies yields an estimated average duration of two months.[25]

Some of these pregnancies would not have run their full term because of spontaneous abortion. The number involved is small, but it could be said that an intentional abortion averts approximately 0.94 birth (90 of 96 pregnancies which reached the two-month point would have run their full term).[26]

The additional fertile period averages seven months but since the average duration of pregnancy is 8.5 months, the additional fertile period is in fact 6.5 months.

The interval until ovulation resumes is taken to be one month after an abortion, and two months after childbirth in the absence of breast-feeding. In order to allow for this factor and for the protection afforded by post-abortum and post-partum IUD insertion, ovulation is regarded as recommencing, on average, six months after confinement.

Induced abortions, compared with the normal course of pregnancy, therefore give rise to an additional 6.5 + 5 = 11.5 fertile months. For every 100 women, this represents 95.8 fertile years.

Given the distribution by marital status (96.6 per cent married women) and by age (29) of women for whom information is available, Marcoux estimates that a population of the same structure has a fertility rate of approximately 290 per 1,000.

At this rate, 27.7 births will occur for every 95.8 woman-years, i.e., 0.277 birth per woman. In short, therefore, an abortion averts: 0.940 − 0.277 = 0.66 birth.

To estimate births averted in 1971, therefore, the number of social abortions carried out under the family planning programme between June 1970 and May 1971 (see table 49) was used, with the following result: 2,753 (social abortions) × 0.66 = 1,817 births averted.

[25] A. Marcoux, "Naissances évitées par les avortements", Tunis, Population Council, 1973 (mimeographed). Also T. B. Ben Cheikh, "L'experience tunisienne de l'avortement provoqué".

[26] *Foetal, Infant and Early Childhood Mortality: vol. I. The Statistics* (United Nations publication, Sales No. 54.IV.7).

TABLE 36. DISTRIBUTION OF WOMEN WHO UNDERWENT TUBAL LIGATION DURING 1964-1970, BY AGE-GROUP DISTRIBUTION IN 1974

Age group	1964	1965	1966	1967	1968	1969	1970
Under 25	4	6	12	11	24	38	38
25-29	29	38	77	74	163	251	254
30-34	81	106	210	204	447	691	698
35-39	114	149	298	289	633	978	988
40-44	57	74	148	143	314	485	490
45 and over	8	11	21	21	46	70	71
TOTAL	293	384	766	742	1 627	2 513	2 539

TABLE 37. WOMEN REMAINING IN SAMPLE *n* MONTHS AFTER TUBAL LIGATION
(Rates per 1 000 women)

Average age at the time of ligation	*Number of months* 6	18	30	42	54	66	78
23	988	965	939	909	879	849	820
27.5	981	944	909	878	852	825	797
32.5	983	948	912	870	826	781	736
37.5	972	916	855	781	701	621	541
42.5	940	819	693	557	417	279	139
47	833	500	166	–	–	–	–
All ages combined	966	900	830	755	681	608	500

Source: Annex II, "Naissances évitées par les ligatures de trompes en Tunisie", prepared by L. Behar.

TABLE 38. NUMBER OF WOMEN REMAINING IN SAMPLE AT END-1970 WHO HAD UNDERGONE TUBAL LIGATION, BY AGE GROUP

Age group	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*
Under 25	3	5	10	10	22	37	37
25-29	23	31	66	65	148	237	249
30-34	60	83	173	177	408	655	686
35-39	62	92	209	226	541	896	960
40-44	8	21	62	80	218	397	461
45 and over	–	–	–	–	8	35	59
TOTAL	156	232	520	558	1 345	2 257	2 452

TABLE 39. DISTRIBUTION OF WOMEN REMAINING IN SAMPLE WHO HAD UNDERGONE TUBAL LIGATION, BY AGE GROUP AT END-1970

Age group	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*	*Total remaining, end-1970*
Under 25	–	–	1	3	11	26	33	74
25-29	2	4	16	26	85	177	228	538
30-34	17	29	76	99	278	529	642	1 670
35-39	49	78	177	192	474	824	933	2 727
40-44	61	91	194	182	380	547	511	1 966
45 and over	25	28	56	56	113	143	99	520
TOTAL	154	230	520	558	1 341	2 246	2 446	7 495
Women leaving the sample as a result of age	2	2	0	0	4	11	6	
TOTAL	156	232	520	558	1 345	2 257	2 452	

TABLE 40. AVERAGE NUMBER OF USERS OF CONDOMS AND JELLY PER MONTH
JUNE 1970-MAY 1971

1970	*Condom*	*Jelly*	*1971*	*Condom*	*Jelly*
June	2 393	374	January	2 339	326
July	2 291	432	February	1 880	218
August	2 044	276	March	2 891	315
September	2 233	284	April	2 526	400
October	2 233	342	May	2 531	465
November	2 219	220	TOTAL:		
December	2 520	353	June 1970-May 1971	28 100	4 005

Note: Average number of users (June 1970-May 1971): 2 342 + 334 = 2 676.

Number of users efficiently practising contraception by means of condoms and jelly: 2 676 × 80 per cent = 2 141 users.

TABLE 41. DISTRIBUTION OF USERS PROTECTED BY CONDOMS AND JELLY, BY AGE GROUP, JUNE 1970-MAY 1971

Age group	Number of users protected
Under 25	377
25-29	514
30-34	590
35-39	500
40 and over	160
TOTAL	2 141

TABLE 42. WOMEN PROTECTED BY THE PILL, PER MONTH, JUNE 1970-MAY 1971

Year and month	Users who came to family planning centre	Additional packs distributed	Women protected by a pill cycle for the month of:
1970			
June	6 528	245	6 625[a]
July	6 354	100	6 540
August	5 898	171	6 070
September	6 024	119	6 159
October	6 621	199	6 766
November	6 429	201	6 588
December	7 342	187	7 542
1971			
January	6 945	149	7 139
February	6 435	365	6 603
March	8 141	478	8 398
April	7 308	405	7 729
May	7 441	482	7 882
Monthly average	6 789		7 003

[a] For June 1970, half of the additional packs distributed in April 1970 and May 1970 (i.e., 97) must be added.

TABLE 43. PERCENTAGE DISTRIBUTION OF PILL ACCEPTORS BY AGE GROUP AND AVERAGE AGE AT TIME OF ACCEPTANCE, ACCORDING TO CONTINUATION SURVEY, 1973

Age group	Distribution of acceptors
Under 25	20.4
25-29	22.0
30-34	25.7
35-39	22.1
40 and over	9.8
All groups	100.0
Average age	30.0

TABLE 44. WOMEN ACTUALLY PROTECTED BY THE PILL BETWEEN JUNE 1970 AND MAY 1971, BY AGE GROUP AT TIME OF ACCEPTANCE

Age group	June 1968-May 1969	June 1969-May 1970	June 1970-May 1971
Under 25	131	526	657
25-29	142	567	709
30-34	166	662	828
35-39	143	570	711
40 and over	63	252	316
All ages	645	2 577	3 221

Appraisal of the method

The component projection approach has great merit since it attempts far more than the methods previously discussed, to incorporate accurate indexes of the effectiveness of contraception. However, to expect to obtain a much more scientific result appears to be over-ambitious, as despite its refinements and perhaps precisely because of them, the method demands a set of data which is impossible to collect and numerous assumptions which are difficult to verify.

Data on the characteristics of acceptors, which are needed to assess the volume of contraceptives really being used, are not readily available; even if they were available on age distribution at time of acceptance per year or on age distribution of users at a given date, the efficiency of contraceptive practice at the level of the couple would still have to be assessed.

These difficulties, which arise from the need for a high degree of accuracy in applying the method, are heightened still further in developing countries—where, generally speaking, official family planning programmes are in existence—because the collection and processing of statistical data are rudimentary. Tunisia is a very favourable case, inasmuch as it has a relatively elaborate statistical organization, particularly for family planning activities.

By conducting surveys of specific problems, more detailed data can, of course, be obtained on certain aspects of the use of contraceptives, but the question arises whether the required investment of effort and financial resources would really be warranted by the importance of the results. Generally speaking, the authorities concerned are interested in action rather than theory.

At all levels of application of the method, assump-

TABLE 45. WOMEN ACTUALLY PROTECTED BY THE PILL BETWEEN JUNE 1970 AND MAY 1971, BY AVERAGE AGE GROUP AT END-1970

Age group	Year of acceptance: June 1968-May 1969	June 1969-May 1970	June 1970-May 1971	Women protected by pill at end-1970
Under 25	65	368	591	1 024
25-29	137	555	704	1 396
30-34	154	633	816	1 603
35-39	154	598	723	1 475
40 and over	135	423	387	945
All ages	645	2 577	3 221	6 443

TABLE 46. WOMEN PROTECTED BY ALL METHODS BETWEEN JUNE 1970 AND MAY 1971

	Contraceptive method				
Age group	Intra-uterine device	Tubal ligation	Condoms and jelly	Pill	All methods
24 and under	2 049	74	377	1 024	3 524
25-29	4 149	538	514	1 396	6 597
30-34	7 198	1 670	590	1 603	11 061
35-39	8 143	2 727	500	1 475	12 845
40 and over	4 729	2 486	160	945	8 320
All ages	26 268	7 495	2 141	6 443	42 347

TABLE 47. POTENTIAL FERTILITY RATES OF CONTRACEPTIVE USERS

	Potential fertility	
Age group	Acceptors of intra-uterine devices, condoms and jelly	Acceptors of pills and tubal ligation
About 20	488	475
About 25	394	381
About 30	345	375
About 35	305	281
About 40	200	260
All ages	349	361

tions had to be made which influenced assessment of the programme impact quite considerably. To change their content would alter, for instance, the relative weight of the individual contraceptive methods. Thus, for condoms, jelly and pills, the theoretical base used here is very precarious and questionable. The continuation rates applied for IUD insertions were drawn from a survey which covered a four-year period; beyond that period, extrapolations were made which would have to be verified.

Lastly, as regards both the potential fertility of users and the probability that they used other contraceptive methods, the deductions made here are based on an unreal situation about which the authors will never have full knowledge: the rates adopted for each contraceptive method can be justified only by a subjective judgement. If a potential fertility rate approximately 20 per cent higher than the legitimate fertility rate for 1966 (base year where the behaviour of couples was natural) had been used, a total of 15,453 births averted (at a rate of 322 per 1,000) would have resulted. A result very close to that of the authors was obtained by a very crude calculation; there are therefore grounds for asking whether it is really useful and profitable to devote a great deal of time and thought to producing such results.

Estimating births averted by the method used by the National Family Planning and Population Office, Tunis

Before discussing the main methodological issues raised by these methods, it should be mentioned that ONPFP has adopted a method of estimating births averted which is quite similar to the component projection approach, but more general in that it does not introduce the age distribution of the women protected.

The continuation rates adopted (see figure X) were established before the survey on continuation of the IUD and the pill was undertaken. For IUDs in particular, the degree of underestimation is sizable, but no allowance is made for various hazards (mortality, widowhood etc.).

For tubal ligation, on the other hand, the number of births averted was over-estimated in relation to the estimates. The rates for proportions of women remaining were drawn from a study made in another country and should also be re-examined.

Lastly, potential fertility was estimated at an overall rate of 250 per 1,000, i.e., at a rate close to the over-all legitimate fertility rate in the absence of contraception.

For abortions, the estimate of births prevented considerably underestimates lactation amenorrhoea, i.e., four abortions prevent three births.

Estimating process

The number of women protected at the end of 1970 are estimated as follows:

(*a*) Protection by IUD, by applying the continuation rates shown in figure X, 23,710 women;

(*b*) Protection by tubal ligation, by applying the survivorship rates of figure X, 8,520 women;

TABLE 48. BIRTHS AVERTED IN 1971 BY WOMEN PROTECTED BY AN INTRA-UTERINE DEVICE, TUBAL LIGATION, CONDOMS AND JELLY, AND PILL, BY AGE GROUP OF THE WOMEN AT END-1970

	Births averted by				
Age group	Intra-uterine device	Tubal ligation	Condoms and jelly	Pill	All methods
24 and under	999	35	183	486	1 703
25-29	1 635	205	202	532	2 574
30-34	2 483	626	203	601	3 913
35-39	2 484	766	152	414	3 816
40 and over	946	646	32	246	1 870
All ages	8 547	2 278	772	2 279	13 876

TABLE 49. DISTRIBUTION OF SOCIAL ABORTIONS CARRIED OUT BETWEEN JUNE 1970 AND MAY 1971, BY MONTH

Year and month	*Number of social abortions*	*Year and month*	*Number of social abortions*
1970		1971	
June	251	January	241
July	237	February	165
August	211	March	281
September ...	242	April	279
October	216	May	250
November ...	163	TOTAL	2 753
December ...	217		

(*c*) Protection by the pill, by applying the method used, except for the month of December 1970; 7,542 women (users in December plus half the additional packs for October and November);

(*d*) Protection by condoms and jelly, by taking the November and December users namely, 5,312 women with a potential fertility rate of 250 per 1,000: 11,266 births averted by IUD, ligation, pill, condom and jelly, to which must be added 2,064 births averted by social abortion (2,753 abortions between June 1970 and May 1971).

This calculation results in the total: 13,330 births averted in 1971.

METHODOLOGICAL ISSUES

The aim of the study was to test various techniques for measuring the impact of family planning programmes on fertility by applying them to the particular case of Tunisia; it therefore appears useful to gather all the criticisms and observations which emerged in the preceding section and to generalize from them. The discussion covers the following aspects:

(*a*) Potential fertility of acceptors;

(*b*) Availability of data;

(*c*) Interaction of factors;

(*d*) Uncontrolled variables;

(*e*) Independence of method;

(*f*) Cost-precision analysis.

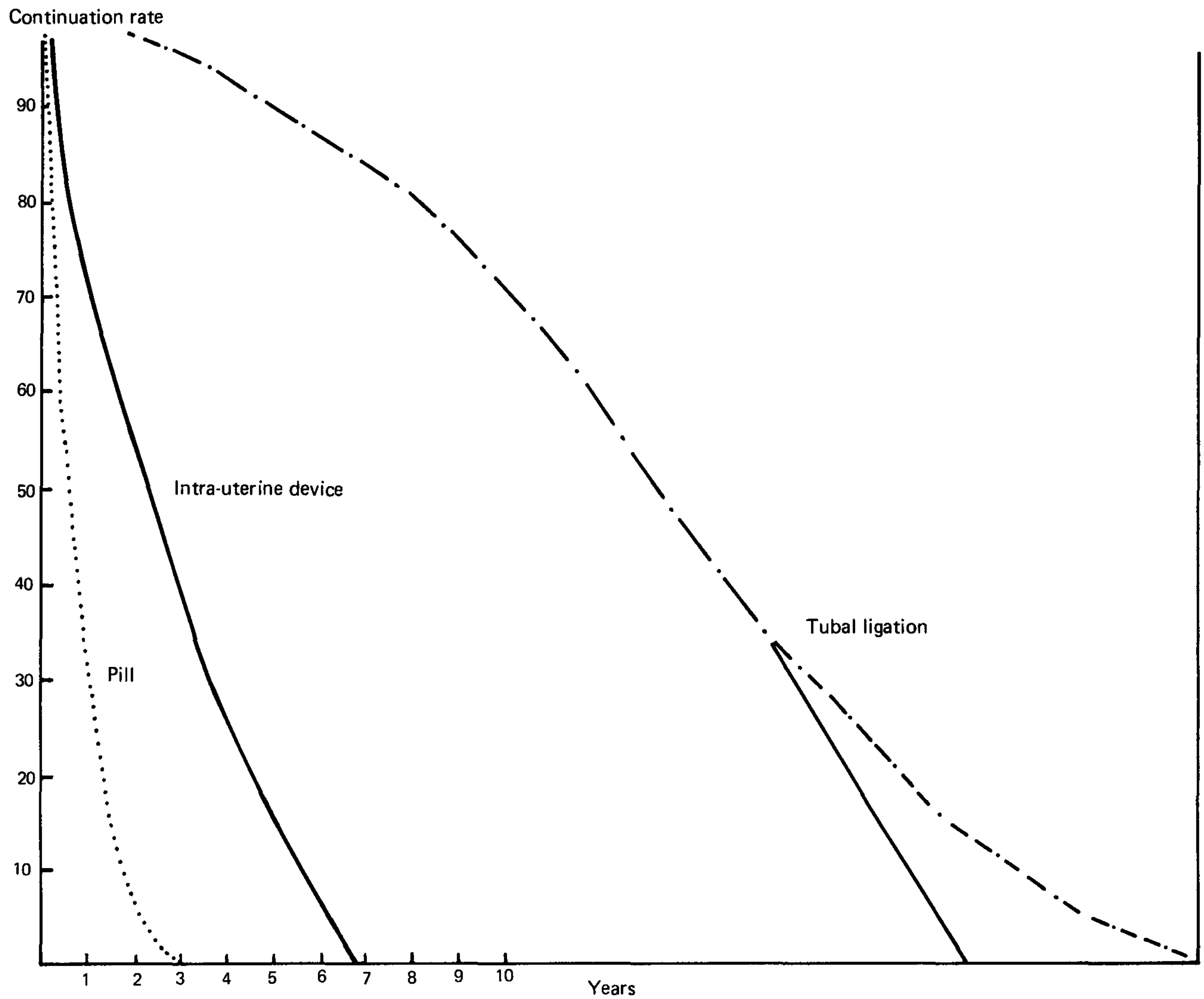


Figure X. Estimated continuation rates

Potential fertility of acceptors

One of the major assumptions on which several measurement methods are based is the estimate of the potential fertility of participants. This process involves assessing an imaginary situation by using reasonable estimates and an analysis of local demographic and social characteristics.

Proposed solutions

In the preceding section, the problem of estimating potential fertility was dealt with in a number of ways. For the method using an index of couple-years of protection, it was assumed that 1 CYP = 0.25 births; that assumption presupposes that the potential fertility of acceptors is 250 per 1,000, which is roughly equal to the legitimate fertility rate of the female population in 1971 increased by 10 per cent. This assumption would mean that contraceptive users were slightly more fertile than married women in general, and the same assumption is used in the estimates of UNPFP, which goes so far as to claim that there is no difference between the two universes if the age distribution is taken into account because acceptors are in the age brackets in which reproduction reaches its highest level.

In fact, this position seems untenable, because the survey on continuation of IUD and the pill showed clearly that fertility is higher among contraceptive users than in the general population (see table 17 and figure V, which show acceptors by number of children living at time of acceptance). Furthermore, cases of sterility are much less frequent among users; given the prevailing social conditions and outlook, the likelihood is that it is chiefly women with more than the average number of children who use contraception to prevent further pregnancies. The idea of using contraception to space births is still unfamiliar to the general population; social norms encourage couples to have children immediately after marriage and regularly thereafter, although permitting contraception after four or five offspring have been produced (even this is a great advance on earlier attitudes, which wanted everything left to nature).

For the component projection method, the potential fertility of acceptors was taken to be the fertility rate of acceptors of IUD and the pill before acceptance, as estimated on the basis of the continuation survey. This estimating process also calls for a number of criticisms:

(*a*) In the absence of any information, these rates had to be applied uniformly to acceptors of tubal ligation, condoms and jelly, whose fertility levels before acceptance were unknown. A survey of sterilization currently in progress ought to clarify this point shortly, but for condoms and jelly no reasonable indexes are available;

(*b*) It was assumed that the fertility rate "at about 30 years of age" of acceptors whose average age was 32.5 could be taken as the potential fertility rate of women aged 30–34, which implies a not insignificant degree of over-estimation of the births which would have been prevented among them;

(*c*) In the case of social abortions, a fertility rate of 290 per 1,000, i.e., the 1971 legitimate fertility rate in a population of the same structure. That estimate appears reasonable, as abortion is not exclusively a method of contraception and the motivation is different.

