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COMMITTEE ON
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Report No. 22

Comparative Analysis of Fertility, Breastfeeding, and Contraception

A Dynamic Model

Toni Richards

Panel on Fertility Determinants
Committee on Population and Demography
Commission on Behavioral and
Social Sciences and Education
National Research Council

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PREFACE

The Committee on Population and Demography was established in April 1977 by the National Research Council in response to a request by the Agency for International Development (AID) of the U.S. Department of State. It was widely felt by those concerned that the time was ripe for a detailed review of levels and trends of fertility and mortality in the developing world. Although most people in the demographic community agree that mortality has declined in almost all developing countries during the last 30 years, there is uncertainty about more recent changes in mortality in some countries, about current levels of fertility, about the existence and extent of recent changes in fertility, and about the factors determining reductions in fertility.

In 1963, a Panel on Population Problems of the Committee on Science and Public Policy of the National Academy of Sciences published a report entitled The Growth of World Population. The appointment of that panel and the publication of its report were expressions of the concern then felt by scientists, as well as by other informed persons in many countries, about the implications of population trends. At that time, the most consequential trend was the pronounced and long-continued acceleration in the rate of increase of the population of the world, and especially of the population of the poorer countries. It was estimated in 1963 that the annual rate of increase of the global population had reached 2 percent, a rate that, if continued, would cause the total to double every 35 years. The disproportionate contribution of low-income areas to that acceleration was caused by rapid declines in mortality combined with high fertility that remained almost unchanged: the birth rate was nearly fixed or declined more modestly than the death rate.

Since the earlier report, however, the peak rate of growth in the world's population has apparently been passed. A dramatic decline in the birth rate in almost all the more developed countries has lowered their aggregate annual rate of increase to well below 1 percent, and the peak rate of increase has also apparently been passed in the less-developed parts of the world as a whole. A sharp decline in fertility in many low-income areas has more than offset the generally continued reduction in the death rate, although the rate of population increase remains high in almost all less-developed countries.

The causes of the reductions in fertility--whether they are the effect primarily of such general changes as lowered infant mortality, increasing education, urban rather than rural residence, and improving status of women, or of such particular changes as spreading knowledge of and access to efficient methods of contraception or abortion--are strongly debated. There are also divergent views of the appropriate national and international policies on population in the face of these changing trends. The differences in opinion extend to different beliefs and assertions about what the population trends really are in many of the less-developed countries. Because births and deaths are recorded very incompletely in much of Africa, Asia, and Latin America, levels and trends of fertility and mortality must be estimated, and disagreement has arisen in some instances about the most reliable estimates of those levels and trends.

It was to examine these questions that the Committee on Population and Demography was established within the Commission on Behavioral and Social Sciences and Education of the National Research Council. It was funded for a period of five and one-half years by AID under Contract No. AID/pha-C-1161 and Grant No. AID/DSPE-G-0061. Chaired by Ansley J. Coale, the committee has undertaken three major tasks:

1. To evaluate available evidence and prepare estimates of levels and trends of fertility and mortality in selected developing nations;

2. To improve the technologies for estimating fertility and mortality when only incomplete or inadequate data exist (including techniques of data collection);

3. To evaluate the factors determining the changes in birth rates in less-developed nations.

Given the magnitude of these tasks, the committee decided to concentrate its initial efforts on the first two tasks. This work is detailed in a series of country and methodological reports from the National Academy Press, and the demographic estimation methodology developed for the country studies is laid out in a volume issued by the United Nations. As of 1982, some 170 population specialists, including 94 from developing countries, have been involved in the work of the committee as members of panels or working groups. The committee, the commission, and the National Research Council are grateful for the unpaid time and effort these experts have been willing to give.

The committee initiated work on the third task in October 1979 when the separately funded Panel on Fertility Determinants was established. Research on the determinants of fertility change has been carried out by scholars from several disciplines, and there is no comprehensive accepted theory of fertility change to guide the evaluation. Because of this state of knowledge of the causes of reductions in fertility and the difficulty of the task, the Panel on Fertility Determinants includes scholars from anthropology, demography, economics, epidemiology, psychology, sociology, and statistics. Three committee members serve on the panel. The work program of the panel includes the preparation of a report that attempts to summarize and integrate scientific knowledge about the determinants of fertility. In addition, the panel has prepared a few illustrative cross-national comparative analyses and studies of several developing countries.

This report is one of the panel's comparative analysis studies. It has been prepared by Toni Richards, research associate, Office of Population Research, Princeton University, who was a National Academy of Sciences postdoctoral fellow with the committee in 1980-81. The initial work on this study was carried out at the Academy, and it was completed at the Office of Population Research (OPR). The panel and the committee are grateful to the author for preparation of the study and to the OPR for logistical support provided to the author.

The author, panel, and committee would like to thank Henry Braun, Rodolfo Bulatao, Mark Montgomery, Krishnan Namboodiri, Anne Pebley, T. Paul Schultz, Burton Singer, James Trussell, and Hania Zlotnik for helpful comments

INTRODUCTION

Breastfeeding and contraception are the two key discretionary variables affecting fertility; that is, they are the primary ways in which women may, through their own behavior, influence when, if ever, they have a next birth. Breastfeeding and contraceptive practice are themselves influenced by socioeconomic characteristics. In addition, a child death may truncate breastfeeding or alter contraceptive behavior. Recent work has shown the importance of these intermediate variables in accounting for differences among populations in aggregate fertility levels (Bongaarts, 1976, 1982). Biometric models and clinical studies give us quite precise estimates of the contribution of an additional month of breastfeeding or contraception to the length of the birth interval (for a summary of some of this work, see Leridon, 1977; Sheps and Menken, 1973; Bongaarts, 1983; or Bongaarts and Menken, 1983). However, the biometric models have relied on mathematical simplifications, while the clinical studies have been restricted to small samples, usually based on local populations for which detailed prospective data could be gathered.

In this paper, a model of the dynamics of childbearing for the birth histories of individual women is developed and applied to World Fertility Survey (WFS) data from Colombia and Costa Rica. The analysis focuses on the determinants of breastfeeding and contraception, and on the ways they, in turn, influence fertility. The sophisticated and precise biometric models are extended so that they are applicable to the gross level of measurement and heterogeneous samples of the retrospective birth histories available from surveys. To the extent that this analysis produces empirical results comparable to those expected from biometric models and clinical studies, it both lends credibility to the use of sophisticated modeling techniques with survey data and extends the validity of the biometric models to broader populations. To the extent that breastfeeding and contraceptive use can be modeled, new insights into some of the behavioral aspects and the dynamics of the fertility decision-making process are gained. The statistical techniques used rely on estimation procedures recently developed for the analysis of survival data and event histories (Cox, 1972; Kalbfleish and Prentice, 1980). These techniques have previously been applied to the analysis of labor force dynamics (Flinn and Heckman, 1982; Tuma et al., 1979), marriage dissolution (Menken et al., 1981), contraceptive discontinuation (Potter and Phillips, 1980) and child survival (Trussell and Hammerslough, 1983), as well as to a wide variety of biomedical data. Their application to fertility is a natural one (see, for example, Singer and Heckman, 1982; Braun and Hoem, 1979).

Previous work has segmented the birth interval into a waiting time to conception, a period of gestation, and a period of postpartum amenorrhea. Typically, each of these segments has been modeled separately. The length of the waiting time to conception has been assumed to be dependent upon fecundity, the monthly risk of conception. The lengths of gestation and postpartum amenorrhea were taken as either constants or their distributions were modeled separately. The modeling strategy adopted here calculates conception rates (which may be equal to zero) by duration, disregarding segmentation of the birth interval. That is, it replaces the idea of fecundability with a conception rate dependent on breastfeeding and contraceptive use, and on a biologically determined propensity to conceive that is dependent on the time elapsed since the last birth. The question is whether, given the reported data on duration of breastfeeding and duration of contraceptive use from retrospective surveys like the WFS, we can estimate the impact of breastfeeding and contraceptive practice on fertility as measured through birth interval length and parity progression. The basic idea is that at each point in time since the previous birth, there is some risk of conception. This risk is influenced primarily by breastfeeding and contraception, as well as by socioeconomic factors. In addition, it is well known that infant mortality can influence the length of the birth interval, either because breastfeeding stops when the child dies or because contraceptive practice changes. A similar strategy is adopted for analyzing termination rates for breastfeeding and contraceptive use. Just as there is some risk of conception at each point in time from the previous birth, there is some risk of terminating breastfeeding or contraceptive use at each point in time after these behaviors begin. Infant mortality influences the conception rate by changing these risks. Similarly, the principal impact of the socioeconomic variables on fertility can be expected to operate through the decision to breastfeed or contracept and through the duration of these practices.