Although the method involving analysis of the reproductive process was not tested, the following formula was proposed to the present authors for estimating the average interval between births:

$$I = \frac{12{,}000}{\text{fertility rate by age or mean age group}}$$

This formula is an approximation which is subject to the same criticisms as before, since it uses the fertility rates of acceptors before their participation in the family planning programme.

As well as the type of data adopted by us, one could conceivably use as potential fertility rates the legitimate fertility rates for the base year 1966, with or without an increment for the higher fertility rate of contraceptive users. This approach was not adopted because it is almost certain that in 1966, fertility was particularly high (owing to, among other things, the minimum age for marriage having been raised in 1964); moreover, economic and social conditions have changed and it is inconceivable that the acceptors alone were not affected by the change.

Non-contraception programme

It is difficult to evaluate the extent to which contraceptive users might have resorted to a non-contraception programme. In Tunisia, as stated earlier, the family planning programme is part of a State-directed national population policy and all measures carried out under that policy are interdependent. The unrestricted sale and distribution of contraceptives, which dates from 1961, and the complete liberalization of social abortion in 1973 are legislative reforms which could have taken place only within the context of co-ordinated family planning. A private sector for the distribution of contraceptives does exist; but it is supervised by the Central Pharmacy of Tunisia and, although it was not included in statistics until recent years, activities within the private sector have been evaluated regularly since the establishment of the National Family Planning and Population Office. In the third quarter of 1975, almost the same number of pill cycles were distributed by the private sector as under the programme (about 32,362 for the programme and 39,976 for the private sector).

The programme authorities place considerable emphasis on educating and informing the public by direct contact and through the mass media.[27] The real effects of the programme are therefore difficult to measure and are closely linked with other aspects of economic and social development.

The ideal estimate and the most reasonable solution

It might be thought, in the absence of any kind of verification, that the ideal would be to ascertain the fertility rate of a control group having the same characteristics as the population of contraceptive users. But that is exactly where the problem arises, as the authors were unable to find a group of women which satisfied these conditions and their opinion is that, in reality, it is impossible to isolate such a group. It is therefore suggested that an intermediate assumption will serve the purpose, namely, to take as the potential fertility of acceptors the legitimate fertility rate, by method of contraception, of contraceptive users before they joined the programme, subject to adjustment for suitable age groups.

Availability of data

Certain statistical data vital for the application of these methods are non-existent or not easily accessible or would be too costly to obtain; in some cases, such data as do exist are of dubious reliability. An account follows of the difficulties encountered in applying the methods described in the preceding section.

Quality of available data

Tunisia has an adequate statistical organization, the activities of which are described below.

Censuses

The first census count was made in 1926 under the French protectorate. Similar very rudimentary counts were made every five years. They provide information mainly on the geographical distribution of the population and distinguish between different nationalities and ethnic groups. Since the obvious objectives of these surveys were of a fiscal or military nature, three age groups are distinguished (under 15 years, 15–20 years and over 21 years).

Beginning in 1936, censuses took place every 10 years and began to serve their true purpose, although in fact only the censuses of 1966 and 1975 deserve the name. Those censuses are considered satisfactory and have been corrected to allow for any possible distortions. The results are, of course, still open to criticism if a very high standard is demanded, but it is generally recognized that the quality of the data obtained is comparable to that of the most developed countries.

Vital records

Vital records were instituted in 1908, but the first very fragmentary data are available only from 1926. After independence was attained in 1956, there was a marked improvement as a result of legislation in 1958 which made the registration of births, deaths and marriages obligatory (the Personal Status Code of 13 August 1956 and the Acts of 1 August 1957 and 4 July 1958), the reorganization of regional administration and of the expansion of school attendance.

As previously stated (see foot-note 9), the estimated rate of coverage of births is 95 per cent, and the statistics are very reliable. However, it has been suggested that in 1971 the omission rate was 6.9 per cent, which would mean that INS underestimated the true situation (see discussion of trend analysis in preceding section).

The distribution of births by age of the mother is known only for 1960 and from 1965 to 1973.

Detailed statistics on births are still very scanty: data are available on births by sex, length of marriage, birth order and governorate from 1966 to 1970; and by socio-professional category of the father and type of confinement (multiple, place, type of attendance) for 1970.

Surveys

Demographic surveys directed to obtaining a better knowledge of the conditions of the Tunisian population began in 1964. These surveys are described briefly below:

(*a*) In 1964, as part of the preparations for the introduction of family planning to Tunisia, J. Morsa organized a KAP survey of 2,175 married women in 12 maternal and child welfare centres. Only one very short preliminary report was published; it served chiefly to demonstrate that the women were favourably disposed towards contraception;

(*b*) In 1967–1968, another survey of the same type was conducted by the Centre for Economic and Social Studies and Research, Tunis. The sample consisted of 1,440 people (820 women and 620 men) from Tunis and its suburbs. The analysis of the results was divided into three parts: the concept of the family size: family planning and the motivations for it; and the characteristics of the legitimate fertility rate;

(*c*) In 1968, INS undertook a national demographic survey[28] the main aim of which was to assess the quality of vital data registration. As pointed out previously, the results were very encouraging. The opera-

[27] Hedi Jemai, *Attitudes des responsables tunisiens vis-à-vis de la politique de planning familial à travers la presse tunisienne*, study for the project "Droit et population" (Tunis, Office national du planning familial et de la population, 1975); and S. Sahli, *Attitudes des responsables tunisiens vis-à-vis de la politique de planning familial à travers les émissions télévisées et les discours*, study for the project "Droit et population" (Tunis, Office national du planning familial et de la population, 1975).

[28] Tunisia, Institut national de la statistique, *Enquête nationale demographique, 1968–1969*, Demographic Series, No. 6 (Tunis, 1974).

tion also provided more detailed material for fertility measurement (in particular, measurement of the gap between urban and rural areas). The survey covered 27,000 households interviewed on three separate occasions;

(*d*) In 1972–1973, INS undertook a large-scale survey of migration and employment at Tunis.[29] Part of the questionnaire dealt with fertility: description of all the wife's offspring and birth control behaviour. The analysis covers 1,790 women and is especially concerned with distinguishing areas of origin (Tunis, urban area, semi-urban area or rural area).

(*e*) In 1973, as previously stated, ONPFP carried out a national survey on the continuation of contraceptive methods (IUD and pill) by 2,060 acceptors (between January 1969 and August 1972). The results have been issued,[30] and continuation rates for those two methods and an analysis of the fertility of contraceptive users before and after acceptance are now available. As a follow-up, a field survey is being carried out in order to provide similar information on women who have had an abortion or tubal ligation.

The results of the surveys described in (*a*)—(*d*) in the field of fertility and family planning are relatively detailed.

Statistics on family planning activities

Since 1964, all statistics compiled for use by the programme itself have been published. The general statistics (on the number of acceptors by method and by governorate) have been published in two volumes covering the period 1964–1973.[31]

Since January 1974, the statistics department of ONPFP has been publishing a quarterly statistical bulletin covering: (*a*) the activities of the centres over time; (*b*) the activities of the centres in space; (*c*) trends in the centres; (*d*) results in relation to number of medical and paramedical personnel.

For the post-partum and post-abortum programme, statistics were published from 1969 to 1971. The possibility of reviving the programme is currently being studied. The ONPFP periodically publishes reports on the demographic characteristics of acceptors, births averted (targets and results) and number of women protected (1974–1975).

Estimates regarded as valid

Some of the data used in preparing this report were not collected or drawn from surveys, but were the product of a valid estimate made by INS or a competent demographer. One example is the INS population perspectives for 1971–2001, the main assumptions for which are described above in footnote 15. It will be recalled that estimates were also used for the proportion of married women in 1971, for the residue of women x years after a tubal ligation and for births prevented by abortion. Reference to these studies will confirm the validity of the estimates.

Assumptions from imperfect data

Apart from the data just mentioned, which may not be unimpeachable but are, despite their faults, quite reliable, it was necessary to formulate for other factors assumptions whose soundness must still be assessed. However, it would be futile to expect to obtain information to verify such data since, despite its very advanced statistical organization, Tunisia is still a developing country; and the establishment of some indicators requires time, material resources and specialized personnel.

Furthermore, the application of the measurement methods demands at many points very detailed data on matters that are difficult to quantify; such data would be difficult to obtain even for a universe that was ideal from the point of view of collecting statistical data. This last observation applies to the use of contraceptives in a couple's private life, to the impact of economic, social and psychological factors on fertility, to the age distribution of women making effective use of contraception and to all the socio-economic indicators required to apply the regression method.

Listed below are only the main assumptions made by the authors in the preceding section on the application of the various methods:

(*a*) Factors affecting fertility are independent and additive;

(*b*) Illegitimate births are negligible;

(*c*) The same fertility rates are attributed to unmarried and unborn women as to women actually married in 1971;

(*d*) The natality trend is taken to be satisfactorily measured by determining the gradient of a line estimated by the least-squares method;

(*e*) The control and experimental groups have the same social, demographic and economic characteristics (see the subsection on this method for details);

(*f*) The acceptance of contraceptive methods is spread evenly over the year;

(*g*) Four abortions protect one woman for one year;

(*h*) Continuation rates can be extrapolated beyond four years;

(*i*) Users of condoms and jelly receive the quantity necessary to provide protection for one cycle;

(*j*) The effects of all the contraceptive methods are additive;

[29] Tunisia, Institut national de la statistique, *Enquête migration et emploi à Tunis, 1972–1973*.

[30] Tunisia, Office national du planning familial et de la population, *Enquête nationale sur la continuation des méthodes contraceptives en 1973*.

[31] Tunisia, Office national du planning familial et de la population, *Statistiques des activités du programme de planning familial de 1964 à 1970* (Tunis, 1971); and *idem*, *Statistiques des activités du programme de planning familial de 1971 à 1973*.

(*k*) Age distribution within age groups is uniform;

(*l*) Continuation within age groups is the same for each age;

(*m*) Eighty per cent of the condoms, jelly and pills distributed are efficiently used by couples.

Given the number of assumptions required for the application of these methods, scepticism as to the real scope and scientific value of the results is justified. Nevertheless, it was found that in many cases the errors cancel each other out and the conclusions are not inconsistent with reality.

In fact, the doubts raised by the reasoning underlying each of the methods and the evaluation process which they imply are more fundamental.

Interaction among factors

On the basis of the foregoing comments, it appears that interaction, among the factors which might affect fertility rates, is one of the basic problems to be considered in any discussion on measuring the impact of family planning programmes. It is hard to imagine family planning programmes being imposed in a social context that would reject them, and this factor is well understood by the Tunisian authorities.

Where the traditional structures of the Moslem family and its relationship with the economic environment prevail, it is certainly difficult to imagine modern contraceptive methods being accepted or even considered by the couple. (This practice would run counter to all the psycho-sociological and religious characteristics of these societies.) It has been possible for the activities of the Tunisian family planning programme to expand precisely because the demographic policy was an integral part of the over-all economic and social development model, as advocated by the authorities.

Interactions among non-programme and programme factors undoubtedly exist, as witnessed by, among other examples, the decline in family planning activities after a speech by President Bourguiba advocating population growth.[32]

The authors are inclined to think that the interdependence of all the political, economic, social and demographic factors is a fundamental principle in the understanding of national trends. However, it is realized why, in order to facilitate the measurement of social phenomena, these factors should be assumed to be independent, provided that the *a priori* bias thereby introduced is not overlooked.

Uncontrolled variables

Some measurement techniques—in particular, the standardization approach and regression analysis—try to account for all factors that may affect the level of fertility. In the present analysis, prominence is given to those factors which can be measured, namely, structure by age and by marital status, and family planning activities.

Attention has been drawn to the influence of universal schooling and of internal and external migration, although it was not possible to evaluate them in quantitative terms. This point was discussed in the preceding section (see subsection on the standardization approach) and is also dealt with in a recent study[33] prepared for the United Nations Educational, Scientific and Cultural Organization (UNESCO), which contains a detailed analysis of trends in a number of economic and social factors which may have affected fertility in Tunisia for the past 10 years: (*a*) economic growth, level of living and income distribution; (*b*) employment, migration and rural development; (*c*) education, health and well-being.

Some of these factors (emancipation of women, universal schooling, decline in mortality, migration etc.) have probably had a significant impact, but it is difficult to measure.

On the other hand, the majority of the population have not experienced decisive improvements in income, employment and housing.

However, it may well be that even though there has been only slight progress in any single one of these factors, they have together caused the change in outlook and the widespread aspiration to attain the social model exemplified by the élite, who are seen to profit from it.

Independence of methods

The main value of this report derives in large part from the juxtaposition of several methods of measuring the impact of family planning programmes on fertility. The simultaneous application of these methods to the same country and the same family planning programme in the same period makes it possible to compare their validity in relation to the same set of facts and the consistency of the reasoning on which they are based.

Two basic types of approach can be distinguished. Under the first type, the methods require an analysis of fertility trends and thereafter an estimate of the relative influence of the determining factors, which ought to demonstrate the relative impact of the family planning programme: such is the case with the standardization, projection, experimental design and regression analysis methods.

The application of the first two methods to Tunisia showed that the declining trend in fertility, which began in 1956, accelerated significantly after the beginning of family planning activities in 1964. It is still difficult, however, to identify the specific share at-

[32] Yolande Jemai, "Droit et population in Tunisie", paper prepared for the International Symposium on Law and Population; Tunis, Office national du planning familial et de la population, 1974 (mimeographed); M. Ayad and Yolande Jemai, *Tunisian Fertility Models* (Paris, UNESCO, forthcoming); and Hedi Jemai and Yolande Jemai, *La politique de la planification familiale en Tunisie*, study for the project "Droit et population" (Tunis, Office national du planning familial et de la population, 1975).

[33] M. Ayad and Y. Jemai, *op. cit.*

tributable to the family planning programme; not only have variations in the female age structure and changes in nuptiality been conducive to a decrease in the average number of children but all economic and social development factors are creating a new society, whose structures and objectives are incompatible with maintaining the traditional concept of the family and therefore imply a fairly rapid spread of family planning among couples.

Despite the imperfections of the control group in the present example the experimental method represents a novel approach to the problem; it shows clearly the fall in fertility among programme acceptors compared with the particularly high fertility rates which they displayed before using contraception and even compared with the female population as a whole. This finding confirms that even if all the decline in fertility cannot be attributed to the programme, the programme has indisputably had direct and indirect effects through information and education, and it has helped to spread new attitudes to reproduction in all sections of society.

A review of these methods indicates that, although their assumptions can be disputed and the measurement of economic and social factors is a difficult process, the standardization method achieves results which are clearer than those of other methods and which are sufficiently accurate. They should, obviously, be supplemented by a reasonable estimate of births averted by the programme—the main objective of the second series of methods tested.

These methods seek to measure the impact of family planning programmes in another way, by evaluating the result of family planning activities in demographic terms. This process involves estimating the degree of protection afforded by contraception or the number of births which have been averted by its use: that is the aim of the methods involving couple-years of protection, component projection or analysis of the reproductive process.

As applied to Tunisia, the first two methods yield almost identical results, which are also similar to the estimates made by ONPFP. According to the assumptions used for the potential fertility of acceptors, some 13,000–15,000 births are believed to have been averted in 1971. Although differing in detail, the estimates lead to the same conclusions: the most effective methods are IUD and tubal ligation. Abortion should be treated separately, since it may or may not be considered a method of contraception.

Cost-precision analysis

It does appear that refining the analysis adds nothing of moment to an assessment of the results. All the conclusions reached in the present study are consistent with one another, and it seems unnecessary to spend a great deal of time and effort to show in greater detail the magnitude of the impact of a family planning programme. It would be enough to improve the standardization method and to estimate the number of births averted by family planning by a homogeneous procedure in order to permit comparisons between countries.

On the other hand, it would certainly be useful to improve techniques for measuring the impact of family planning programmes on fertility from the scientific point of view, in order to make possible an in-depth assessment of the consequences of a State-directed population policy at the national level.

In most countries, the authorities are more concerned with action than with abstract thinking; they should be given the tools for measuring the result of family planning activities by methods that are simple and easy to apply systematically. On the other hand, the specialists must seek methods of monitoring population policies in order to evaluate their long-term consequences and to warn against any possible dangers to society.

Conclusion

The application of the methods discussed above to Tunisia for the period 1966–1971 has served to confirm what was already known from other studies. It would have been much more instructive to have done this study on a more recent period (1971–1975), but lack of statistical data made that impossible.

Family planning programmes are still very new and organizational changes occur frequently. Until 1973, structural changes were being made—a good indication that the responsible authorities were seeking an ideal operational model. Since 1973, when the National Family Planning and Population Office was established, family planning activities have been given a definite, permanent place in national economic and social development planning.

Family planning is now seen as a fundamental option of national policy, knowledge well known to and accepted by the population.

Currently, however, despite the unquestionable success experienced in recent years, the fact that since the liberalization of abortion in 1973, abortions have been increasingly resorted to, to the detriment of preventive contraception, gives cause for concern.

The authorities want to see couples make greater use of birth-spacing contraception rather than absolute contraception, a development which would provide tangible evidence of the success of their policies.

The function of evaluation experts is to help the authorities to assess the measures taken and, more importantly, to try to become more familiar with the workings of a policy which has a direct impact on personal, family and social well-being.

Annex I

TUNISIA: DEMOGRAPHIC AND FAMILY PLANNING INDICATORS

TABLE 50. DEMOGRAPHIC INDICATORS, 1966 AND 1971-1975

Indicator	*1966*	*1971*	*1972*	*1973*	*1974*	*1975* [a]
Population						
Population at mid-year [b]	4 717 500	5 228 400	5 331 800	5 444 200	5 616 300	5 572 229
Male	2 323 700	2 557 200	2 612 600	2 652 600	2 758 900	2 808 622
Female	2 393 800	2 671 200	2 719 200	2 791 600	2 857 400	2 763 607
Women of reproductive age (15-54) [c]	1 071 300	1 229 300	1 268 200	1 314 200	1 350 000	...
Population of communes (*percentage*) [d]	40.0	...	...	...	...	49.1
Urban population (*percentage*) [d]	...	50.4	...	...	...	...
Rural population (*percentage*) [d]	...	49.6	...	...	...	...
Structure						
Age distribution (*percentage*) [e]						
0-14 years	46.5	45.5	44.8	44.3	43.7	43.2
15-64 years	49.9	50.5	51.1	51.6	52.1	52.6
65 years and over	3.6	4.0	4.1	4.1	4.2	4.2
Vital statistics [b]						
Births registered [f]	206 730	183 311	198 785	194 764	191 049 [g]	...
Deaths registered [f]	48 307	48 625	40 053	43 716	39 062 [g]	...
Marriages registered	27 037	37 750	45 043	43 183	...	...
Divorces registered	4 616	4 584	4 930	5 099	...	...
Corrected birth rate (*per 1,000 population*)	43.8	36.9	39.3	37.7	35.8	...
Corrected death rate (*per 1,000 population*)	14.0	12.7	10.3	11.0	9.5	...
Corrected general fertility rate	193.0	157.0	165.0	156.0	149.0	...
Marriage rate (*per 1,000 population*)	5.7	7.2	8.4	7.8	...	...
Divorces (*per 1,000 population*)	0.98	0.88	0.93	0.93	...	...
Increase						
Balance of migration [h]	–12 637	–32 281	–24 552	–12 768	+2 352	...
(Estimated) births minus deaths [b]	140 556	126 350	154 830	145 128	137 540	...
Crude rate of natural increase (*percentage*) [b]	29.8	24.2	29.0	26.7	26.3	...
Net rate of increase (*percentage*) [i]	27.1	18.0	24.4	24.4	26.7	...