In what follows the data from the World Fertility Surveys for Colombia and Costa Rica are described along with the social, economic, and demographic settings of these two countries for the period 1960 to 1976. A three-stage scheme for the analysis of breastfeeding, contraception, and fertility is also described. The stages of the model include: first, defining a set of background covariates that predict whether or not a woman breastfed and whether she used contraception; second, modeling durations of breastfeeding and of contraceptive use; third, development of a biometrically-based model of the interval between births. Since the theory for the last stage is most fully developed, the scheme is described in reverse order in the text. Estimation procedures for descriptive statistics and for the equations specified are given next, along with a description of the birth intervals sampled and definitions of the variables used. This is followed by a set of descriptive results, the final results, and a summary.

NOTES ON THE DATA

As already noted, the data used are from the World Fertility Surveys for Colombia and Costa Rica, which obtained reproductive histories, including dates of birth and death of all children, for nationally representative samples of women in the reproductive ages. (These are described in detail in the First Country Reports, and the quality of the data have been explored in other WFS publications, c.f. the Scientific Reports.) Detailed information on breastfeeding and contraceptive use are, however, available only for the last closed and the open interval, and information on duration of contraceptive use was collected only in the two countries studied here. Despite being selected because of data availability, Colombia and Costa Rica are appropriate for a comparative study of the impact of breastfeeding and contraceptive use on reproduction because they are countries with relatively similar levels of fertility, but quite different patterns of breastfeeding and contraceptive use.

In both countries, the WFS was taken in 1976; in both cases, 93 percent of last and next-to-last birth intervals are concentrated in the period since 1960. Yet these intervals are not representative of all birth intervals begun in this period; in fact, the farther from the survey date (i.e., the closer to 1960) an interval began, the less likely it is to be the last or even next-to-last in 1976. The situation is problematic because the estimation procedures used here require that we assume the childbearing process to have remained relatively unchanged over the entire period; a stationarity assumption that may not be met by the data because the period between 1960 and 1976 was one of considerable social, economic, and demographic change for both countries. In order to understand potential sources of bias, we will examine some of these changes rather closely.

Figure 1 shows the downward trends for the period 1960-76 in fertility (total fertility rate) and infant mortality (${}_1q_0$). The level of fertility and the pace of decline are similar in both countries, but infant mortality is somewhat lower in Costa Rica than in Colombia. Figure 2 displays the age profile of fertility for both countries for two time points. The pattern of decline has been similar in both countries, resulting in a concentration of childbearing at younger ages, that is perhaps more marked in Costa Rica than in Colombia.

There has also been considerable social and economic change. While both Colombia and Costa Rica still have large agricultural sectors (with 30 and 22 percent, respectively, of the gross domestic product being derived from agriculture), urbanization and industrialization have both increased since 1960. The mid-1960s also saw the development of family planning programs in both countries. Although Colombia and Costa Rica are both about equally urbanized, per capita income and literacy are considerably higher in Costa Rica, as is contraceptive prevalence. In contrast, breastfeeding is more common and of longer duration in Colombia than in Costa Rica. Thus, similar levels of fertility are obtained by quite different behavioral mechanisms. In both countries, family planning clinics have tended to be concentrated in cities, and contraceptives have been more available to the urban population (see Sanin, 1976; Gomez and Bermudez, 1974).

These social and demographic changes affect the representativeness of the last two birth intervals. As already noted, births occurring farther away from the survey date and associated with the last two intervals are less and less representative of all births for that period. In particular, births occurring far from the survey date will be associated with longer intervals; short intervals from earlier periods will be correspondingly underrepresented. These long intervals will tend to be associated with births to women who are subfecund, older women, higher-parity women, and women using contraception. This last group is of some concern since these women must have started using contraception at a time when it was relatively unusual to do so. Therefore, they may be an atypically more "modern" group for their period, and their childbearing experience may be closer to that of women who gave birth in the more recent period. In

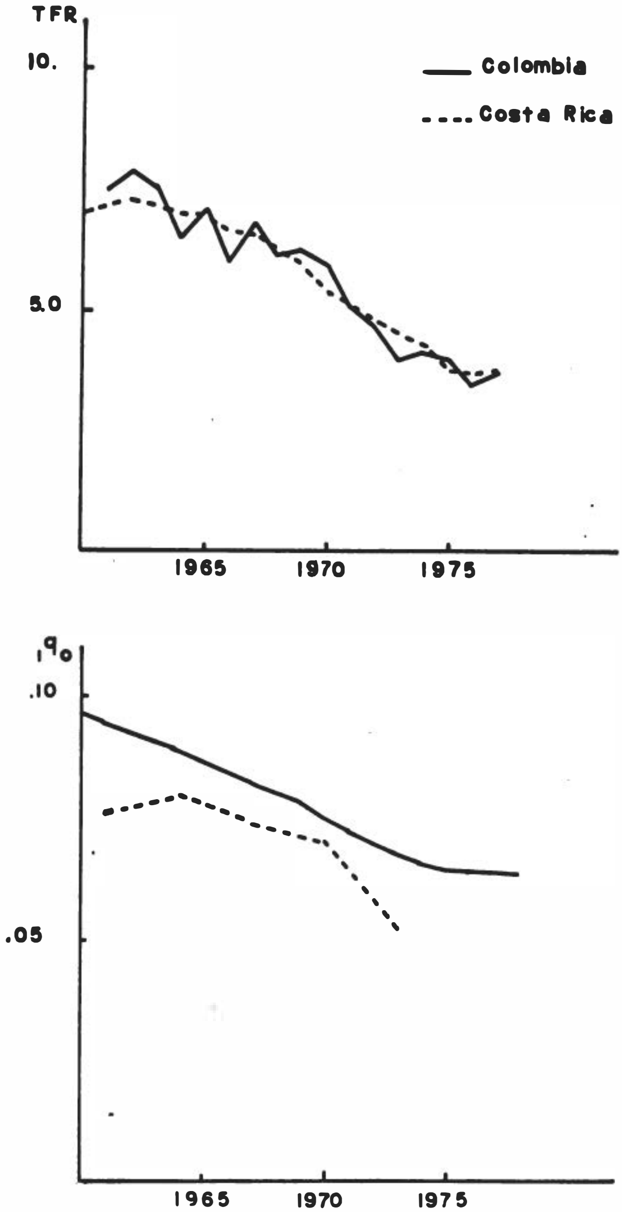


FIGURE 1 Total Fertility Rates and Infant Mortality Rates, 1960-78

Sources: National Research Council (1982); tabulations from the Costa Rica study by the Panel on Latin America, Committee on Population and Demography, National Academy of Sciences.