[a] Numbers taken from provisional returns from census of 8 May 1975.

[b] Tunisia, Institut national de la statistique, *Statistiques de l'INS*, Serie démographie No. 5 (Tunis, December 1975).

[c] Tunisia, Institut national de la statistique, *Niveau et tendances de la fécondité en Tunisie*, Serie démographie No. 5 (Tunis, May 1974).

[d] Tunisia, [Ministère du Plan], *Aménagement du territorie: l'armature urbaine en Tunisie, 1973.*

[e] Tunisia, Institut national de la statistique, *Perspectives d'évolution de la population, 1971-2000*, fasc. II (Tunis, 1972).

[f] The numbers of births and deaths registered have been increased by 5 per cent and 27 per cent, respectively. The figure for births in 1966 has not been corrected; INS believes the rate to be 100 per cent for that year (figure becomes 46.1 per cent for births if increased by 5 per cent).

[g] Unpublished data provided by Institut national de la statistique.

[h] Tunisia, Ministère de l'Intérieur, cited in Institut national de la statistique, *Economie de la Tunisie en chiffres de 1967 et 1971* (for 1966 and 1971); and in *idem, Bulletin mensuel de la statistique* (November-December 1974 and January 1975) (for 1972-1975).

[i] In estimating net rates of increase, the balance of migration was included.

TABLE 51. FAMILY PLANNING INDICATORS, 1966 AND 1971-1975

Indicator	*1966*	*1971*	*1972*	*1973*	*1974*	*1975*
Contraceptive users						
Total number of female contraceptive users...	41 517	239 916	246 675	241 335	256 984	51 714[a]
New female contraceptive users	16 176	40 360	43 665	43 840	50 901	30 927[a]
New acceptors of:						
Intra-uterine device	12 077	12 381	13 250	16 790	19 084	9 917[a]
Pill	350	11 778	12 026	11 194	10 795	7 709[a]
Tubal ligation	766	2 280	2 453	4 964	10 757	6 503[a]
Social abortions	1 326	3 197	4 621	6 547	12 427	7 833[a]
Women protected by family planning programme at end of year	...	49 900	54 868	64 109	77 959	...
Rate of protection per 100 married women, aged 15-49, at end of year	...	...	...	8.47	10.06	...
Rate of protection per 100 married women, aged 15-54, at end of year	...	...	...	7.75	9.21	...
Target and achievement						
Births to be averted	...	12 000	15 500	19 000	22 500	26 250
Births averted by family planning programme..	...	13 330	15 515	17 288	23 117	29 720
Target achievement (*percentage*)	...	111	100	91	103	113
Infrastructure			330	309	392	...
Operational family planning centres	...	360				
Married women of reproductive age (15-49) per			...	2 432	1 976	...
centre	...	...				
Medical specialists	...	35	...	...	69	83[a]
Midwives	...	40	...	...	92	81[a]
Medical aides	...	60	...	...	265	447[a]
Female contraceptive users per doctor	...	6 855	...	...	3 724	...
Female contraceptive users per midwife	...	5 998	...	...	2 793	...
Female contraceptive users per medical aide ...	...	3 999	...	...	970	...

[a] Data for first half-year.

Annex II

BIRTHS AVERTED BY TUBAL LIGATIONS IN TUNISIA*

Tubal ligations have been performed in Tunisia since the beginning of the experimental programme in 1964, and the number performed has risen steadily (see table 52). Since the demographic effects of this radical method of birth control are felt over a long period, a way of accurately quantifying the number of births averted by tubal ligations is required.

TABLE 52. TUBAL LIGATIONS PERFORMED FROM 1964 TO MID-1974

Year	*Number of ligations*	*Year*	*Number of ligations*
1964	293	1970	2 539
1965	384	1971	2 280
1966	766	1972	2 459
1967	742	1973	4 964
1968	1 627	1974 (first quarter) ..	3 480
1969	2 513	1974 (second quarter).	3 096

GENERAL PRINCIPLES OF THE ESTIMATING PROCESS

Ostensibly, a tubal ligation performed on a woman aged 25 years would cause all possible births to her between that age and menopause at, say, 50 years of age, to be averted. This reasoning implicitly assumes that this 25-year-old woman, if she had not undergone ligation, would have been exposed to all the risks of fertility during the remainder of her reproductive span. However, even if she had not undergone tubal ligation, she might have: (*a*) died between the ages of 25 and 50; (*b*) been widowed between the ages of 25 and 50; (*c*) had a divorce; (*d*) become sterile; or (*e*) resorted to another method of contraception.

In any event, the average reproductive span of the couple would have lasted less than 25 years. These factors must therefore be taken into account in producing a breakdown of births actually averted by tubal ligation. All of the following estimating processes therefore rely upon a comparison between the absence of births following a tubal ligation and what might have happened in the absence of tubal ligation. It is assumed, with no great risk of error, that fertility is nil after age 50. Illegitimate births are ignored.[a]

ESTIMATING BIRTHS AVERTED BY TUBAL LIGATION

Assuming that the probabilities of death, widowhood, divorce or becoming sterile from the time of ligation to menopause (at 50 years) are independent of one another, changes in the number of fecund couples surviving and cohabiting after tubal ligation are first estimated.[b] When all these factors are taken into account, one will obtain, for each age, the number of surviving, fecund, cohabiting couples there would have been in the absence of tubal ligation per 1,000 women having undergone tubal ligation at a given age (see table 53). It is to this residual number at each age that the age-

*Prepared by L. Behar for the Tunisian case study.

[a]Births classified as illegitimate constituted 0.37 per cent of all births in 1968, according to Institut national de la statistique, *Naissances 1966 à 1968, statistiques détaillées*, Demographic Series, No. 4 (Tunis, February 1974), pp. 57–59.

[b]For mortality, use was made of the life tables for both sexes prepared by Institut national de la statistique, on the basis of the National Demographic Survey, 1968–1969. It was assumed that, on average, husbands are five years older than their wives. The distribution of divorces by length of marriage was estimated from divorces in the 1964 marriage cohort and the distribution by length of marriage of divorces in 1969. See "Naissances, décès, mort-nés, mariages, divorces, 1969", Demographic Series, No. 3 (February 1973), pp. 229 and 243. For sterility, the age-specific data are those estimated by L. Henry, "Fécondité des mariages, nouvelle méthode de mesure", *Cahiers de l'I.N.E.D.*, No. 16 (1953). An attempt was made to allow for the possibility that a woman who has not undergone a ligation may resort to traditional means of contraception by relying on the age distribution of new acceptors of intra-uterine devices and the age-specific rates of exposure to family planning.

TABLE 53. RESIDUE OF FECUND COHABITING COUPLES BY AGE AT TIME OF LIGATION

Age at time of ligation	Age of couples					
	25	30	35	40	45	50
25	1 000	829	703	532	285	0
30		1 000	845	639	342	0
35			1 000	744	398	0
40				1 000	535	0
45					1 000	0
50						0

specific legitimate fertility rates will be applied in order to estimate the number of births averted by tubal ligations.

On the basis of table 53, the average period[c] of protection by tubal ligation (see table 54) is estimated. It will be found that the average periods of protection are much lower than the difference between age at menopause (50 years) and age at time of ligation.

However, in order to eliminate as far as possible distortion arising from incorrect statements of age, five-year age groups should be taken as the departure point.

TABLE 54. AVERAGE PERIOD OF PROTECTION BY AGE AT TIME OF TUBAL LIGATION

(*Years*)

	Age at time of ligation			
	25	30	35	40
Average period of protection	14.3	11.6	8.2	5.2

For each five-year age group between ages 20 and 50, 1,000 women who had undergone ligation were taken and that initial arbitrary number was subjected to the risks of death, widowhood, divorce, sterility and resort to another method of contraception up to the age of 50 years, year by year (see table 58 in appendix). Each age group at time of ligation is represented by its mid-point, except the age group 20–24, in which the average age at time of ligation is 23, and the 45–49 age group, in which the average age is 47. These average ages were estimated on the basis of the ages of women who underwent ligation during the first half of 1974. The residual numbers of women are reduced to zero after a number of years equal to the difference between the average age and the upper age limit for fertility, i.e., 50 years.

In order to determine for all ages combined the residual number of women 1, 2, . . . *n* years after ligation (table 55), each residual number was weighted by a quantity representing the proportion of women in that age group at the time of ligation to the total number of women having undergone ligation. The weighting coefficients are those relating to the age distribution of women having undergone ligation during the second quarter of 1974.[d]

It is clear, therefore, that 35 per cent of the women are outside the field of observation at the end of 5 years and over 68 per cent at the end of 10 years. After 15 years, the residue is 10 per cent of the women and after 20 years only 2 per cent. It must be borne in mind that these figures are for surviving, cohabiting, fecund couples in which the age distribution of the wives is the same as that of women having undergone ligation, but in the absence of ligation.

On the basis of table 58, and proceeding in the same way as in estimating life expectancy from a life table, the average period of protection was estimated (table 56).

It is to the residue at each age, as shown in table 1, that the legitimate fertility rates are applied in order to derive the number of births averted by tubal ligation. Use was made of the legitimate fertility rates taken from the Tunisian national population survey.[e] As the women grow older, the legitimate fertility rates corresponding to the age groups into which they move are applied (see table 59). In the summation (table 57), for each age group at time of ligation the number of births averted per 1,000 women having undergone ligations in the age group in question is determined.

Thus, for each woman who has undergone ligation between the ages of 20 and 25 (the average age being 23 years), 4.06 births are averted; for each woman who has undergone ligation between the ages of 25 and 30, 2.8 births, on average, are averted etc.

The weighted average of births averted by age at time of ligation, using the same weighting coefficients as before, will yield the actual number of births averted by tubal ligation. This number is 1,095 births averted per 1,000 women who have undergone ligation. To simplify the computation, the figure may be rounded off to 1.1 births averted by ligation. The distribution over time of these 1,095 births averted shows a heavy concentration in the years immediately following ligation. In fact, 48 per cent of the averted births are averted in the 3 years following ligation, 66 per cent within 5 years of ligation and 92 per cent in the first 10 years after ligation.

[c]In this connexion, it was assumed that the "departure" for the universe used here was a linear process between age x and age $x + 5$. That hypothesis is probably invalid after age 40, but the relatively small numbers remaining after that age greatly reduces the risk of error in the results.

[d] The age distribution of women who have undergone tubal ligation is available for only a few years, the most reliable data—and the only data covering the whole of Tunisia—being those for the second quarter of 1974. Moreover, the age distribution of women who have undergone tubal ligations and the average age do not appear to have changed significantly, except perhaps for greater concentration between the ages of 30 and 40, a corollary of the slightly smaller relative weight of the extreme age groups, 20–24 and 45–49 (see table 60 in appendix).

[e] See Tunisia, Institut national de la statistique, *Niveau et tendances de la fécondité en Tunisie,* Demographie Series, No. 5 (Tunis, May 1974), p. 16.

TABLE 55. RESIDUE OF WOMEN *n* YEARS AFTER LIGATION PER 1 000 WOMEN HAVING UNDERGONE LIGATION, ALL AGES COMBINED

n	Residue of women	*n*	Residue of women	*n*	Residue of women	*n*	Residue of women
1	933	8	429	15	101	22	7
2	867	9	372	16	75	23	4
3	793	10	313	17	50	24	3
4	718	11	253	18	34	25	2
5	645	12	196	19	27	26	1
6	572	13	150	20	20	27	0
7	498	14	126	21	14	28	0

TABLE 56. AVERAGE PERIOD OF PROTECTION BY AGE GROUP AT TIME OF LIGATION

(*Years*)

Age group at time of ligation	*Average period of protection*
20-24	15.88
25-29	12.98
30-34	9.99
35-39	6.79
40-44	3.87
45-49	1.50
All ages	7.70

TABLE 57. BIRTHS AVERTED, BY AGE AT TIME OF LIGATION

Age group at time of ligation	*Births averted per 1,000 women having undergone ligation in the age group*
20-24	4 057
25-29	2 810
30-34	1 630
35-39	716
40-44	191
45-49	3
All ages	1 095

A PRACTICAL EXAMPLE: WOMEN WHO UNDERWENT A LIGATION IN 1973

Since the age distribution of women who underwent a tubal ligation operation in 1973 was not available, it was assumed that the distribution was the same as that for the second quarter of 1974. The residue of women and births averted each year from 1973 to 2000, when this group of women will be completely outside the field of observation, are given in table 61. All told, 5,440 births will be averted by the 4,964 ligations performed in 1973. Most of these births will be averted in the years immediately following the ligation and 94 per cent before 1985.

CONCLUSION

Each tubal ligation operation performed in Tunisia averts, on the average, 1.1 births. The births averted among a group of women who undergo the operation during a given year are spread over 30 years, but over 90 per cent of them are averted in the 10 years following the operation. It is very unlikely that there will be any great change in the age distribution and average age of the women undergoing the operation which would significantly alter the data.

Births averted by tubal ligations have been underestimated owing to the fact that the life table for the years 1968–1969 was used. The death rate in Tunisia is falling steadily, a fact which increases the proportion of surviving couples allowed for in these estimates. Nevertheless, the fact that use was made of fertility data for the years 1968–1969 may offset this underestimation in view of the decline in fertility in Tunisia.

Appendix

TABLE 58. RESIDUE OF WOMEN *n* YEARS AFTER LIGATION

Average age at time of ligation	Number of years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
23	977	954	924	894	864	835	865	781	758	734	740	687	655	623	592	560	528	480	432	384	336	288	230	173	115	57	0	
27.5	963	926	892	865	839	811	784	751	714	677	640	603	556	502	448	394	339	280	218	156	94	32	0					
32.5	966	931	893	848	804	758	715	655	595	530	466	408	328	260	185	111	37	0										
37.5	944	889	821	742	661	582	501	414	322	231	137	47	0															
42.5	880	758	628	486	349	210	68	0																				
47	667	333	0																									
All ages combined	933	867	793	718	645	572	498	429	372	313	253	196	150	126	101	75	50	34	27	20	14	7	4	3	2	1	0	

TABLE 59. BIRTHS AVERTED EACH YEAR
(*Per 1 000 women*)

Average age at time of ligation	Number of years 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Births averted per 1,000 women who have undergone ligation in the age group
23	379	370	328	317	307	296	286	217	211	204	198	190	130	123	117	111	105	37	34	30	27	23	5	4	3	2	1	0	4 057
27.5	342	329	284	241	231	226	218	179	141	134	127	120	78	39	35	31	27	15	5	4	3	1	0						2 810
32.5	269	260	200	168	159	151	142	92	46	42	37	32	17	6	5	3	1	0											1 630
37.5	188	177	115	58	52	46	40	21	7	6	4	2	0																716
42.5	69	61	33	11	8	6	3	0																					191
47	2	1	0																										3
All ages combined	201	191	139	199	92	86	80	54	32	29	27	24	14	7	6	5	4	2	1	1	1	04							1 095

TABLE 60. AGE DISTRIBUTION AND AVERAGE AGE OF WOMEN WHO HAVE UNDERGONE TUBAL LIGATION

	Age distribution of women who have undergone tubal ligation (Per 1 000)						
	Under 25	*25-29*	*30-34*	*35-39*	*40-44*	*45+*	*Average age*
1969 (seven hospitals)	23	153	280	338	151	45	34.9
1970 (Bizerta and M. Bourguiba)	30	152	255	336	186	41	34.6
1974 (first quarter)	10	99	307	357	204	23	35.2
1974 (second quarter)	15	94	269	413	184	25	35.17

TABLE 61. WOMEN WHO UNDERWENT TUBAL LIGATION IN 1973; RESIDUE OF WOMEN REMAINING AND BIRTHS AVERTED, 1974-2001

	1974	*1975*	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*
Women remaining at mid-year ..	4 631	4 304	3 936	3 564	3 202	2 839	2 472	2 130	1 847	1 554	1 256	973	747	625	501	372	248	169	134	99	69	34	20	15	10	5	0	0
Births averted ..	998	948	690	492	457	427	317	268	159	144	134	119	70	35	30	25	20	10	5	5	5	2						

APPLICATION OF METHODS OF MEASURING THE IMPACT OF FAMILY PLANNING PROGRAMMES ON FERTILITY: THE CASE OF CHILE*

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INTRODUCTION

Chile, which is situated on the south-western coast of South America, had a population of 8.9 million at the time of the 1970 census. Of that number, 219 million lived in the capital. Of the total population, 75.1 per cent live in urban areas.

At the same date, the female population of childbearing age, from 15 to 49 years, accounted for 24.1 per cent of the population. The illiteracy rate was 10.6 per cent, and 8.9 per cent for women of childbearing age.

The crude birth rate, which was stable at 35 per 1,000 or more for several decades, has been steadily declining since 1964; by 1974 it had reached a rate of almost 25 per 1,000. Over the same period, the infant mortality rate dropped to approximately 40 per cent and the general mortality rate fell from 11 to 7.4 per 1,000.

The annual growth rate, which was 2.51 per cent between 1959 and 1964, dropped to 1.95 per cent during the period 1969–1974.

Family planning activities were officially begun in 1964. They do not constitute a programme as such, but form part of the mother and child care programme. Most of the activities are carried out under the National Health Service, which covers approximately 70 per cent of the country's population.

The objectives of family planning activities are defined in terms of health indexes and are directed mainly to lowering the maternal mortality rate, and particularly mortality due to abortion. It is therefore not the purpose of these activities to lower the fertility rate, although that is one effect of making available to women the means of spacing births and limiting families.

This framework explains why there is no separate statistical system for family planning and why the information on it is gathered as if it were just one other activity within the health statistics system.

Data sources

In order to apply the various methods of evaluating the impact of family planning activities on fertility, data were needed which can be classified as follows: measurements of fertility; non-programme factors; and programme factors.

Measurements of fertility

To obtain the data concerning measurements of fertility, two sources were used: vital statistics and censuses.

Vital statistics in Chile are compiled and published by two bodies, the National Institute of Statistics and the National Health Service. Although the former organization is the official agency for the entire country, its most recent publication is dated 1970; the National Health Service, on the other hand, has issued publications up to and including 1974. For this reason, both sources of information had to be used. Furthermore, both institutions have different methods of tabulating births which made it necessary to use one or the other, depending upon the needs of the method. It should be explained that births are published taking into account the date of occurrence.

For one of the methods, information on the total number of live births as recorded in the census was used.

Non-programme factors

From the vital statistics, data were obtained on nuptiality by age and on the age of mothers of live-born children.

As an indicator of the existence of medical resources, the percentage of confinements without professional care, published in the annual birth record of the National Health Service, was used for the regression method.

The remainder of the non-programme factors were obtained from census data, for which use was made of the publications of the 1960 and 1970 censuses, and the samples of these censuses in the data bank of Centro Latinoamericano de Demografia (CELADE).

Programme factors

As previously mentioned, in Chile there is no separate statistical system to provide data on family planning activities. Various sources therefore had to be used to obtain data.

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Information on new participants in the programme during the period 1964–1966 was obtained from a publication by Requena and Monreal;[1] in 1967–1973, from a CELADE publication; and in 1974, from the Chilean Family Protection Association (APROFA). This association also made available data covering the family planning programme by province.