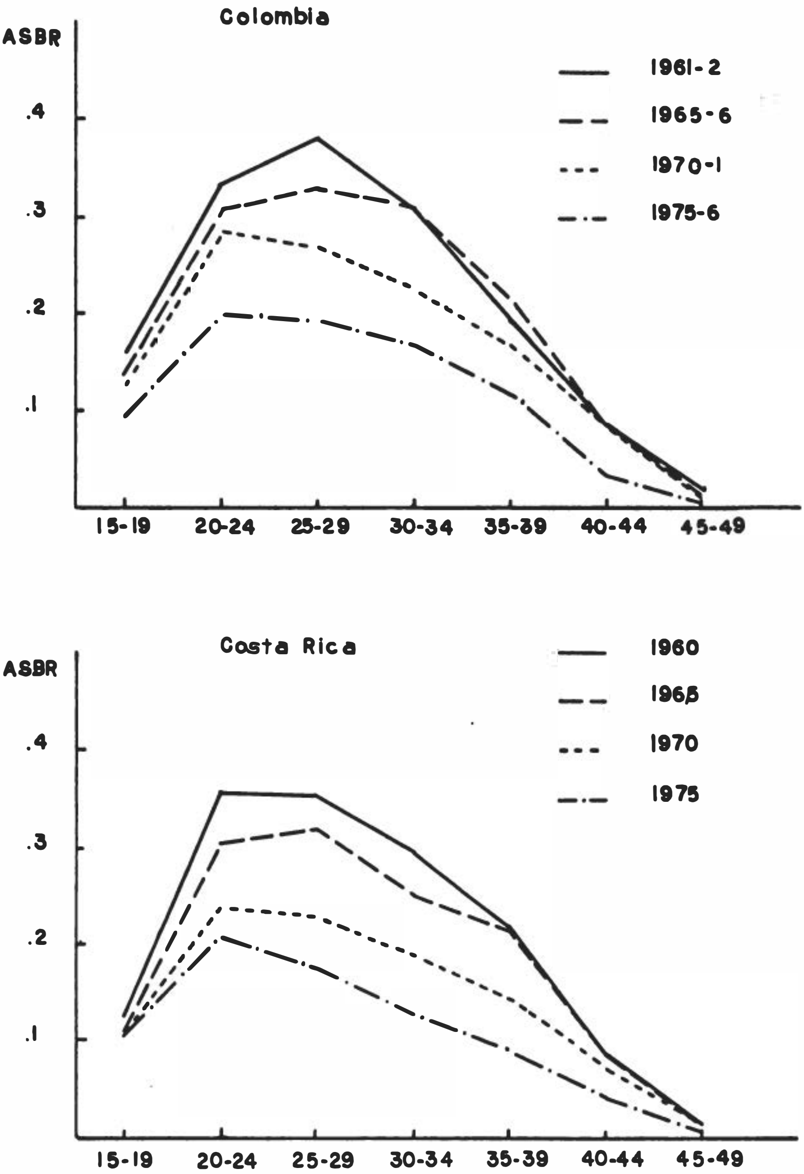


FIGURE 2 Age-Specific Fertility Rates, 1960-75

Sources: National Research Council (1982); tabulations from the Costa Rica study by the Panel on Latin America, Committee on Population and Demography, National Academy of Sciences.

addition, modern coitus-independent contraceptives were, for the most part, not available until the 1970s, which means that these longer intervals had to be achieved through the effective use of more traditional methods, and thus may bias upwards our estimates of the impact of the use of these methods on fertility. An attempt to assess these biases is made by progressively excluding births from earlier periods, repeating analyses and comparing results. Thus, all last and next-to-last births are analyzed first, followed by only those occurring since 1960, since 1965, and since 1970.

THE MODEL

In an effort to understand the dynamics of fertility as regards its responsiveness to breastfeeding, contraceptive use, and their durations at the birth interval level, the reproductive history of a woman is treated as a sequential process marked by events including births, initiation and termination of breastfeeding, initiation and termination of contraceptive use, and infant deaths. Although decisions about breastfeeding or contraception and about childbearing are simultaneously determined, and child mortality both affects and is affected by fertility, this highly endogenous system will be broken into a multi-stage process.

The stages of the model are as follows. A set of background social and economic variables is developed for the purpose of predicting whether a woman breastfed or whether she used contraception during the last closed or the open interval. Durations of breastfeeding and of contraceptive use are then predicted for women with positive durations on each variable, respectively. Finally, a model for the full interval between births is devised and tested. Because the WFS collected information on relatively few social and economic variables which might be expected to influence the decision to breastfeed or to contracept, and the duration of either, and because we know relatively little about this decision-making process, the first portion of the model is not as fully developed as it might otherwise be. In contrast, more information is available about how the intermediate variables ought to enter a model of the waiting time to the next birth. Thus in our conceptual scheme, a set of social and economic characteristics influences whether and how long a woman breastfeeds or contracepts, and these two intermediate variables, along with child mortality, influence the waiting time to the next birth. This scheme can be thought of as a translation of the Davis and Blake (1956) framework to the individual level, with the first portion involving behavioral modeling and the second biometric modeling. It is shown in diagram form at the beginning of the section on final results.

The model will be described from the inside out: first, the biometric model of fertility; then determinants of the duration of breastfeeding and of contraception; and finally, determinants of the probability of breastfeeding or contraception. To do this, we must define some statistical terms and functions. The reproductive history of a woman is taken to be a point process, that is, a random collection of points along the time axis (Cox and Isham, 1980). Events such as a birth, initiation or termination of breastfeeding, initiation or termination of contraception, or a child death define the points; the time between related events defines intervals on the axis, for example, birth intervals or duration of breastfeeding. Such a process can be specified in three ways, each containing the same information expressed differently: the interval specification, the counting specification, and the conditional intensity specification. The interval specification is based on the joint distribution of intervals. The counting specification is based on the distribution of the number of events in some fixed interval. The conditional intensity specification tells the probability of an event in a small time interval, conditional on the history of the process up to that point in time (Cox and Isham, 1980). For example, it would tell the probability of a birth at a given time instant conditional on the woman's reproductive history. For our purposes, this is the most intuitive approach to modeling the childbearing process.