To break down the new participants by age group, use was made of data from publications by CELADE concerning the application of the Service Statistics System (SIDES) in the National Employees' Medical Service (SERMENA). Continuation rates for the use of contraceptive methods were obtained from the same source.

Methods applied

Of the eight evaluation methods suggested, for the study of cases, only five could be applied. With respect to the experimental design method, there was no study especially designed for the purpose and the accessible data were not suited for this type of analysis. Nor was it possible to obtain data on intervals between births, required for analysis of the reproductive process. Lastly, there was neither enough information nor facilities for producing a simulation model.

The present study therefore covers the following methods: standardization approach; trend analysis; couple-years of protection (CYP); component projection approach and regression analysis.

Discussion

The methods whose application is described below are discussed in the light of the problems encountered during application and the results obtained.

Application of methods

Availability and quality of data

It was only in the standardization approach that problems were encountered with the measurement of the fertility selected, which was the number of live births per woman as reported in the census. In 1960, there was a major omission in the datum; and in 1970, it was discovered that a coding error had produced an inflated figure. However, these errors appear to have had a uniform effect on different groups, as the ratios between groups for each census were reasonable. This led the authors to correct the information, which made it possible to determine the significance of the changes given by different variables. No estimate was made of the amount of the differences between the two years, which would only have reflected the correction procedure used.

In the other methods, vital statistical publications provided the necessary data on births. Omissions in the register of births were studied both for the country as a whole and for individual regions, and the data could be satisfactorily corrected.

Potential fertility for the couple-years of protection and the component projection methods was estimated on the basis of marital fertility rates. That procedure entailed correcting the census data on married women by age group, making a nuptiality cohort analysis, with the data obtained from vital statistics.

There was no difficulty in obtaining data on legitimate children since they are published in the vital statistics.

With regard to programme factors, they were not included directly either in the trend analysis or in the standardization approach.

In the regression analysis, use was made of the datum of coverage of women of childbearing age by province.

Therefore, the two most demanding methods as concerned programme data were the couple-years of protection and the component projection approach. It was necessary to assume that the age distribution of new participants and the rates of continuation in the use of contraceptive methods in the SERMENA experiment could be applied to new participants throughout the country. The validity of this assumption was tested by comparing this information with that contained in a number of Chilean studies; and it appeared to be reasonable, in the absence of more comprehensive new and up-to-date information.

The data on non-programme factors, necessary for the regression analysis, did not present any major problems. With regard to the standardization approach, it is unfortunate that the wealth of information contained in the statistical report on live births (age, level of education, occupation, occupational category and place of residence of each parent and the number of live-born children still alive, live-born children now dead or stillborn children of the mother), has not been published in full. It was therefore necessary to resort to data from census samples, with the drawbacks already mentioned.

Problems of application

Once the problem of obtaining data was solved, the couple-years of protection method and the component projection approach presented no obstacles, since they are quite clear-cut.

An important application problem appeared in the regression analysis, concerning the choice of the analytical method. Several computer programs were available, but all of them are based on distribution assumptions which might not be met by the available data. On the other hand, the small number of observation units (25 provinces) did not allow multivariate analysis with distribution free methods.

[1] M. Requena and T. Monreal, "Evaluación del programa de control del aborto inducido y planificación familiar en Chile", *Milbank Memorial Fund Quarterly*, vol. XLVI, No. 3 (July 1968), part 2, pp. 213–246.

The fertility projections also posed a problem of selection with regard both to the functions to be used and to the base data for the projections.

In the present case, the standardization approach required the use of a computer because the data were recorded on magnetic tape, and it was further complicated by the need to make a special computer program.

Results of application

Validity

With the background information already provided on the quality of the data and on the assumptions adopted, it is difficult to be categorical about the validity of the methods. An effort is made to analyse this aspect of the question by comparing the results obtained by independent methods designed to achieve the same estimates.

Before proceeding further with this analysis, mention should be made of two problems that affect the interpretation of the results obtained: abortions and sterilizations.

It should be noted that family planning activities in Chile were mainly designed to reduce abortion, which was a serious problem as concerned the health of mothers and hospitalization costs (see annexed Table 40). According to data of the National Health Service, of the total number of obstetrical hospitalizations, the percentage for abortion which had amounted to 21 per cent in 1964, had declined to about 16 per cent by 1973. Mortality due to abortions dropped between 1964 and 1974, from 10 per 10,000 live births to 4 per 10,000 live births. This decline could be an indication that the use of contraceptives is partially replacing abortion as a means of avoiding childbirth.

As for sterilization, although there are no specific figures, the growing proportion of births by Caesarian section implies sterilization after the third or fourth child delivered by this method. Furthermore, in a number of clinics—just how many it is hard to determine—female sterilization is carried out in accordance with certain socio-economic and health criteria, although this activity is not quantifiable.

If one analyses the results obtained by means of both methods used in an attempt to identify the factors having the greatest impact on fertility, one finds that both in the standardization approach and in regression analysis, the level of education proves to be an important variable.

The same is not true of economic activity, which becomes important in regression analysis but not in the standardization approach.

The urban or rural area of residence has been found significant in the standardization approach but is negligible in regression analysis.

Lastly, the effect of the coverage of family planning activities in 1970 could be studied only in the regression analysis.

The fertility figures estimated using the variables of illiteracy, female economic activity and family planning coverage are very close to the figures observed. However, the positive sign of the regression coefficient of the coverage variable makes this method useless, in this case, as a means of measuring the effects of the programme on fertility.

It is possible that the variables selected and the types of regression used may be responsible for this situation. It would appear that the indirect effects of illiteracy and economic activity on fertility cancel and exceed the negative correlation between coverage and fertility ($r = -0.5156$), so that the direct effect of coverage on fertility becomes positive. There was not enough time to undertake a more exhaustive analysis of these problems.

The three methods directed towards estimating live births averted gave more satisfactory results which may be intuitively judged sound.

If the fertility projection is taken as a reference point and it is borne in mind that the decline in the number of live births is due not only to activities in connexion with the family planning programme it is expected that the methods for quantifying the number of live births averted (couple-years of protection and component projection approach) will give lower results. In fact, one finds the following situation:

Difference between live births averted according to the projection and live births observed

Period	*Difference*
1965–1970	283 709
1965–1974	639 623

Live births averted

Period	*Intra-uterine device*	*Oral gestagens*[a]	*Total*
	Couple-years of protection		
1965–1970	138 379	34 720[a]	173 099
1965–1974	328 704	84 832[a]	413 536
	Component projection approach		
1965–1970	140 577	35 271[b]	175 848
1965–1974	391 135	100 944[b]	492 079

[a]Estimate made on new participants using oral gestagens, with distribution and continuation rates by the National Employees' Medical Service (SERMENA), marital fertility adjusted by age and on the basis of a two-year period of participation in the programme.

[b]Estimate, applying proportions of live births averted through oral gestagens out of the total in the couple-years of protection method.

It will be noted that the two methods for estimating live births averted give lower figures than the projection figures.

While comparing the number of births averted resulting from the application of the CYP and component projection methods, a relatively greater difference in results for the period 1965–1970 is found, always with higher values for the component projection method. An analysis of the assumptions underlying each method explains this differential behaviour.

In applying the component projection method, the potential fertility of contraceptive users was obtained by increasing the marital fertility rates by 20 per cent above the level adopted in applying CYP, on the assumptions that acceptors have higher than average fertility.

The other factor responsible for an increase in the component projection estimate is the assumption regarding continuation rates. In this method, acceptors are corrected only once by a hypothetical continuation rate modified for death and widowhood. In the present case, this correction coefficient was 0.714085. On the other hand, CYP assumes a geometrical decrease of continuation rates. Comparing figures for six years, the following ratios show the difference in results obtained with the component projection and CYP methods:

	Continuation rates		
Year of the programme	*Couple-years of protection*	*Component projection*	*Couple-years of protection component projection*
1.	0.8223	0.714085	0.8684
2.	0.7307	0.714085	0.9773
3.	0.5890	0.714085	1.2124
4.	0.4750	0.714085	1.5033
5.	0.3832	0.714085	1.8635
6.	0.3090	0.714085	2.3109

Another differential factor is that in the component projection method, it is assumed that in a specific year t only one half of the acceptors of year (t-1) avoid births. Although it is correct that, on average, these acceptors remain only six months of the year (t-1), all of them reach one year of permanence at some moment of year t. Therefore, the $Qi_{(t)}$ underestimate the population of year t.

For these reasons, the underestimation features of the component projection method for the first year have more weight over short periods of analysis, whereas for long periods the factors tending to lead to an over-estimate have a predominant influence on the results.

Assuming that CYP would be preferred for calculating births averted by the programme, there still remains the problem that they might over-estimate its impact, since an unknown number of women might have resorted to abortion if they had not had access to the programme. Therefore, this measurement is somewhere in between births and pregnancies averted.

Interpretation

There are no interpretation problems in the couple-years of protection and component projection methods once the assumptions on which they are based are accepted. Interpretation of the results of projections requires study of the factors affecting fertility and is open to subjective influences.

Accepting that the trend projection contains some effects of non-programme variables, it was assumed that in the present case, this estimate would show higher figures than the births averted, calculated directly with CYP and component projection. This assumption was based on the fact that neither sterilization nor use of contraceptives outside the programme are considered in the latter methods. Although the over-all results were in accordance with this assumption, the interpretation still presents problems. Programme effects are probably not additive and they might interact with some of the non-programme variables affecting trends, especially with abortion practice for which the programme might be partially substitutive.

Therefore, trend projections might be considered to be a useful descriptive technique but not a method for measuring impacts of the programme.

Regression analysis should, in theory, lead to objective interpretations. None the less, in the authors' experience, it was necessary to find reasons to explain the results that did not turn out as expected.

In the path analysis, the subjective assumptions of the research worker acquire even greater importance.

Lastly, the interpretation of the results of the standardization approach is most complex, since it is difficult to separate direct effects from interactions.

Standardization approach

In order to standardize according to different variables, it would have been necessary to have cross tabulations of births on several criteria. Such tables could not be found in the vital statistics publications, nor could access be had to original birth data. Therefore, the 1960 and 1970 Chilean census samples in the CELADE data bank were used for the application of this method.

To measure fertility, the average number of children born alive to married women of 15 years of age and over was taken, classified by:

(a) *Age group:* 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50 and over;

(b) *Area of residence:* city, capital, urban, rural;

(c) *Economic activity:* economically active, not economically active;

(d) *Level of education:* no education, 1–3 years, 4–6 years, 7–9 years, 10 years or more.

Procedure

The 1970 population was taken as the standard population. The average number of children born alive per woman for each age group was standardized separately by: level of education; economic activity; and area of residence. In addition, it was standardized simultaneously by level of education and economic activity, and by level of education, economic activity and area of residence. The average number of children born alive for the total number of women in 1960 was standardized by age and, simultaneously, by age and the same variables and associations of variables described for the standardizations in each age group.

Application of the method

When the average number of children born alive in the master tables had been obtained, it was found that for 1960 there was an omission in the registration of children born alive. In 1970, owing to a coding error, the figures were higher than the probable real amounts. However, the relative position of the averages between the various categories was consistent, as were the directions in which the changes occurred in the course of standardization.

Since the object of this method is to determine the influence of the different variables on the change in the average number of children born alive rather than the actual change in this index, the averages obtained were corrected. The correction procedure consisted of comparing the average number of children born alive by age group of mothers from the census sample with an estimate of children born alive, based on age-specific fertility rates obtained from vital statistics.

Since the census sample data referred to married women, assuming legitimacy of their children, whereas the fertility rates were based on total births per total women in each age group, the first step had to be the conversion of the averages from the census sample into total averages per total women:

$$\frac{HL}{MC} \times \frac{MC/MT}{NL/NT} = \frac{HT}{MT}$$

Where HL = legitimate children born alive (census sample);
HT = total children born alive;
MC = married women (census data corrected with nuptiality data from vital statistics);
MT = total women (census);
NL = legitimate births (vital statistics);
NT = total births (vital statistics).

The estimate of parity from age-specific fertility rates was based on the methodology developed by Brass.[2]

Lastly, the ratios between estimated parity and average number of children born alive from the census sample gave the correction factors for the various age groups in 1960 and 1970.

In order to obtain the corrected averages by level of education, economic activity and area of residence, regardless of age, which appear in table 2, an average correction factor was needed. Therefore, the correction factors per age group were weighted by the overall age structure of the population that appears in table 1.

A more refined technique would have been to weigh the coefficients by age, by the specific age structure of

TABLE 1. RELATIVE DISTRIBUTION OF MARRIED FEMALE POPULATION AGED 20-49 YEARS ACCORDING TO THE DIFFERENT VARIABLES INVESTIGATED, IN CENSUS SAMPLES OF 1960 AND 1970
(Percentages)

Age group and variables investigated	*Distribution in:* 1960	1970
Age group		
20-24	14.4	13.4
25-29	19.2	19.6
30-34	20.9	18.7
35-39	18.2	19.9
40-44	15.2	16.4
45-49	12.1	12.0
TOTAL	100.0	100.0
Level of education		
No education	15.3	9.6
1-3 years	20.0	18.6
4-6 years	38.9	39.0
7-9 years	13.8	16.0
10 years or more	12.0	16.8
TOTAL	100.0	100.0
Economic activity		
Active	10.4	11.9
Non-active	89.6	88.1
TOTAL	100.0	100.0
Area of residence		
Capital	29.7	31.4
Urban	41.8	47.8
Rural	28.5	20.8
TOTAL	100.0	100.0

TABLE 2. AVERAGE NUMBER OF CHILDREN BORN ALIVE TO MARRIED WOMEN AGED 20-49 YEARS IN SUBGROUPS OF VARIABLES INVESTIGATED IN CENSUS SAMPLES OF 1960 AND 1970

Age group and variables investigated	*Average number of live-born children* 1960	1970
Age group		
20-24	2.524	2.163
25-29	3.646	2.665
30-34	4.747	3.261
35-39	5.711	3.735
40-44	6.464	4.092
45-49	7.049	5.051
Level of education		
No education	6.560	5.428
1-3 years	5.792	4.505
4-6 years	4.715	3.547
7-9 years	3.636	2.605
10 years or more	3.252	2.262
Economic activity		
Active	3.292	2.572
Non-active	5.071	3.668
Area of residence		
Capital	3.869	2.998
Urban	4.659	3.421
Rural	6.275	4.619

[2] See *Manual IV. Methods of Estimating Basic Demographic Measures from Incomplete Data* (United Nations publication, Sales No. 67.XIII.2).

each subgroup of the variables. The procedure actually employed is based on the assumption that the different structure by age of these groups might have a minor effect on the average correction factors. The validity of this assumption was not tested.

The percentage distribution of the 1960 and 1970 populations is given below according to different variables, as well as the average numbers of children born alive for the same groups and the results of standardization. In these tables and in subsequent calculations, the 15–19 age group was omitted because the data obtained for it did not seem reliable. Moreover, it was found that in this group fertility is low and relatively constant over the years; and, therefore, it was not suited for study in terms of changing factors. One of the more striking changes in structure between 1960 and 1970 was that of the level of education, where a definite increase in level can be discerned for the last year. The increase in urban residence is also noteworthy. In general, all the changes in structure were statistically significant:

$$p < 0.01 \text{ for the proof of } X^2$$

The great difference in the average number of live children born to women in the different categories within the variables investigated will be noted.

The standardized averages, the absolute differences with 1970 averages and the percentage reductions with respect to 1960 are given in table 3.

The averages resulting from standardizing separately by level of education (*I*), economic activity (*AE*) and area of residence (*Z*), as well as from standardizing simultaneously by the three variables, are shown in part (*a*) of table 3. The standardized averages are always greater than the 1970 figures for the same age groups, which shows that the differences between 1970 and 1960 averages cannot be attributed solely to structural changes in these variables but might be due also to others not investigated or to real changes in parity.

In part (*b*) of table 3 it is easy to see that absolute differences between standardized averages and those observed in 1970 increase with age, up to age group 40–44. This means that in the older groups the structural changes play a less important role than in the younger ones.

A similar fact is shown in part (*c*) of table 3, where the absolute differences registered were related to values of averages in 1960 in order to show the percentage reductions of observed and standardized averages.

Under the assumption of independence among the variables considered for standardization, the percentage of reduction attributable to each variable and to the three variables simultaneously, were calculated. For example, in the first age group, 20–24, the percentage of reduction attributable to changes in level of education (*I*) came from: 14.30 – 8.52 / 14.30 – 0.4042 = 40.42 per cent.

This result means that if the structures by level of

TABLE 3. RESULTS OF STANDARDIZATION BY LEVEL OF EDUCATION (*I*), ECONOMIC ACTIVITY (*AE*) AND AREA OF RESIDENCE (*Z*)

(a) *Average figures*

Age group	Averages observed 1970	Averages observed 1960	Averages standardized by I	AE	Z	I×AE×Z
20-24	2.163	2.524	2.378	2.524	2.458	2.390
25-29	2.665	3.646	3.456	3.579	3.542	3.428
30-34	3.261	4.747	4.565	4.730	4.654	4.566
35-39	3.735	5.711	5.508	5.664	5.495	5.457
40-44	4.092	6.464	6.248	6.418	6.276	6.210
45-49	5.051	7.049	6.861	7.030	6.846	6.811

(b) *Absolute differences compared with 1970*

Age group	From averages observed in 1960	From averages standardized by I	AE	Z	I×AE×Z
20-24	0.361	0.215	0.361	0.295	0.227
25-29	0.981	0.791	0.914	0.877	0.763
30-34	1.486	1.304	1.469	1.393	1.305
35-39	1.976	1.773	1.929	1.760	1.722
40-44	2.372	2.156	2.326	2.184	2.118
45-49	1.998	1.810	1.979	1.795	1.760

(c) *Percentage reductions with respect to 1960*

Age group	From averages observed in 1970	From averages standardized by I	AE	Z	I×AE×Z
20-24	14.30	8.52	14.30	11.69	8.99
25-29	26.91	21.70	25.07	24.05	20.93
30-34	31.30	27.47	30.95	29.34	27.49
35-39	34.60	31.04	33.78	30.82	30.15
40-44	36.70	33.35	35.98	33.79	32.77
45-49	28.34	25.68	28.08	25.46	24.97

TABLE 4. CONTRIBUTION OF EACH VARIABLE INVESTIGATED

Age group	Percentage reduction in crude average	Percentage reduction attributable to I	AE	Z	$I \times AE \times Z$
20-24	14.30	40.42	0.00	18.25	37.13
25-29	26.91	19.36	6.84	10.63	22.22
30-34	31.30	12.24	1.12	6.26	12.17
35-39	34.60	10.29	2.37	10.92	12.86
40-44	36.70	9.13	1.96	7.93	10.71
45-49	28.34	9.39	0.92	10.16	11.89

Note: I = level of education; AE = economic activity; Z = area of residence.

education had not changed within the 20–24 age group, the average standardized by this variable would have been the same as that for 1960 (as is the case for AE in this same group). The difference between the percentage of reduction of the crude average and the standardized average, related to the crude average, shows the effect of this change (table 4).

In order to interpret the percentages of reduction attributable to the different variables and to their combinations, an analysis of the components of effects of standardization must be made.[3] Age groups 20–24 and 40–44 were chosen for this analysis, because they represent extreme cases of differences between 1960 and 1970 averages and the contributions of the variables under study. Standardizing separately for each of the three variables and for all their possible combinations, the following standardized averages were obtained:

Variables standardized for	Standardized averages for age group 20-24	40-44
I	2.378	6.248
AE	2.524	6.418
Z	2.458	6.276
$I \times AE$	2.399	6.247
$I \times Z$	2.436	6.195
$AE \times Z$	2.464	6.251
$I \times AE \times Z$	2.390	6.210

If the effect E of standardizing is: E = average observed in 1960 minus standardized average, there are in this case three orders of effects:

First order: $E^{(1)}$ = average observed in 1960 minus average standardized by one variable i:

Second order: $E^{(2)} = \sum_{1}^{2} E^{(1)} - I^{(2)}$

where $I^{(2)}$ = the interaction between two variables:

Third order: $E^{(3)} = \sum_{1}^{3} E^{(1)} - \sum_{1}^{3} I^{(2)} + I^{(3)}$

where $I^{(3)}$ = the interaction among three variables.

The upper figures on the summation signs represent the number of effects or interactions that have to be added according to the number of variables considered in each specific case. The variables corresponding to these effects and interaction are put as subindices.

As an example, $E^{(1)}$ is the effect of standardizing by level of education.

For age group 20–24, the 1960 average was 2.524, whereas the average standardized by level of education was 2.378; therefore:

$$E_I^{(1)} = 2.524 - 2.378 = 0.146$$

All the effects can be calculated in the same way.

To provide a clear image of the different components of the effects in age groups 20–24 and 40–44, the values for effects and interactions are given below in table 5.

TABLE 5. DIRECT AND INTERACTION EFFECTS

	Age group 20-24 Absolute value	Percentage[a]	Age group 40-44 Absolute value	Percentage[a]
$E_I^{(1)}$	0.146	40.4	0.216	9.1
$E_{AE}^{(1)}$	0.000	0.0	0.046	2.0
$E_Z^{(1)}$	0.066	18.3	0.188	7.9
$I_{I \times AE}^{(2)}$	0.021	5.8	0.045	1.9
$I_{I \times Z}^{(2)}$	0.124	34.3	0.135	5.7
$I_{AE \times Z}^{(2)}$	0.006	1.7	0.021	0.9
$I_{I \times AE \times Z}^{(3)}$	0.073	20.2	0.005	0.2

[a] Proportion of absolute value with respect to difference: observed crude average in 1960 minus observed crude average in 1970.

Note: I = level of education; AE = economic activity; Z = area of residence.

Therefore, the percentage reduction attributable to first-order, second-order and third-order effects are:

First-order effects: $E^{(1)}$

Effect	Age group 20-24	40-44
$E_I^{(1)}$	40.4	9.1
$E_{AE}^{(1)}$	0.0	2.0
$E_Z^{(1)}$	18.3	7.9

[3] Analysis based on an unpublished paper by Albino Bocaz, Centro Latinoamericano de Demografia, Santiago, Chile.

Second-order effects: $E^{(2)} = \Sigma E^{(1)} - I^{(2)}$

Effect	Age group 20-24	40-44
$E^{(1)}_{I}$	40.4	9.1
$E^{(1)}_{AE}$	0.0	2.0
$I^{(2)}_{I \times AE}$	−5.8	−1.9
$E^{(2)}_{I \times AE}$	34.6	9.2
$E^{(1)}_{I}$	40.4	9.1
$E^{(1)}_{Z}$	18.3	7.9
$I^{(2)}_{I \times Z}$	−34.3	−5.7
$E^{(2)}_{I \times Z}$	24.4	11.3
$E^{(1)}_{AE}$	0.0	2.0
$E^{(1)}_{Z}$	18.3	7.9
$I^{(2)}_{AE \times Z}$	−1.7	−0.9
$E^{(2)}_{I \times Z}$	16.6	9.0

Third-order effects: $E^{(3)} = \Sigma E^{(1)} - \Sigma I^{(2)} + I^{(3)}$

Effect	Age group 20-24	40-44
$E^{(1)}_{I}$	40.4	9.1
$E^{(1)}_{AE}$	0.0	2.0
$E^{(1)}_{Z}$	18.3	7.9
$I^{(2)}_{E \times AE}$	−5.8	−1.9
$I^{(2)}_{I \times Z}$	−34.3	−5.7
$I^{(2)}_{AE \times Z}$	−1.7	−0.9
$I^{(3)}_{I \times AE \times Z}$	20.2	0.2
$E^{(3)}_{I \times AE \times Z}$	37.1	10.7

In summary, the percentage reductions for these two age groups are:

Effect	Age group 20-24	40-44
$E^{(1)}_{I}$	40.4	9.1
$E^{(1)}_{AE}$	0.0	2.0
$E^{(1)}_{Z}$	18.3	7.9
$E^{(2)}_{E \times AE}$	34.6	9.2
$E^{(2)}_{I \times Z}$	24.4	11.3
$E^{(2)}_{AE \times Z}$	16.6	9.0
$E^{(3)}_{I \times AE \times Z}$	37.1	10.7

This table clearly shows the greater influence of the structure by the considered variables on the 20–24 age group than on the 40–44 age group. Neither of the standardizations is satisfactory from the point of view of explaining the decrease of averages. By standardizing simultaneously for the three variables, there remains unexplained changes of 62.9 per cent in the 20–24 age group and 89.3 per cent in the 40–44 age group.

The standardization by age leads to an average of 4.934, compared to an average of 3.538 for 1970 and an average of 4.886 for 1960.

The percentage reduction attributable to age is −3.55 per cent. The interpretation of this negative figure is that the age distribution of women in 1970 changed by comparison with 1960 in the sense that there was a slight relative increase of older age groups which showed a greater reduction in the average number of children born alive. This change explains the relative higher decline in the average adjusted by age (1.396) in comparison with the crude figure (1.348). The standardization by age, level of education, economic activity and area of residence yields an average of 4.719. The percentage contribution of the four variables is 12.40 per cent, which leaves 83.6 per cent of reduction unexplained by structural changes with respect to these variables.

Trend analysis

Figure I shows the development of the crude birth rate for the period 1935–1974; the sharp drop in this rate after 1964 is striking. Although the period marked by this drop is that in which development of family planning activities began, changes in fertility obviously cannot be attributed solely to those activities. It was decided to discontinue work with the crude birth rate because it was too approximate an indicator and better sources of information were available; it was therefore decided to make projections of specific fertility rates according to age.

In order to estimate fertility rates according to age group, use was made of information on registered births published by the National Institute of Statistics (INS) and the National Planning Office (ODEPLAN) population projection for the period 1950–2000. Analysis of information on the female population of childbearing age in the ODEPLAN projection showed that population growth rates between 1950 and 1960 for the different age groups did not tally with growth rates for 1960–1970. In order to even out the popula-

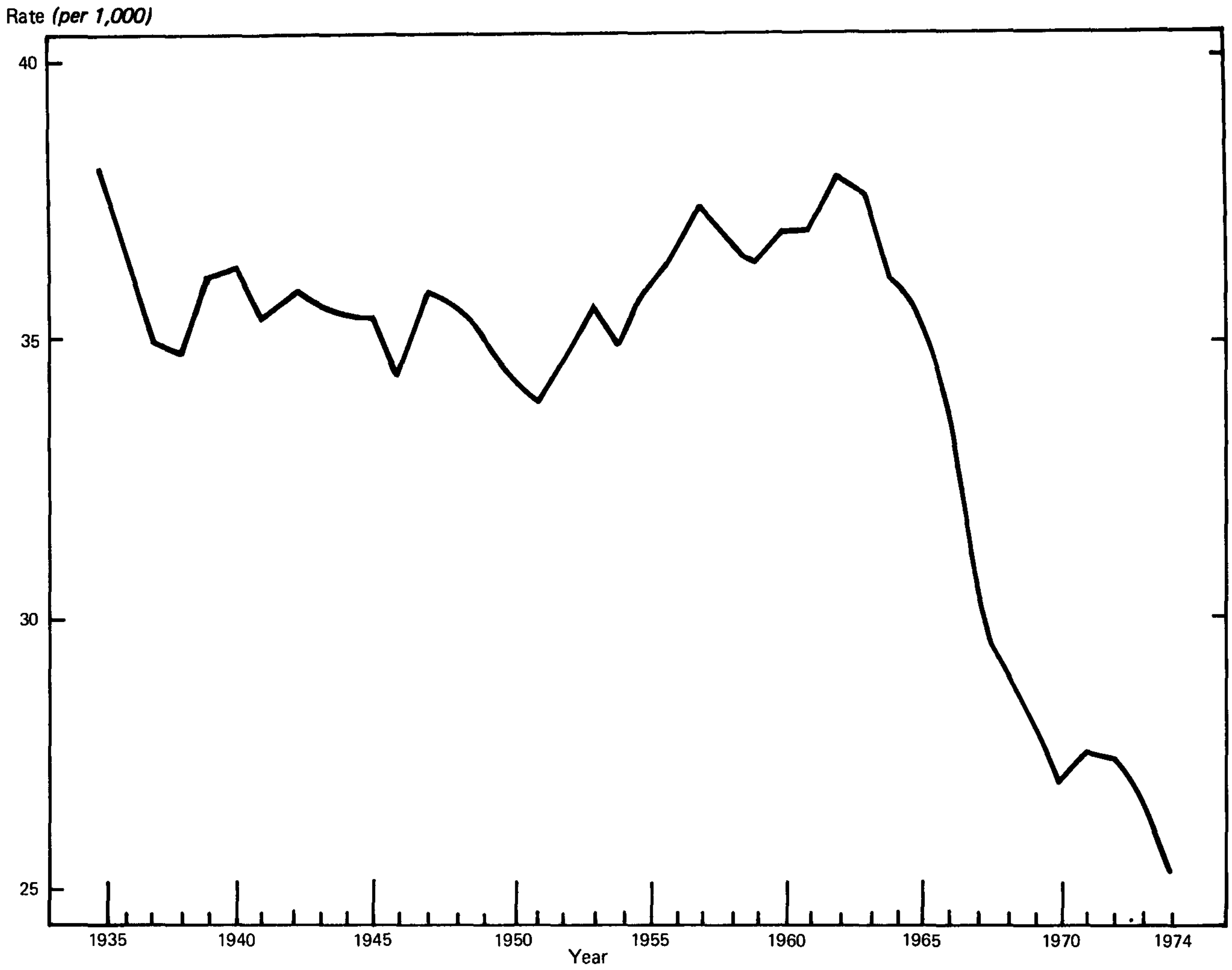


Figure I. Chile: crude birth rate, 1935–1974

Source: Chile, Servicio Nacional de Salud, *Anuario 1974, defunciones y causes de muerte* (Santiago, 1975).

tion series, the rule of a single but specific geometrical variation per age group was adopted for the period 1950–1970. Registered births were also evened out by a geometrical function because they showed sharp annual fluctuations. The values thus obtained were corrected by official estimates of omissions.

Once the two series had been evened out, specific fertility rates were determined for the period 1956–1964, and extrapolated values for the period 1965–1974 were calculated. The resulting fertility rates show a slight variation in time, as can be seen from table 6 and from figure II. Fertility levels in age groups under 20 years were relatively constant in time.

The values recorded for age group 20–24 were less than those projected (see table 7); however, the differences were not as striking as those recorded in the four age groups between 25 and 44 years. Lastly, the projection for women between 45 and 49 years of age was almost identical with the figures recorded. This variation in behaviour could be interpreted in terms of the impact of family planning, that impact being the greatest between the ages of 25 and 44 years, less in women between 20 and 24 years who are still setting up families and practically nil in those under 20 years. Family planning could be regarded as a substitute for abortion in women between 44 and 49 years.

It must be borne in mind that, although probably correct, these interpretations are subjective. Moreover, one must consider the influence on fertility of other factors, such as age of marriage, the use of contraceptives outside the family planning programme, induced abortion and stability of marriage.

Couple-years of protection

The information used for the CYP method refers to the entire country and covers the period 1964–1974. The results presented here refer only to new participants using the intra-uterine device (IUD).

In order to estimate potential fertility, use was made

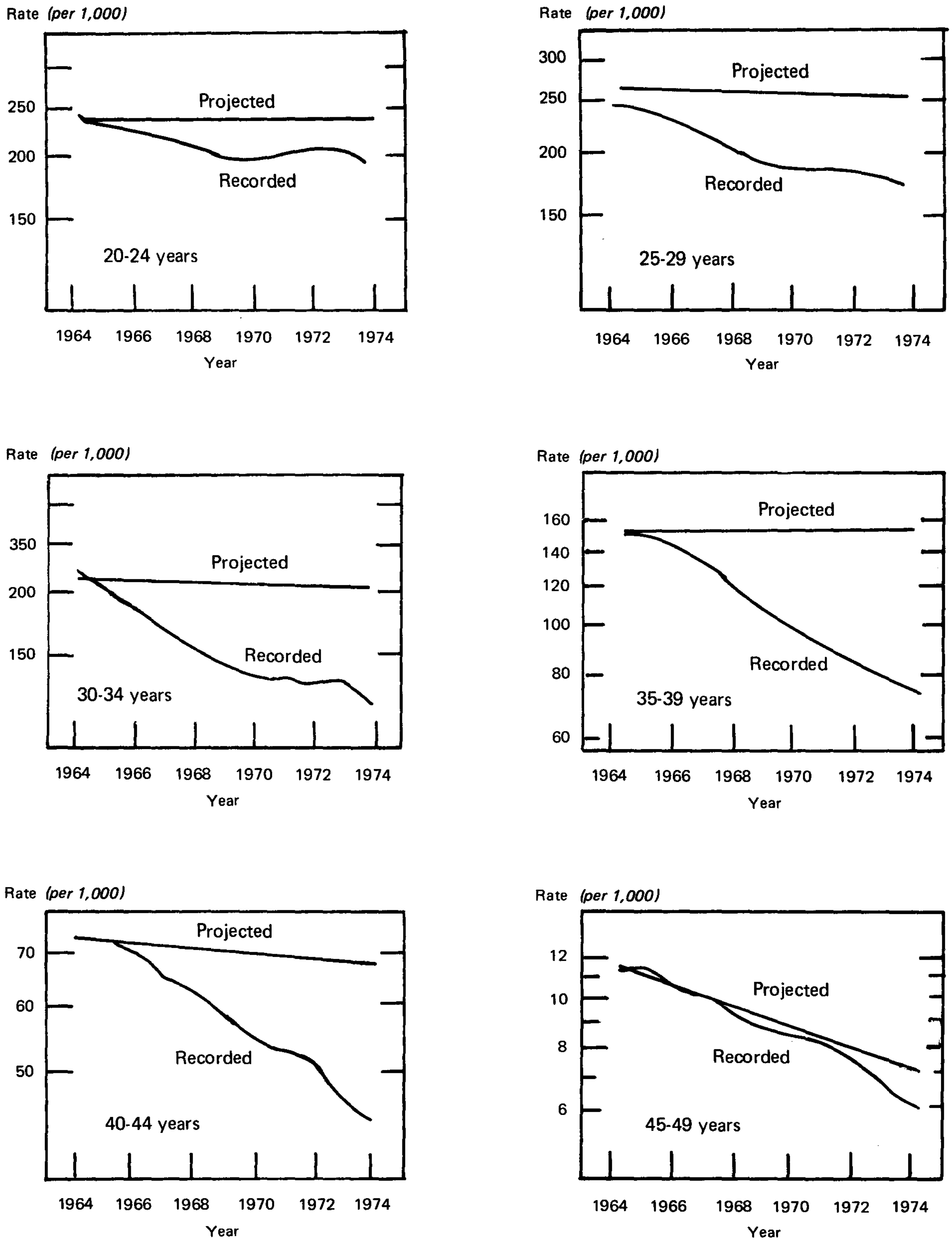


Figure II. Chile: trends in age-specific projected and recorded fertility rates, 1964–1974
(Semi-logarithmic scale)

TABLE 6. RECORDED AND ESTIMATED [a] AGE-SPECIFIC FERTILITY RATES, 1964-1974

Age group	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
					Estimated on basis of trends						
12-14	2.7	2.8	2.8	2.8	2.8	2.8	2.9	2.9	2.9	3.0	3.0
15-19	80.8	80.8	80.8	80.8	80.8	80.8	80.7	80.7	80.7	80.7	80.7
20-24	231.6	231.9	232.1	232.4	232.6	232.9	233.1	233.4	233.6	233.9	234.2
25-29	264.7	263.5	262.2	261.0	259.8	258.5	257.3	256.1	254.9	253.7	252.4
30-34	214.2	213.2	212.2	211.2	210.2	209.2	208.2	207.2	206.2	205.9	204.3
35-39	152.8	153.0	153.1	153.3	153.5	153.7	153.9	154.1	154.3	154.5	154.7
40-44	65.1	64.5	63.9	63.3	62.7	62.1	61.5	60.9	60.4	59.8	59.2
45-49	11.6	11.0	10.5	10.0	9.6	9.1	8.7	8.3	7.9	7.5	7.2
					Recorded						
12-14	2.9	2.9	2.8	2.9	2.5	2.7	2.3	2.8	3.1	2.8	3.1
15-19	81.9	82.8	82.1	82.5	79.2	78.9	80.7	84.3	86.4	83.5	79.3
20-24	235.4	227.9	220.2	215.0	206.2	194.8	192.7	200.1	203.0	202.5	191.3
25-29	247.5	242.7	230.5	213.2	200.0	186.1	182.5	186.0	183.6	175.5	169.4
30-34	220.1	207.4	186.3	168.8	152.1	141.6	135.0	136.2	131.0	123.9	116.9
35-39	150.4	149.5	142.4	120.4	116.0	105.2	94.4	88.7	82.3	76.4	73.4
40-44	65.5	64.5	60.3	55.3	52.9	48.0	44.7	42.4	40.0	35.4	33.5
45-49	11.1	11.4	10.4	9.9	8.9	8.4	8.4	7.9	7.3	6.3	6.0

[a] Estimated by geometrical adjustment of the trend for 1956-1964.

of the average rates for 1961–1963, the period immediately preceding the official beginning of family planning activities. The over-all rate of marital fertility was adjusted to the age structure of new participants in order to obtain a more realistic estimate of births avoided by IUD users. Information on new participants, according to method, was obtained from various sources for the period 1964–1974 (see annexed table 37). The continuation rates for IUDs were taken from an application of the Service Statistics System of CELADE in the National Employees' Medical Service (see annexed table 39). The age structure of new participants was also drawn from that source (see annexed table 38).