The intensity specification is a generalization of the well-known hazard function. The hazard approach requires the existence of a density function for waiting times, that is, times between events. The relationships among the hazard, and the density and the distribution functions for waiting times is given below. Let T be a random variable denoting time between events. Suppose it has probability density function f(t) and cumulative distribution function F(t), then

$$F(t) = Pr\{T \leq t\} = \int_0^t f(u)du$$

and

$$f(t) = \lim_{\partial \to 0+} \frac{\Pr\{t \le T < t+\partial\}}{\partial} .$$

The survivor function is defined as

$$\tilde{F}(t) = 1 - F(t) = \Pr\{T \ge t\}.$$

The hazard function is now given by

$$h(t) = \lim_{\partial \to 0+} \Pr\{t < T \le t+\partial \mid T > t\}$$

$$= \lim_{\partial \to 0+} \frac{\Pr\{t < T \le t+\partial\}}{\partial} \quad \frac{1}{\Pr\{T > t\}}$$

$$= \frac{f(t)}{\tilde{F}(t)} .$$

The hazard function is related to the survivor and density functions by

$$h(t) = -\frac{\tilde{F}'(t)}{\tilde{F}(t)} = -\frac{d}{dt} \log \tilde{F}(t) .$$

Using the initial condition that F(0) = 1 and integrating one has

$$\tilde{F}(t) = \exp[-\int_0^t h(u)du]$$

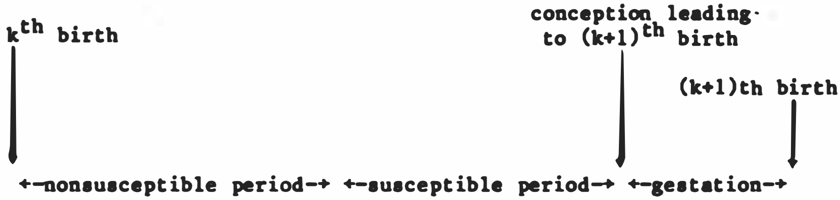
from which it follows that

$$f(t) = h(t)\exp[-\int_0^t h(u)du] .$$

Clearly information about the hazard function is equivalent to information about the density of waiting times or the survivor function.

THE FERTILITY EQUATION: MODELING THE TIME TO NEXT CONCEPTION

Our approach will be to model the conditional probability of having a birth (or conception), given that it has not already happened in the birth interval in question, and then to consider how this hazard function (or conception rate) is modified by breastfeeding or contraception, or other characteristics such as a child death. Consider the following schematic representation of the birth interval:

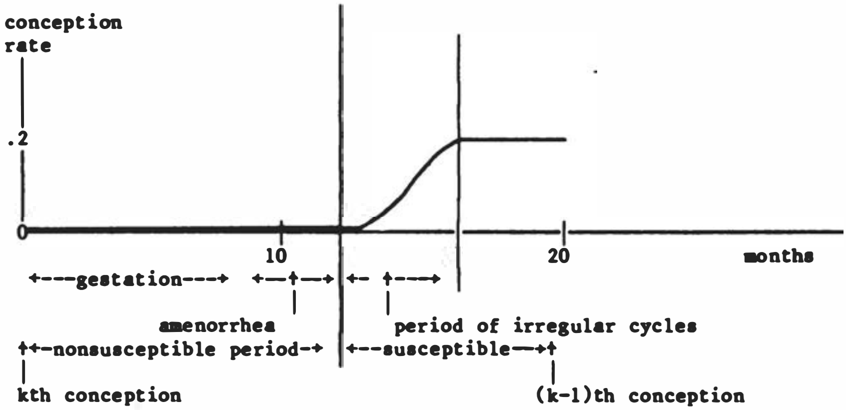


The discussion of the hazard function is based on this decomposition of the birth interval into components influenced by different factors: a nonsusceptible period following a birth composed of postpartum and possibly lactational amenorrhea, a susceptible period where the probability of conception may be modified by contraception, and a period of gestation. The goal is to derive some notion of the shape of the hazard function and how it behaves by consideration of these components. The model will not explicitly include fetal mortality. (Underreporting of pregnancy wastage is very severe in the WFS; see Chidambaram et al., 1980). Spontaneous abortions are implicitly included in the sense that they reduce observed conception rates in the susceptible period. In addition, the probability of conception for any given woman is influenced by a variety of factors, some of them genetic, which cannot be measured and which will not be included in the model. This means that the estimated hazard function may appear to decline where the true hazard does not. (Explicit modeling of this unmeasured heterogeneity is beyond the scope of the present research; for a discussion of the biases involved see Flinn and Heckman, 1982; Singer and Heckman, 1982; Heckman and Singer, 1982).