TABLE 7. ESTIMATED AND RECORDED BIRTHS AND DIFFERENCES BETWEEN ESTIMATES AND TOTALS RECORDED, BY AGE GROUP, 1964-1975

Age group	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
					Projected birth estimates							
12-14	723	745	783	801	819	838	860	895	911	938	965	994
15-19	33 737	34 725	35 742	36 789	37 867	38 976	40 117	41 292	42 502	43 746	45 028	46 346
20-24	82 401	84 922	87 521	90 199	92 958	95 802	98 734	101 754	104 868	108 076	111 383	114 791
25-29	79 712	80 614	81 527	82 450	83 384	84 328	85 283	86 249	87 226	88 213	89 212	90 222
30-34	56 215	56 851	57 495	58 146	58 804	59 470	60 144	60 825	61 513	62 210	62 915	63 627
35-39	37 061	38 059	39 085	40 138	41 219	42 330	43 470	44 641	45 844	47 079	48 348	49 650
40-44	13 206	13 266	13 326	13 387	13 448	13 509	13 571	13 633	13 695	13 757	13 820	13 883
45-49	2 113	2 046	1 981	1 919	1 838	1 799	1 743	1 688	1 634	1 583	1 533	1 484
					Recorded births							
12-14	771	763	761	846	755	831	751	912	1 054	973	1 121	...
15-19	33 960	35 057	35 356	36 060	35 157	35 561	36 973	40 254	42 931	43 189	42 538	...
20-24	84 253	84 251	83 479	83 547	82 086	79 381	80 323	84 808	87 397	88 572	85 004	...
25-29	73 774	73 998	72 993	70 013	67 993	65 450	66 309	69 368	70 202	68 781	65 993	...
30-34	58 103	54 925	50 591	47 014	43 435	41 404	40 385	42 345	42 265	41 475	40 414	...
35-39	36 995	38 002	36 364	33 408	29 857	27 166	24 508	23 625	22 477	21 384	21 054	...
40-44	13 323	13 311	12 959	12 349	12 227	11 500	11 072	10 580	9 992	8 900	8 451	...
45-49	2 029	2 098	1 946	1 877	1 736	1 649	1 662	1 645	1 578	1 440	1 400	...
					Differences between estimates and totals recorded							
12-14	−48	−18	22	−45	64	7	109	−27	−143	−36	−156	...
15-19	−223	−332	386	729	2 710	3 415	3 144	1 038	−429	557	2 490	...
20-24	−1 852	671	4 042	6 652	10 872	16 421	18 411	16 946	17 471	19 504	26 379	...
25-29	5 938	6 616	8 534	12 437	15 391	18 878	18 974	16 891	17 024	19 432	23 219	...
30-34	−1 888	1 926	6 904	11 132	15 369	18 066	19 759	18 480	19 248	20 795	22 501	...
35-39	66	57	2 721	6 730	11 362	15 164	18 962	21 016	23 367	25 695	27 294	...
40-44	−117	−45	367	1 038	1 221	2 009	2 499	3 053	3 703	4 857	5 369	...
45-49	84	−52	35	42	122	150	81	43	56	143	133	...
TOTAL	1 960	8 823	23 011	38 715	57 111	74 110	81 939	77 440	80 297	90 948	107 229	...

TABLE 8. RELATIVE REDUCTION IN BIRTHS DUE TO USE OF THE INTRA-UTERINE DEVICE IN THE FAMILY PLANNING PROGRAMME, BY AGE GROUP, 1965-1970, 1971-1974 AND 1965-1974

Age group	Live births: Recorded value	Live births: Trend value	Reduction in births (All causes)	Births averted (component projection)	Relative reduction due to use of intra-uterine device (percentage)
		1965-1970			
12-14	4 707	4 846	139	...	...
15-19	214 164	224 216	10 052	...	...
20-24	493 067	550 136	57 069	41 429	72.6
25-29	416 756	497 586	80 830	47 230	58.4
30-34	277 754	350 910	73 156	32 066	43.8
35-39	189 305	244 301	54 996	13 305	24.2
40-44	73 418	80 507	7 089	2 752	38.1
45-49	10 968	11 346	378	...	...
		1971-1974			
12-14	4 060	3 699	−361	...	...
15-19	168 912	172 568	3 656	...	...
20-24	345 781	426 081	80 300	58 436	72.8
25-29	274 334	350 900	76 566	87 762	114.6
30-34	166 439	247 463	81 024	64 731	79.9
35-39	88 540	185 912	97 372	28 136	28.9
40-44	37 923	54 905	16 982	6 435	37.9
45-49	6 063	6 438	375	...	...
		1965-1974			
12-14	8 767	8 545	−222	...	...
15-19	383 076	396 784	13 708	...	...
20-24	838 848	976 217	137 369	99 865	72.7
25-29	691 090	848 486	157 396	134 992	85.8
30-34	444 193	598 373	154 180	96 797	62.8
35-39	277 845	430 213	152 368	41 441	27.2
40-44	111 341	135 412	24 071	9 187	38.2
45-49	17 031	17 784	753	...	...

Methodology and results

The estimates of annual number of births averted were based on the CYP prevalence index,[4] taking continuation rates from the experience in SERMENA:

CYP prevalence index for year

$$T = \frac{a}{r} \sum_{i=0}^{j} N_{T-i} \{e^{-ri} - e^{-r(i+1)}\}$$

where $a = 0.9884$ = continuation rate at the end of the first month;

$r = 0.2150$ = rate of attrition during one year;

N_{T-i} = number of insertions in year $T - i$;

i = years of participation in the programme—i varies from 0 to j; $j = 5$.

The addenda of this formula: $N_{T-i} \frac{a}{r} \{e^{-ri} - e^{-r(i+1)}\}$

are shown in the columns of table 9, and the CYP prevalence indexes for each year appear in the total row at the bottom of this table.

[4] Samuel M. Wishik and K. H. Chen, *The Couple-Year of Protection: A Measure of Family Planning Program Output*, Manuals for Evaluation of Family Planning and Population Programs, No. 7 (New York, Columbia University, International Institute for the Study of Human Reproduction, 1973).

The coefficients that multiply N_{T-i} in each of the six years of permanence considered in the programme ($i = 0,\ldots,5$) are the same for every cohort:

i	Coefficient: $\frac{a}{r} \{e^{-ri} - e^{-r(i+1)}\}$
0	0.8223
1	0.7307
2	0.5890
3	0.4750
4	0.3832
5	0.3090

Therefore, each row of table 9 shows the successive products of new participants and these coefficients.

For example, in the row of the year 1964, the 11,264 new participants multiplied by 0.8223 yield a prevalence of 9,262 for 1964, multiplied by 0.7307 a prevalence of 8,231 for 1965 and so on.

Average marital fertility rates for 1961–1963 were used to estimate the number of births avoided. The information available was specific fertility rates, which were converted into marital fertility rates using a conversion factor corresponding to the ratio between the percentage of legitimate births and the percentage of married women (see table 10).

TABLE 9. CYP PREVALENCE: $\frac{a}{r} \sum_{i=0}^{5} N_{T-i} \{e^{-ri} - e^{-r(i+1)}\}$

$(a = 0.9884;\ r = 0.2150)$

Year	New participants	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1974	121 879											100 221
1973	80 155										65 911	58 569
1972	35 167									28 918	25 697	20 713
1971	36 142								29 720	26 409	21 288	17 167
1970	43 602							35 854	31 860	25 682	20 711	16 708
1969	40 674						33 446	29 720	23 957	19 320	15 586	12 568
1968	46 422					38 173	33 921	27 343	22 050	17 789	14 344	
1967	45 375				37 312	33 156	26 726	21 553	17 388	14 021		
1966	33 686			27 700	24 614	19 841	16 001	12 908	10 409			
1965	20 467		16 830	14 955	12 055	9 722	7 843	6 324				
1964	11 264	9 262	8 231	6 634	5 350	4 316	3 481					
TOTAL		9 262	25 061	49 289	79 331	105 208	121 418	133 702	135 384	132 139	163 537	225 946

On the assumption that the percentage of married women according to age group does not vary significantly in the short term, information available for the 1960 census was used. On the same assumption, the percentage of legitimate births in turn corresponds to the average of the percentages for 1959–1961:

$$\text{Marital fertility rates} = \frac{N_i}{M_i} \times C_i$$

$$C_i = \frac{NL_i}{N_i} \bigg/ \frac{MC_i}{M_i}$$

where N_i = births to mothers in age group i;
M_i = total number of women in age group i;
NL_i = legitimate births to mothers in age group i;
MC_i = married women in age group i;
C_i = conversion factor for group i.

If the rates for women of 20 years and over are correct, those for the women between 15 and 19 years must be underestimated. No adjustment was made in view of the small proportion which this group represents in the total, although the rate for the Hutterites could, for example, have been used as a reference to make an adjustment. One of the methods of estimating the number of live births averted consisted in applying the over-all marital fertility rate to couple-years of protection, which were obtained using the achievement and prevalence indexes. In order to make a more precise estimate, the age distribution of new participants and its evolution during their years of participation in the programme were taken into consideration.

TABLE 10. AGE-SPECIFIC FERTILITY RATES
(Rates per 1 000)

Age group	Fertility rate, 1961-1963 average	C_i	Marital fertility rate
15-19	82.47	6.41	528.63
20-24	235.13	2.35	552.36
25-29	265.90	1.52	404.17
30-34	240.53	1.30	312.69
35-39	156.10	1.24	193.56
40-44	67.10	1.26	84.55
45-49	12.83	1.33	17.06
TOTAL	141.20	1.70	240.04

The five-year age groups were divided up into one-year age groups, adopting a logarithmic variation of numbers, and women who had reached the highest age in a given group were transferred to the following group. This procedure resulted in the percentage distribution given in table 11.

By weighting the specific rates of marital fertility for the age structure in successive years, over-all potential fertility rates for the different age groups were obtained for each year of participation in the programme (see table 12).

The need to consider the age structure of participants becomes obvious if one examines the weighted rates obtained and compares them with the over-all marital fertility rate of 240.04 in the population as a whole. For the particular distribution assumed in the present case, a comparison was made between live births avoided per woman in the programme, estimated on the basis of the over-all marital fertility rates, with and without adjustment (table 13).

It should be pointed out that, for the purposes of the estimate, it was assumed that births were averted, as from the year following that in which the women concerned joined the programme, when they were already one year older; for this reason, the rates corresponding to the following year were applied to couples who had joined the programme the previous year.

Thus, for the six-year period of participation considered, there would in this case be a 28.3 per cent underestimation if the age of new participants was not considered. The need for information on rates of continued participation is reflected in the following comparison (table 14) between cumulative couple-years of protection obtained with the prevalence rates used in this report and those used in Pakistan: 0.75 for the first year; 0.50 for the second; and 0.35 for the third.

If one assumes that the over-all fertility rate is 240.04 per 1,000, one obtains the estimates of live births averted given in table 15. Thus, for the period 1965–1970, live births averted totalled 93,512.38; and for 1965–1974, they reached a total of 229,077.60.

Using marital fertility rates adjusted by age of new participants in successive years, one obtains the fig-

TABLE 11. RELATIVE DISTRIBUTION BY AGE GROUP IN SUCCESSIVE YEARS OF PARTICIPATION IN THE PROGRAMME

	Number of years of participation in programme						
Age group	*Under one*	*One*	*Two*	*Three*	*Four*	*Five*	*Six*
15-19	4.0	2.47	1.45	0.77	0.31	0.00	0.00
20-24	30.0	25.61	20.67	15.35	9.77	4.00	2.47
25-29	29.0	29.84	30.39	30.61	30.49	30.00	25.61
30-34	21.0	22.77	24.47	26.10	27.62	29.00	29.84
35-39	12.0	13.84	15.71	17.57	19.36	21.00	22.77
40-44	4.0	4.98	6.21	7.73	9.63	12.00	13.84
45-49	– [a]	0.49	1.10	1.87	2.82	4.00	4.98
50 and over	–	–	–	–	–	–	0.49

[a] It was assumed that there were no new participants aged over 45 but that women who joined the programme between the ages of 40 and 44 continued to participate.

ures for births averted per couple and over-all. On this basis, for the period 1965–1970, live births averted totalled 138,379.1; for 1965–1974, the total was 328,703.8 (see table 16).

The live births averted per couple up to 1970 and up to 1974 are based on the figures given in the last column of part (*b*) of table 13.

As can be seen, the live births averted by a couple entering the programme in 1964 are the same up to 1970 and up to 1974 since in both cases it was assumed that a six-year duration constituted permanence in the programme.

Since a woman entering in 1965 can only be counted for five years up to 1970, assuming that she begins averting births in the year following that of her entrance, the live births averted reduce to 1.02593 in this group, whether up to 1974 she still will be able to avoid 1.10845 births in a six-year span. Therefore, the columns of live births averted per couple differ according to the time left from the time of entrance up to the year of the evaluation.

COMPONENT PROJECTION APPROACH

The data used for the component projection approach relate to the country as a whole and, like the couple-years of protection method, cover the period 1964–1974. The method was applied only to data on IUD users.

Measurement of fertility and estimation of other parameters

Vital statistics were used to obtain the data needed to calculate age-specific fertility rates, using as denominators the official population projections of the National Planning Office. The average rates for 1961–1963 were taken as the base fertility, as this was the period immediately preceding the official commencement of family planning activities.

To determine the actual user population, use was made of information on available acceptors (see annexed table 35). The age distribution of participants and the continuation rates for the purpose of estimating drop-outs were calculated on the basis of data from the SERMENA experiment (see tables 36 and 37). The survivorship of men and women was obtained from life tables for Chile compiled by Tacla and Pujol.[5] In applying the method, no account was taken of women in age group 45–49, since the number of participants in this age group is negligible in comparison with the other groups. For purposes of comparison with the CYP figures calculated for six years, it was assumed that all the women remained in the programme for six years, regardless of age.

[5] Odette Tacla and José M. Pujol, *Tablas abreviadas de mortalidad 1952–1953 y 1960–1961*, CELADE Series C, No. 11 (Santiago, 1965).

TABLE 12. MARITAL FERTILITY RATES WEIGHTED BY RELATIVE AGE DISTRIBUTION

		Number of years of participation in programme						
Age group	*Marital fertility rate*	*Under one*	*One*	*Two*	*Three*	*Four*	*Five*	*Six*
15-19	528.63	21.14	13.06	7.66	4.07	1.64	–	–
20-24	552.56	165.77	141.51	114.21	84.82	53.98	22.10	13.65
25-29	404.17	117.21	120.60	122.83	123.72	123.23	121.25	103.51
30-34	312.69	65.66	71.20	76.51	81.61	86.36	90.68	93.31
35-39	193.56	23.23	26.79	30.41	34.01	37.47	40.65	44.07
40-44	84.55	3.38	4.21	5.25	6.54	8.14	10.15	11.70
45-49	17.06	–	0.08	0.19	0.32	0.48	0.68	0.85
Over-all marital fertility rate		396.39	377.45	357.06	335.09	311.30	285.51	267.06

TABLE 13. LIVE BIRTHS AVOIDED PER COUPLE, CALCULATED BY VARIOUS METHODS

Year	*Proportion of protected couples*	*Marital fertility rate*	*Live births avoided per couple*	*Cumulative live births avoided*
		(a) *Unadjusted*		
Under one	0.8223	0.24004	0.19738	0.19738
One	0.7307	0.24004	0.17540	0.37278
Two	0.5890	0.24004	0.14138	0.51416
Three	0.4750	0.24004	0.11402	0.62818
Four	0.3832	0.24004	0.09198	0.72016
Five	0.3090	0.24004	0.07417	0.79433
		(b) *Adjusted*		
Under one	0.8223	0.37745	0.31038	0.31038
One	0.7307	0.35706	0.26090	0.57128
Two	0.5890	0.33509	0.19737	0.76865
Three	0.4750	0.31130	0.14787	0.91652
Four	0.3832	0.28551	0.10941	1.02593
Five	0.3090	0.26706	0.08252	1.10845

(c) *Comparison*

	Cumulative live births avoided per couple		*Percentage underestimation due to lack of adjustment*
	Unadjusted	*Adjusted*	
Under one	0.19738	0.31038	36.4
One	0.37278	0.57128	34.7
Two	0.51416	0.76865	33.1
Three	0.62818	0.91652	31.5
Four	0.72016	1.02593	29.8
Five	0.79433	1.10845	28.3

TABLE 14. CUMULATIVE PREVALENCE FOR NEW WOMEN PARTICIPANTS

Year	*Pakistan*	*Chile*	*Percentage underestimation under Pakistan assumptions*
Under one	0.75	0.8223	8.79
One	1.25	1.5530	19.51
Two	1.60	2.1420	25.30

TABLE 15. LIVE BIRTHS AVERTED PER PROGRAMME YEAR, ESTIMATED FROM PREVALENCE INDEX

Year	*Protected couples, prevalence*	*Live births averted per couple protected the previous year*	
		Annual	*Cumulative*
1964	9 263		
1965	25 061	2 223.49	2 223.49
1966	49 289	6 015.64	8 239.13
1967	79 331	11 831.33	20 070.46
1968	105 208	19 042.61	39 113.07
1969	121 418	25 254.13	64 367.20
1970	133 702	29 145.18	93 512.38
1971	135 384	32 093.83	125 606.21
1972	132 139	32 497.57	158 103.78
1973	163 536	31 718.64	189 822.42
1974	225 946	39 255.18	229 077.60
1975	...	54 236.08	283 313.68

TABLE 16. LIVE BIRTHS AVERTED PER COUPLE AND OVER ALL, 1964-1970 AND 1964-1974

Year	New participants	Live births averted per couple up to 1970	Live births averted up to 1970	Live births averted per couple up to 1974	Live births averted up to 1974
1964	11 264	1.10845	12 485.6	1.10845	12 485.6
1965	20 467	1.02593	20 997.7	1.10845	22 686.6
1966	33 686	0.91652	30 873.9	1.10845	37 339.2
1967	45 375	0.76865	34 877.5	1.10845	50 295.9
1968	46 422	0.57128	26 250.0	1.10845	51 456.5
1969	40 674	0.31038	12 624.4	1.02593	41 728.7
1970	43 602			0.91652	39 962.1
1971	36 142			0.76865	27 780.5
1972	35 167			0.57128	20 090.2
1973	80 155			0.31038	24 878.5
1974	121 879				
TOTAL	514 833		138 379.1		328 703.8

Procedures and results

It was necessary to obtain:

$$f_{i,t} = \frac{F_{i,t} f_{i,o} - Q_{i,t} G_i}{F_{i,t}}$$

where $f_{i,t}$ = fertility of women in age-group i in year t;
$f_{i,o}$ = fertility rate of women in age-group i, before beginning the programme;
$F_{i,t}$ = total number of women in age group i in year t;
G_i = potential fertility of users in group i;
$Q_{i,t}$ = women in age group i actually using IUD in year $t-1$;
i = 1, ... 6: age groups 15-19, ... 40-44.

The average fertility rates for 1961–1963 were taken for $f_{i,o}$ and the corresponding marital fertility rates calculated for the CYP figures, increased by 20 per cent to adapt them to the present method, were taken for G_i (table 17).

TABLE 17. FERTILITY RATES, BY AGE GROUP, 1961-1963

Age group	Average fertility rates, 1961-1963 ($f_{i,o}$)	Marital fertility rates	Potential fertility of users (G_i)
15-19	82.47	528.63	634.36
20-24	235.13	552.56	663.07
25-29	265.90	404.17	485.00
30-34	240.53	312.69	375.23
35-39	156.10	193.56	232.27
40-44	67.10	84.55	101.46

On the basis of the age distribution of new participants by conventional groups, a breakdown by individual ages was made by means of geometrical interpolation, and transference of the figures for women at the age-group limits was used to obtain the distribution for women one year younger (table 18).

The percentage of new participants actually using IUD, which was estimated at 70 per cent by component projection, was estimated in this case at 74.825 per cent. This figure was obtained by averaging the first- and second-year continuation rates observed in SERMENA: first year, 81.16 per cent; second year, 68.49 per cent; average, 74.825 per cent.

TABLE 18. AGE DISTRIBUTION OF NEW PARTICIPANTS USING AN INTRA-UTERINE DEVICE

Conventional age group	Percentage	Age group one year younger	Percentage
15-19	4.00	14-18	2.67
20-24	30.00	19-23	25.61
25-29	29.00	24-28	29.84
30-34	21.00	29-33	22.77
35-39	12.00	34-38	13.84
40-44	4.00	39-43	4.98

The correction for female mortality and widowhood was approximated by calculating survivorship over five years (until reaching the following age group) of women of average age on admission to the programme (28.5 years). For widowhood, it was estimated that men are, on average, three years older than women:

Women	*Men*
$l_{28.5} = 0.82754$	$l_{31.5} = 0.78750$
$l_{33.5} = 0.81317$	$l_{36.5} = 0.76482$

$$\underset{\textit{Women}}{\frac{l_{33.5}}{l_{28.5}}} \times \underset{\textit{Men}}{\frac{l_{36.5}}{l_{31.5}}} = 0.95434$$

Consequently, the admissions to the programme were corrected by 0.74825 for continuation and by 0.95434 for mortality and widowhood, giving a combined correction factor of 0.714085.