For convenience, instead of considering the intervals between births, consider the intervals between conceptions leading to live births, so that an interval begins with a period of gestation followed by postpartum amenorrhea. For the purposes of modeling, we will assume that the period of gestation is fixed at 9 months. This follows standard biometric practice (see Leridon, 1977). During this period, the probability of conception is zero. The period of amenorrhea following a birth is often taken to be fixed at 2-3 months. (Leridon cites a mean of 58 days [1977:83]; Bongaarts cites 1.5 to 2 months [1983].) However, this distribution is considerably more variable than is that for the duration of gestation, and seems to bear incorporating into the model. (Leridon suggests a maximum of 11 months of amenorrhea in the absence of lactation [1977:83].) The period of amenorrhea may be followed by irregular cycles. In 90 percent of cases, ovulation returns before the first menses or in the first cycle (Leridon, 1977:84; Bongaarts, 1983). However, the first few cycles following the return of menses tend to be more variable in length, with the proportion of anovulatory cycles falling from 10 percent to less than 5 percent in the first five cycles (Leridon, 1977:84). After this period of irregular cycles, the risk of conception is usually taken to be a constant, estimated to be .20 or .25 near marriage for women in their twenties, with a mean waiting time to conception of 5 to 8 months depending on the variability of fecundity (Leridon, 1977:33-36). Specifically, the distribution of waiting times in the susceptible period is assumed to be exponential with a constant occurrence rate. Combining this information yields the graphical display of the conception rate shown at the top of page 14. Here the hazard is constant and equal to zero for 12 months during the nonsusceptible period (9 months gestation plus 3 months postpartum amenorrhea), and then gradually rises to a second constant level as the woman enters the susceptible period.

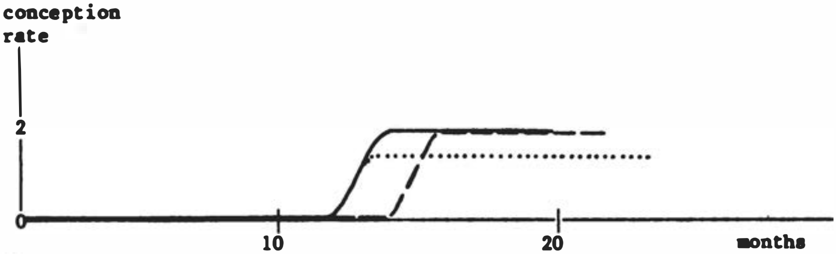
Now consider how this hazard may be modified by breastfeeding and by contraception, respectively. Breastfeeding lengthens the period of postpartum amenorrhea. The extent of this impact depends on the duration of breastfeeding: with up to 3 months of breastfeeding, the duration of amenorrhea exceeds the duration of breastfeeding; after 3 months, each additional month of breastfeeding adds less than 1 month of amenorrhea (Leridon, 1977:85; Bongaarts, 1983). The impact of breastfeeding on amenorrhea also

DIAGRAM 1 Hazard Function for Conceptions for Women Who do not Breastfeed and do not Contracept



depends on both the frequency of nursing and whether breastfeeding is full (no supplementation) or partial (the infant receives other nourishment). Full breast-feeding appears to have a much greater impact than partial on amenorrhea, but neither has any apparent effect after 18 months. In addition, little is known about the return of ovulation, the proportion of anovu-latory cycles, or the regularity of menses among women who have stopped lactating. Once menses return, it is plausible that the same model of constant conception rates is appropriate both for noncontracepting women who are breastfeeding and for those who are not, although there is some evidence that conception rates may be lower among women who continue breastfeeding after the menses resume. The expected impact of breastfeeding is shown by the dashed line in Diagram 2 on page 15. Contraception reduces the conception rate during the susceptible period. Most biometric models assume that a woman contracepts with an effectiveness ε, which is method-specific and constant throughout the period of contraceptive use. During this period, the conception rate is proportionately reduced by the factor ε. This is shown by the dotted line in Diagram 2. Once contracep-tion ceases, the conception rate shifts back up and is the same as for women who do not breastfeed and do not contracept. Thus, breastfeeding shifts the curve to the right, whereas contraception shifts it down. It is beyond

DIAGRAM 2 Hazard Function for Conception: Three Cases



—— "natural fertility: women who do not breastfeed and do not contracept.
--- case 1: women who breastfeed and do not contracept.
... case 2: women who contracept and do not breastfeed.

the scope of the present research to study interactions of breastfeeding and contraception; moreover, only a small fraction of women simultaneously breastfeed and contracept in the countries we are studying (Pebley et al., 1981).