When $Q_{i,t}$ had been obtained for each year, the next step was to calculate the anticipated fertility rates in each age group in subsequent years of the programme, as a result of the use of IUD contraception ($f_{i,t}$) (see table 19).

A comparison of the fertility rates calculated for 1970–1974 with those of the base period 1961–1963 gave the results shown in table 20.

For both years it can be seen that the decline is greatest in the 25–29 age group, followed closely by the 30–34 age group.

TABLE 19. FERTILITY RATES EXPECTED AS A RESULT OF USE OF INTRA-UTERINE DEVICES, 1965-1974

Year	Fertility rate in age group 15-19	20-24	25-29	30-34	35-39	40-44
1965	82.33	233.39	264.01	239.19	155.56	66.98
1966	81.96	228.99	259.00	235.47	153.98	66.64
1967	81.41	222.42	250.97	229.19	151.15	66.02
1968	80.72	214.14	239.93	220.11	146.86	65.06
1969	80.11	206.64	228.03	209.57	141.55	63.85
1970	79.82	202.61	217.95	199.43	135.97	62.52
1971	79.81	200.97	211.41	193.31	132.37	61.42
1972	79.96	201.39	208.35	190.11	130.19	60.62
1973	80.16	203.60	209.58	191.02	130.20	60.40
1974	79.96	199.93	207.68	190.67	129.98	60.32

TABLE 20. DECLINE IN FERTILITY RATES IN 1970 AND 1974, COMPARED WITH THE BASE PERIOD, 1961-1963

Age group	Base rate	Estimated rate 1970	Estimated rate 1974	Percentage decline with respect to the base year 1970	1974
15-19	82.47	79.82	79.96	3.2	3.0
20-24	235.13	202.61	199.93	13.8	15.0
25-29	265.90	217.95	207.68	18.0	21.9
30-34	240.53	199.43	190.67	17.1	20.7
35-39	156.10	135.97	129.98	12.9	16.7
40-44	67.10	62.52	60.32	6.8	10.1

Births avoided were estimated for 1965–1970 and 1965–1974 by adding, in each age group, the Q_iG_c values calculated for the corresponding periods (see table 21).

TABLE 21. LIVE BIRTHS AVERTED, 1965-1970 AND 1965-1974

Age group	1965-1970	1965-1974
15-19	3 795	8 853
20-24	41 429	99 865
25-29	47 230	134 992
30-34	32 066	96 797
35-39	13 305	41 441
40-44	2 752	9 187
TOTAL	140 577	391 135

REGRESSION ANALYSIS

The 25 provinces of Chile were used as observation units and regressions were calculated for the years 1960 and 1970 (see tables 22 and 23).

Measurement of fertility and estimation of other parameters

The fertility measurement used was the gross reproduction rate (variable 1), derived from birth data from the National Health Service and population data from the census. Since data on births by age groups of mothers for each province were only published from 1963 onward, the age structure for 1960 was obtained by linear extrapolation based on the years 1963–1965 and 1968–1970.

The following variables were used:

(1) Gross reproduction rate;

(2) Average of age-specific percentages of urban residence of women between the ages of 10 and 49;

(3) Average of age-specific percentages of illiteracy of women between the ages of 15 and 49;

(4) Average of age-specific percentages of economically active women between the ages of 15 and 49;

(5) Percentage of economically active population engaged in agriculture, aged 12 and over, both sexes;

(6) Percentage of births without professional attention;

(7) Percentage of women of childbearing age covered by the family planning programme.

Variables 2–5 were obtained from the 1960 and 1970 censuses.

In order to reproduce the uniform age distribution implicit in the gross reproduction rate, the average of the percentages by age group was taken for variables 2, 3 and 4. Since variable 5 was not broken down by sex, use was made of the over-all percentage of economically active population aged 12 and over engaged in agriculture. Variable 6, obtained from the information on births published by the National Health Service, was selected as an indicator of the existence of general medical facilities, as no data were available on personnel engaged in family planning activities and it was assumed that there would be a direct relationship between the number of such personnel and general facilities. The coverage datum (variable 7) was kindly provided by APROFA. It exists only for 1970 because in 1960 family planning activities had not yet been

TABLE 22. CHILE: VARIABLES FOR THE STUDY OF REGRESSION, BY PROVINCE, 1960

Province	Variable No.					
	1	2	3	4	5	6
Tarapacá	2.34	90.20	7.79	11.56	14.01	17.1
Antofagasta	2.29	96.27	5.93	10.57	3.02	9.8
Atacama	2.95	79.16	11.64	17.11	11.95	44.8
Coquimbo	2.89	56.82	20.94	19.27	36.53	54.8
Aconcagua	2.59	61.16	16.41	20.01	45.38	34.7
Valparaíso	2.05	91.17	6.04	25.86	12.63	14.8
Santiago	2.10	92.33	7.83	33.38	8.45	13.0
O'Higgins	2.97	58.78	17.29	16.23	48.49	35.3
Colchagua	3.23	37.88	27.28	15.05	63.14	56.6
Curicó	3.29	48.21	25.11	17.51	58.11	54.3
Talca	2.89	50.84	23.15	20.70	50.93	46.8
Maule	2.59	46.19	23.28	16.23	60.29	58.7
Linares	3.05	41.31	23.78	16.42	58.44	50.9
Ñuble	2.91	45.67	26.35	17.28	59.91	62.2
Concepción	2.80	84.85	15.17	23.13	16.68	36.0
Arauco	3.38	39.60	32.79	14.05	46.78	68.9
Bío-Bío	2.94	43.20	29.01	16.78	55.70	61.5
Malleco	3.39	50.61	31.66	16.14	53.63	55.1
Cautín	2.48	43.94	29.17	16.30	55.76	69.3
Valdivia	3.22	49.26	24.41	17.20	45.59	55.8
Osorno	2.80	52.17	22.48	21.61	46.29	58.9
Llanquihue	3.01	46.46	21.99	18.60	47.82	61.0
Chiloé	2.69	23.04	18.72	26.32	67.38	81.0
Aysén	3.25	58.16	21.10	17.64	42.33	43.0
Magallanes	1.49	93.14	6.39	23.28	17.00	3.0

Sources: For variables 1 and 6, Chile. Servicio Nacional de Salud, *Anuario de nacimientos, 1960;* for variables 2-5, data of 1960 census.

Notes: Variable 1: gross reproduction rate;
Variable 2: average percentage of women residing in urban areas;
Variable 3: average percentage of illiterate women;
Variable 4: average percentage of economically active women;
Variable 5: percentage of economically active population engaged in agriculture;
Variable 6: percentage of births without professional attention.

officially introduced. Since the coverage corresponds to the balance between participants joining and leaving the programme between 1964 and 1970, for each province, and therefore depends upon developments during that period, it appeared appropriate to relate it to fertility in 1970. The coverage relates only to institutional data, mainly those of the National Health Service and SERMENA, which cover almost 90 per cent of the population.

Procedures and results

After constructing the zero-order correlation matrices with all the variables for 1960 and 1970 (tables 24 and 29), a forward stepwise inclusion procedure was applied to arange the variables in order of importance (tables 25 and 30). The following order was obtained:

1960: 3, 4, 6, 5, 2 $R^2 = 0.67093$
1970: 3, 5, 4, 7, 6, 2 $R^2 = 0.84957$

If variable 5 (percentage of economically active population engaged in agriculture) (tables 26 and 31) is excluded, one finds that the order is as follows:

1960: 3, 4, 6, 2
1970: 3, 4, 7, 6, 2

The regression with variables 3 and 4 for 1960 and variables 3, 4 and 7 for 1970 was then calculated (tables 27 and 32):

1960: 3, 4 $R^2 = 0.62713$
1970: 3, 4, 7 $R^2 = 0.80785$

Using the component regression method[6] in which the measurement of the total variation is the sum of all elements of the zero-order correlation matrix, the following order was found:

1960: 3, 4, 1, 6, 5, 2
1970: 3, 7, 4, 1, 6, 5, 2

This means that dependent variable 1 is explained by 3 and 4 in 1960 and by 3, 7 and 4 in 1970.

In this way, both procedures gave a similar order, according greatest importance, among the selected variables, to the indicators of level of education and economic activity and, also, coverage in 1970.

In the authors' opinion, if information had been available for measuring the level of education by years

[6] Per Ottestad, "Component analysis: an alternative system". *International Statistical Review*, vol. 43, No. 1 (April 1975).

TABLE 23. CHILE: VARIABLES FOR THE STUDY OF REGRESSION, BY PROVINCE, 1970

Province	Variable No. 1	2	3	4	5	6	7
Tarapacá	2.02	92.91	5.39	21.76	11.78	7.1	14.53
Antofagasta	1.94	97.51	4.06	17.30	2.78	5.2	10.23
Atacama	2.13	88.54	8.80	16.54	9.03	18.2	5.40
Coquimbo	2.21	65.19	13.99	17.89	26.59	32.3	5.06
Acomcagua	1.86	65.29	12.07	20.64	31.16	17.2	8.19
Valparaíso	1.55	92.93	4.49	24.25	9.54	5.8	12.27
Santiago	1.58	94.72	5.82	30.84	5.79	6.6	15.18
O'Higgins	2.12	61.41	12.22	17.71	35.72	20.9	8.41
Colchagua	2.40	41.72	20.05	15.65	53.80	31.1	1.16
Curicó	2.19	52.58	18.25	18.70	48.15	29.0	3.55
Talca	2.12	59.27	17.10	20.70	44.06	34.6	4.50
Maule	2.08	51.55	18.95	16.81	51.70	39.9	3.68
Linares	2.44	48.43	17.60	17.60	53.58	30.4	0.57
Ñuble	2.58	53.02	19.16	16.82	49.63	42.5	10.41
Concepción	2.06	88.33	10.09	22.96	13.27	20.7	4.62
Arauco	2.86	54.21	23.36	13.81	43.17	47.1	0.26
Bío-Bío	2.59	54.58	21.66	16.48	48.11	36.2	0.58
Malleco	2.88	56.65	25.16	15.59	49.08	35.8	5.75
Cautín	2.36	54.82	18.84	17.67	48.22	38.2	3.89
Valdivia	2.34	58.25	16.87	17.24	41.66	32.6	11.91
Osorno	2.15	59.58	15.48	18.88	41.24	31.3	2.36
Llanquihue	2.40	55.30	16.05	19.20	43.92	34.8	6.16
Chiloé	2.00	34.33	13.64	24.78	60.28	49.1	5.27
Aysén	2.62	69.18	15.66	20.96	36.11	28.2	10.02
Magallanes	1.45	91.06	4.17	22.78	17.42	2.1	9.95

Sources: For variables 1 and 6, Chile, Servicio Nacional de Salud, *Anuario de nacimientos, 1970;* for variables 2-5, data of 1970 census; for variable 7, Asociación Chilena de Protección de la Familia (APROFA).

Notes: Variable 1: gross reproduction rate;
Variable 2: average percentage of women residing in urban areas;
Variable 3: average percentage of illiterate women;
Variable 4: average percentage of economically active women;
Variable 5: percentage of economically active population engaged in agriculture;
Variable 6: percentage of births without professional attention;
Variable 7: percentage of coverage of family planning programmes.

of school attendance instead of illiteracy, the present estimates might have been better.

The regressions of variable 1 on variables 3 and 4 for 1960 and of variable 1 on variables 3, 7 and 4 for 1970 gave the following F figures:

1960: F: 18.50, $F_{2.22;\ 0.99} = 5.72$

1970: F: 29.43, $F_{3.21;\ 0.99} = 4.87$

	Sum of squares	Additional reduction/ mean square error for all variables
1960		
Regression with all the variables	3.4423	0.2248/0.088859 = 2.53
Regression with variables 3 and 4	3.2175	
1970		
Sum of squares for regression all variables	2.7466	0.1349/0.027018 = 4.99
Sum of squares for regression 3, 4, 7	2.61169	
		$F_{1.18;\ 0.95} = 4.41$
		$F_{1.18;\ 0.99} = 8.29$

	Sum of squares	Additional reduction/ mean square error for all variables
Sum of squares for regression 3, 4, 7	2.61169	0.07189/0.0295817 = 2.43
Sum of squares for regression 3, 4	2.5398	
		$F_{1.21;\ 0.95} = 4.32$
		$F_{1.21;\ 0.99} = 8.02$

It will be seen that, in formulating the regression on variables 3, 4 and 7, the additional increment including the remaining variables is not very significant.

The odd thing about the results is that variable 7 (coverage) appears with positive regression coefficients, although statistically it does not differ from 0 in all the regressions calculated, despite the fact that the zero-order coefficient of correlation between variable 1 (gross reproduction rate) and variable 7 is -0.5156. One possible explanation of this phenomenon is that because coverage is highly dependent upon the other variables, its direct effect, once those variables are fixed, is of no significance.

[*Tables 24–34 on pages 126–129; text continued on page 129.*]

Table 24. Correlation matrix, 1960

Variable No.	Variable No. 1	2	3	4	5	6
1	1	–0.6796	0.77464	–0.42247	0.60444	0.69952
2	–0.6796	1	–0.87005	0.20308	–0.9599	–0.93152
3	0.77464	–0.87005	1	–0.34611	0.84601	0.85841
4	–0.42247	0.20308	–0.34611	1	–0.20451	–0.19252
5	0.60444	–0.9599	0.84601	–0.20451	1	0.83634
6	0.69952	–0.93152	0.85841	–0.19252	0.83634	1

Table 25. Arrangement of variables in order of importance using method 1, 1960
(Forward stepwise inclusion)

Variable No.	Coefficient: Partial correlation		(Multiple correlation)	
3	r_{13}	0.77464	R^2_{13}	0.60006
4	$r_{14.3}$	–0.26015	$R^2_{1.34}$	0.62713
6	$r_{16.34}$	0.17306	$R^2_{1.346}$	0.63829
5	$r_{15.346}$	–0.19329	$R^2_{1.3465}$	0.65181
2	$r_{12.3465}$	–0.23434	$R^2_{1.34652}$	0.67093

Table 26. Multiple regression of variable 1 on variables 3, 4, 6, 5 and 2, and analysis of variance, 1960

Variable No.	Coefficient	Standard error	T value
3	0.038062	0.017379	2.1901
4	–0.017455	0.013649	–1.2788
6	–0.0021915	0.010711	–0.20461
5	–0.018568	0.013885	–1.3373
2	–0.019998	0.019032	–1.0507
Constant	4.4028		

Multiple correlation coefficient, $R = 0.8191$ ($R^2 = 0.67093$)

Analysis of variance

	Regression	Error	Total
Degrees of freedom	5	19	24
Sum of squares	3.4423	1.6883	5.1306
Mean square	0.68845	0.088859	
Standard error of estimate	0.29809		
F value	7.7477		

Table 27. Multiple regression of variable 1 on variables 3 and 4, and analysis of variance, 1960

Variable No.	Coefficient	Standard error	T value
3	0.039926	0.0077602	5.145
4	–0.016569	0.013111	–1.2637
Constant	2.3038		

Multiple correlation coefficient, R: 0.79191 ($R^2 = 0.62713$)

Analysis of variance

	Regression	Error	Total
Degrees of freedom	2	22	24
Sum of squares	3.2175	1.913	5.1306
Mean square	1.6088	0.086957	
Standard error of estimate	0.29488		
F value	18.501		

TABLE 28. OBSERVED AND ESTIMATED VALUES, 1960

Observed value	Estimated value: 1 on 2, 3, 4, 5 and 6	Estimated value: 1 on 3 and 4
2.34	2.40	2.42
2.29	2.44	2.36
2.95	2.64	2.48
2.89	2.93	2.82
2.59	2.54	2.63
2.05	2.09	2.11
2.10	2.09	2.06
2.97	2.62	2.72
3.23	3.12	3.14
3.29	2.89	3.01
2.89	2.86	2.88
2.59	2.83	2.96
3.05	3.00	2.98
2.91	2.94	3.07
2.80	2.49	2.52
3.38	3.59	3.38
2.94	3.18	3.18
3.39	3.20	3.30
2.48	3.16	3.20
3.22	3.08	2.99
2.80	2.85	2.84
3.01	2.96	2.87
2.69	2.77	2.61
3.25	2.85	2.85
1.49	2.05	2.17

TABLE 29. CORRELATION MATRIX, 1970

Variable No.	Variable No. 1	2	3	4	5	6	7
1	1	−0.60738	0.85917	−0.72419	0.62598	0.73518	−0.5156
2	−0.60738	1	−0.84183	0.46966	−0.97823	−0.88958	0.64685
3	0.85917	−0.84183	1	−0.65032	0.86473	0.87426	−0.67753
4	−0.72419	0.46966	−0.65032	1	−0.46161	−0.4986	0.57914
5	0.62598	−0.97823	0.86473	−0.46161	1	0.87256	−0.62015
6	0.73518	−0.88958	0.87426	−0.4986	0.87256	1	−0.64141
7	−0.5156	0.64685	−0.67753	0.57914	−0.62015	−0.64141	1

TABLE 30. ARRANGEMENT OF VARIABLES IN ORDER OF IMPORTANCE BY METHOD 1, 1970
(Forward stepwise inclusion)

Variable No.	Coefficient: Partial correlation		(Multiple correlation)^2	
3	r_{13}	0.85917	R^2_{13}	0.73818
5	$r_{15.3}$	−0.45518	$R^2_{1.35}$	0.79243
4	$r_{14.35}$	−0.35569	$R^2_{1.354}$	0.81869
7	$r_{17.354}$	0.2819	$R^2_{1.3547}$	0.83309
6	$r_{16.3547}$	0.29089	$R^2_{1.35476}$	0.84722
2	$r_{12.35476}$	0.12412	$R^2_{1.354762}$	0.84957

TABLE 31. MULTIPLE REGRESSION OF VARIABLE 1 ON VARIABLES 3, 5, 4, 7, 6 AND 2, AND ANALYSIS OF VARIANCE, 1970

Variable No.	*Coefficient*	*Standard error*	*"T" value*
3	0.053521	0.015707	3.4075
5	−0.0043201	0.010554	−0.40933
4	−0.029465	0.013075	−2.2535
7	0.015053	0.011358	1.3253
6	0.0091066	0.0064961	1.4019
2	0.0053956	0.010167	0.53072
Constant	1.4505		

Multiple correlation coefficient, $R = 0.92172$ ($R^2 = 0.84957$)

Analysis of variance

	Regression	*Error*	*Total*
Degrees of freedom	6	18	24
Sum of squares	2.7466	0.48632	3.2329
Mean square	0.45776	0.027018	
Standard error of estimate	0.16437		
F value	16.943		

TABLE 32. MULTIPLE REGRESSION OF VARIABLE 1 ON VARIABLES 3, 7 AND 4, AND ANALYSIS OF VARIANCE, 1970

Variable No.	*Coefficient*	*Standard error*	*"T" value*
3	0.046522	0.0085726	5.4267
7	0.017666	0.011334	1.5587
4	−0.033363	0.01287	−2.5922
Constant	2.0588		

Multiple correlation coefficient, $R = 0.8988$ ($R^2 = 0.80785$)

Analysis of variance

	Regression	*Error*	*Total*
Degrees of freedom	3	21	24
Sum of squares	2.61169	0.621215	3.2329
Mean square	0.870563	0.0295817	
Standard error of estimate	0.171993		
F value	29.4291		

TABLE 33. OBSERVED VALUES AND ESTIMATED VALUES, 1970

Observed value	*Estimated value: 1 on 2, 3, 4, 5, 6 and 7*	*Estimated value: 1 on 3, 7 and 4*
2.02	1.83	1.84
1.94	1.87	1.85
2.13	2.12	2.01
2.21	2.28	2.20
1.86	1.99	2.08
1.55	1.67	1.67
1.58	1.63	1.57
2.12	2.08	2.18
2.40	2.36	2.49
2.19	2.27	2.35
2.12	2.27	2.24
2.08	2.44	2.44
2.44	2.19	2.30
2.58	2.60	2.57
2.06	1.99	1.84
2.86	2.83	2.69
2.59	2.55	2.53
2.88	2.84	2.81
2.36	2.43	2.41
2.34	2.46	2.48
2.15	2.19	2.19
2.40	2.26	2.27
2.00	1.90	1.96
2.62	2.30	2.26
1.45	1.59	1.67

TABLE 34. MULTIPLE REGRESSION OF VARIABLE 1 ON VARIABLES 3 AND 4, AND ANALYSIS OF VARIANCE, 1970

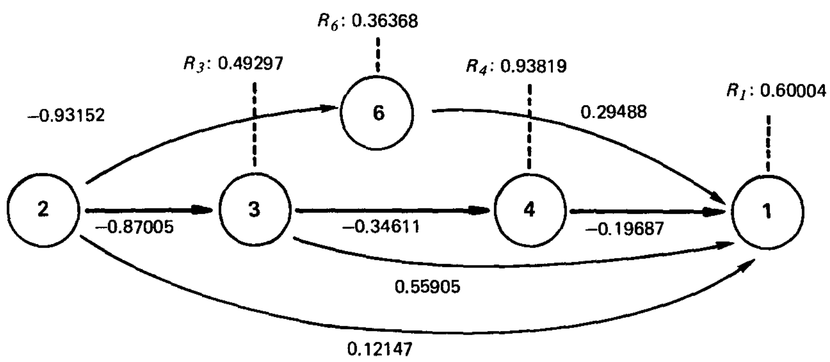
Variable	*Coefficient*	*Standard error*	*"T" value*
3	0.040029	0.0077323	5.1769
4	−0.028389	0.0128670	−2.2063
Constant	2.1716		
Multiple correlation coefficient, $R = 0.88635$ ($R^2 = 0.78562$)			

Analysis of variance

	Regression	*Error*	*Total*
Degrees of freedom	2	22	24
Sum of squares	2.5398	0.69308	3.2329
Mean square	1.2699	0.031504	
Standard error of estimate	0.17749		
F value	40.31		

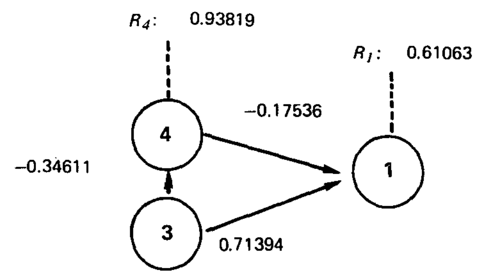
Lastly, a number of models were constructed for the relations among the variables, and the path analysis method was applied. In that analysis, variable 5, which was closely correlated with variable 2, was omitted.

The models for 1960 obviously do not include variable 7, coverage of the family planning programme.



Dependent variable	*Independent variable* 2	3	4	6	*Multiple correlation coefficient* R^2	*Residue* $\sqrt{1-R^2}$
1	0.12147	0.55905	−0.19687	0.29488	0.63996	0.60004
3	−0.87005	0	0	0	0.75699	0.49297
4	0	−0.34611	0	0	0.11980	0.93819
6	−0.93152	0	0	0	0.86774	0.36368

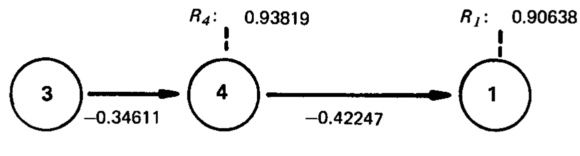
When the model was reduced to the relations of variable 1, 3 and 4, which were investigated by the multiple regression method, the following result was obtained:



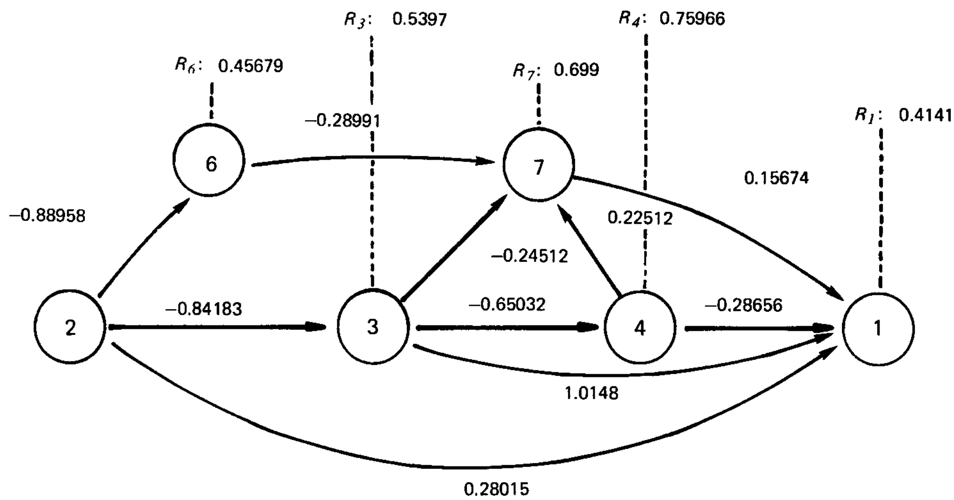
Dependent variable	Independent variable 3	4	Multiple correlation coefficient R^2	Residue $\sqrt{1-R^2}$
1	0.71394	−0.17536	0.62713	0.61063
4	−0.34611	0	0.11980	0.93819

It can be seen that, as in the analysis conduction by multiple regression, the residue of variable 1 does not vary significantly when the model is reduced to two independent variables.

In addition, another model with the same variables was proposed, in which there is a marked increase of the residue of variable 1.



The models constructed for 1970 are given below.



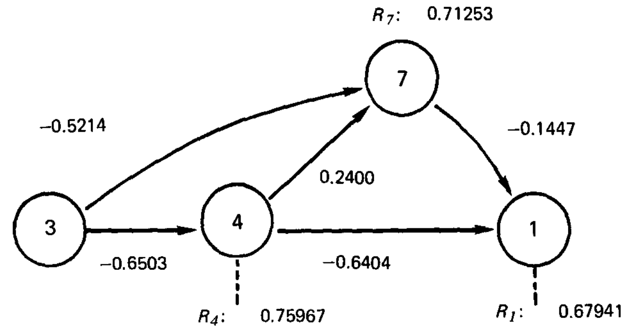
Dependent variable	Independent variable 2	3	4	6	7	Multiple correlation coefficient R^2	Residue $\sqrt{1-R^2}$
1	0.28015	1.01480	−0.28656	0	0.15674	0.82849	0.41410
3	−0.84183	0	0	0	0	0.70867	0.53970
4	0	−0.65032	0	0	0	0.42292	0.75966
6	−0.88958	0	0	0	0	0.79134	0.45679
7	0	−0.24512	0.27518	−0.28991	0	0.51139	0.69900

It can be seen that although the value of the residue for variable 1 suggests that the model formulated is a good one, the coefficients obtained are not what might be expected.

It is noteworthy, for example, that the coefficient between variable 2 (percentage of urban residents) and variable 1 (gross rate of reproduction), and the coefficient between variable 7 (percentage of coverage of the family planning programme) and variable 1 are both positive in sign. The direct relationships implied by these results are obviously inconsistent with reality.

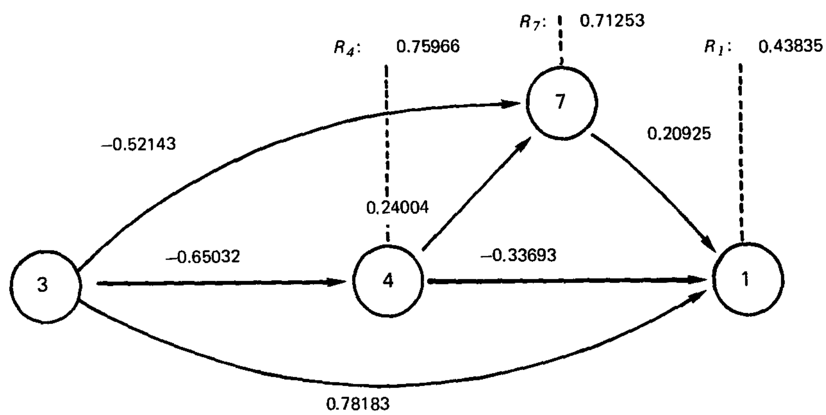
The reason for this result is, no doubt, that the model formulated in accordance with the present hypothesis of relations omits some direct effects of other variables on variable 1 and the intercorrelations of the variables considered.

Lastly, a model was formulated based on the results obtained in the arrangement of the variables in order of importance with the multiple regression analysis.



Although the residue for variable 1 is greater than in the first model for 1970, the signs of the coefficients agree with the signs expected from the relations.

The last model constructed was that given below. Except for the sign of the coefficient between variables 7 and 1, which one would have expected to be negative, this model appears to be fairly satisfactory.



Annex

BASIC DEMOGRAPHIC DATA FOR CHILE

TABLE 35. FEMALE POPULATION OF CHILDBEARING AGE, BY AGE GROUP, 1959-1974
(*Thousands*)

Year	Age group								
	12-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	12-49
1959	246.8	364.9	304.4	270.1	252.1	209.4	188.8	169.2	2 005.7
1960	253.1	376.8	311.3	270.8	260.4	212.4	191.1	172.2	2 048.1
1961	256.0	385.2	323.0	277.6	261.3	220.7	194.2	174.6	2 093.6
1962	258.9	395.6	334.6	284.4	262.2	229.1	197.2	177.1	2 139.1
1963	261.8	405.0	346.3	291.3	263.1	237.4	200.2	179.5	2 184.6
1964	264.7	414.4	358.0	298.1	264.0	245.8	203.3	181.9	2 230.2
1965	267.6	423.8	369.7	304.9	264.8	254.2	206.3	184.4	2 275.7
1966	279.3	430.6	379.1	316.6	271.7	255.2	214.7	187.5	2 334.7
1967	291.0	437.3	388.5	328.3	278.6	256.3	223.0	190.7	2 393.7
1968	302.6	444.1	398.0	340.0	285.5	257.3	231.4	193.8	2 452.7
1969	314.3	450.9	407.5	351.7	292.3	258.4	239.7	197.0	2 511.8
1970	326.0	457.6	416.9	363.4	299.2	259.4	248.1	200.2	2 570.8
1971	334.1	477.4	423.8	372.8	310.9	266.3	249.2	208.3	2 642.8
1972	342.2	497.1	430.7	382.4	322.5	273.1	250.3	216.5	2 714.8
1973	350.3	516.8	437.5	391.9	334.2	280.0	251.4	224.7	2 786.8
1974	358.4	536.6	444.4	401.4	345.8	286.8	252.5	232.9	2 858.8

Source: Chile, Oficina de Planificación Nacional (ODEPLAN), *Proyección de la población de Chile, por sexo y grupos quinquenales de edad, 1958-2000.*

TABLE 36. AGE-SPECIFIC FERTILITY RATES, CORRECTED, 1960-1974
(*Rates per 1 000 women*)

Year	Age group 12-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49
1956	2.5	81.3	232.5	269.4	207.5	147.6	70.3	16.5
1957	2.2	83.0	237.6	280.9	217.1	155.0	71.5	16.8
1958	2.1	81.0	231.7	276.0	218.2	156.2	71.1	16.3
1959	2.6	79.6	228.7	269.5	223.5	155.2	69.0	14.3
1960	2.7	79.6	235.2	273.3	229.3	160.1	67.3	15.5
1961	2.9	82.1	230.7	275.6	241.0	158.1	64.4	13.6
1962	2.6	81.5	233.4	268.6	245.9	155.0	68.4	13.1
1963	3.0	83.8	241.3	253.5	234.7	155.2	68.5	11.8
1964	2.9	81.9	235.4	247.5	220.1	150.4	65.5	11.1
1965	2.9	82.8	227.9	242.7	207.4	149.5	64.5	11.4
1966	2.8	82.1	220.2	230.5	186.3	142.4	60.3	10.4
1967	2.9	82.5	215.0	213.2	168.8	130.4	55.3	9.9
1968	2.5	79.2	206.0	200.0	152.1	116.0	52.9	8.9
1969	2.7	78.9	194.8	186.1	142.6	105.2	48.0	8.4
1970	2.3	80.7	192.7	182.5	135.0	94.4	44.7	8.4
1971	2.8	84.3	200.1	186.0	136.2	88.7	42.4	7.9
1972	3.1	86.4	203.0	183.6	131.0	82.3	40.0	7.3
1973	2.8	83.5	202.5	175.5	123.9	76.4	35.4	6.3[a]
1974	3.1	79.3	191.3	169.4	116.9	73.4	33.5	6.0

Sources: Births per age group were calculated by applying the structure of recorded births to the total of births estimated by H. Gutiérrez, *La integridad del registro de nacidos vivos en Chile, 1953-1966;* and since 1967, from unpublished data. For 1956-1970, the information used was the birth data published by Instituto Nacional de Estadísticas in its journal *Demografía;* and for 1971-1974, those published by Servicio Nacional de Salud in its journal *Nacimientos.* The number of women of childbearing age was taken from data for 1960, 1965, 1970 and 1975 given in Chile, Oficina de Planificación Nacional, *Proyección de la población de Chile por sexo y grupos quinquenales de edad 1958-2000* (Santiago).

[a] The initial value obtained was 15.3, which is inconsistent with the trend of this specific rate: it indicates a defect in the basic information. The final value of 6.3 was obtained by projecting the ratio ($5^f45/5^f40$).

TABLE 37. ADMISSIONS PER ANNUM TABULATED ACCORDING TO INTRA-UTERINE DEVICE AND ORAL GESTAGENS, 1964-1974

Year	Intra-uterine device Number	Intra-uterine device Percentage	Oral gestagens Number	Oral gestagens Percentage	Total Number	Total Percentage
1964	11 264	96.0	471	4.0	11 735	100.0
1965	20 467	69.3	9 056	30.7	29 523	100.0
1966	33 686	67.1	16 515	32.9	50 201	100.0
1967	45 375	77.1	13 477	22.9	58 852	100.0
1968	46 422	77.1	13 788	22.9	60 210	100.0
1969	40 674	68.1	19 070	31.9	59 744	100.0
1970	43 602	71.3	17 528	28.7	61 130	100.0
1971	36 142	63.4	20 835	36.6	56 977	100.0
1972	35 167	60.1	23 331	39.9	58 498	100.0
1973	80 155	66.5	40 399	33.5	120 554	100.0
1974	121 879	66.1	62 450	33.9	184 329	100.0

Sources: For 1964-1966, M. Requena and T. Monreal, "Evaluación del programa de control del aborto inducido y planificación familiar en Chile", *Milbank Memorial Fund Quarterly,* vol. XLVI, No. 3 (July 1968), part 2, pp. 213-246; for 1969-1973, Z. Soto, *América Latina: situación de los programas de planificación de la familia hasta 1973,* CELADE Series A, No. 130 (Santiago, 1975); for 1974, Asociación Chilena de Protección de la Familia (APROFA).

Note: Figures for 1967 and 1968 are estimated. In the report by Soto, the totals are: for 1967, a total of 16,976, with no distinction as to method; and for 1968, a total of 102,086, grouped into intra-uterine devices (IUD) and oral gestagens. Since these figures are not in satisfactory agreement with the general trend, it was assumed that some of the admissions listed for 1968 were actually admissions for 1967. The number of admissions for the two years was therefore prorated in the same ratio as existed between the years 1969 and 1970. The resulting totals were distributed under the headings of admissions with IUD and admissions with gestagens, in accordance with the respective percentages recorded for the year 1968 in the document referred to, as no such information was available for 1967.

TABLE 38. PERCENTAGE DISTRIBUTION OF ACCEPTORS OF THE INTRA-UTERINE DEVICE AND ORAL GESTAGENS, BY AGE GROUP

Age group	*IUD*	*Oral gestagens*
15-19	4	8
20-24	30	34
25-29	29	36
30-34	21	15
35-39	12	4
40 and over	4	3
	100	100

Note: These percentages correspond to the average percentages of admissions for the periods January 1968-August 1971 and September 1971-June 1972 at the National Employees' Medical Service, Valparaíso, rounded off to make a total of 100 per cent. Centro Latinoamericano de Demografía, Series A, No. 115, November 1972, annex 2.

TABLE 39. CUMULATIVE RATES OF CONTINUATION BY METHOD, ACCORDING TO DURATION OF USE
(*Rates per 100*)

	Cumulative rates	
Duration of use (months)	*Intra-uterine device*	*Gestagens*
1	98.84	98.26
2	97.04	94.61
3	95.26	91.35
4	93.20	87.50
5	91.35	83.76
6	90.10	81.35
7	88.29	78.06
8	87.08	75.45
9	85.66	72.11
10	83.93	69.21
11	82.72	66.56
12	81.16	64.06
13	79.72	60.42
14	78.61	57.24
15	76.91	54.45
16	76.35	52.23
17	75.51	49.70
18	74.75	47.23
19	74.34	44.49
20	73.06	41.77
21	72.02	39.40
22	71.06	36.13
23	69.89	33.79
24	68.49	31.56
30	62.12	20.12
36	59.06	13.12
42	54.99	8.36
48	48.85	2.79
54	42.74	2.79

Source: Chile, National Employees' Medical Service (SERMENA).

TABLE 40. HOSPITALIZATION FOR ABORTION AT THE NATIONAL HEALTH SERVICE AND RECORDED LIVE BIRTHS, 1937-1964

Year	*Abortions*	*Live births*	*Abortions per 100 births*
1937	12 963	153 354	8.4
1938	13 982	154 927	9.0
1939	14 730	163 589	9.0
1940	16 254	166 593	9.7
1941	18 265	165 004	11.0
1942	19 342	170 222	11.3
1943	20 009	172 095	11.6
1944	19 449	174 864	11.1
1945	21 581	178 292	12.1
1946	23 619	175 686	13.4
1947	24 535	186 784	13.1
1948	26 448	189 236	13.9
1949	28 514	189 719	15.0
1950	29 512	188 323	15.6
1951	30 571	191 332	15.9

TABLE 40 (*continued*)

Year	*Abortions*	*Live births*	*Abortions per 100 births*
1952	32 862	195 470	16.5
1953	33 862	211 808	15.9
1954	35 748	209 920	17.0
1955	39 340	225 352	17.4
1956	41 429	237 268	17.0
1957	44 945	262 746	17.1
1958	49 041	262 759	18.6
1959	49 448	249 799	19.8
1960	47 096	256 674	18.3
1961	49 195	263 985	18.6
1962	51 246	275 960	18.6
1963	49 772	280 167	14.9
1964	56 391	277 893	20.3

Source: Francisco Mardones Restat, Jorge Rosselot Vicuña and Lucía Lopez Cazenave, *Política y programa de regulación de la natalidad en el Servicio National de Salud de Chile* (Santiago, Servicio Nacional de Salud, 1967).