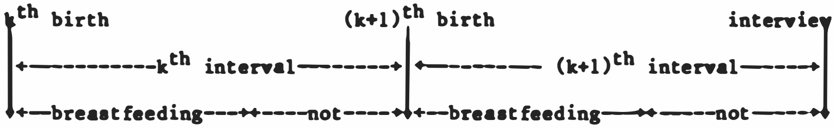
Infant and child mortality pose a difficult problem in this study of fertility. Short birth intervals and high child mortality are often mutually reinforcing. First, mortality rates of children born only a short time after an older sibling are known to be higher than rates for children born after long intervals (Wolfers and Scrimshaw, 1975). Second, a child death may truncate breastfeeding or alter contraceptive practice. This last effect should be captured through the inclusion of breastfeeding and contraception in the fertility equation. Nevertheless, there may be an additional behavioral effect if couples try to replace children who die, for example, by increasing coital frequency. To determine whether there is a residual impact of child mortality on fertility apart from changes in breastfeeding and contraception; therefore, child mortality is included in the model.

For the most part, social and demographic characteristics of the woman or her husband that may affect fertility are expected to work primarily through their influence on breastfeeding and contraception. Two possible exceptions to this are age and parity. Empirical results suggest that intrauterine mortality and the probability of stillbirth rise with parity (Leridon, 1977; Bongaarts, 1983). Since these pregnancy outcomes are much less likely to be reported than live births

(Chidambaram et al., 1980), this increasing risk may lead to longer live-birth intervals and conception rates that appear to be lower at higher parities. Parity has been included among the covariates to help alleviate this problem. The particular specification for parity and the other covariates will be described following the discussion of estimation procedures. In addition, results will be presented separately for five-year cohorts for two reasons: fecundity declines with age, and reproductive behavior may differ substantially for different cohorts. Duration of marriage is omitted from this model because, although coital frequency may decline with duration of marriage, recent research using WFS data shows little or no effect of marriage duration on fertility (Casterline and Hobcraft, 1981). Although social and economic characteristics of the woman or her husband can be expected to influence fertility primarily through their influence on breastfeeding and contraception, these variables are included in the model to determine whether there is any residual impact on fertility. Therefore, the model includes information on the education of both spouses and whether they reside in urban areas. Although it would be of some interest to examine the joint decisions about female labor force participation, fertility, breastfeeding, and contraception, to do so adequately is beyond the scope of the present research; the model therefore includes only some rudimentary information on the woman's work experience since marriage.

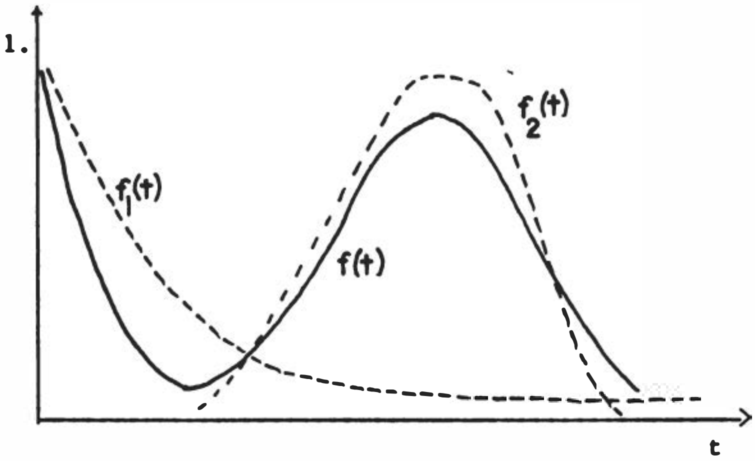
THE BREASTFEEDING EQUATION: MODELING THE DURATION OF BREASTFEEDING

Information on the duration of breastfeeding for the last closed and the open birth interval is available from the WFS core questionnaire. We are therefore limited to modeling the probability of breastfeeding in either the last closed or the open interval and the duration of breastfeeding, that is, discontinuation rates, for women who breastfeed. More careful modeling of the probability of initiating breastfeeding following any birth is not possible with the simple estimation strategy used here. A schematic representation of breastfeeding for the last closed and the open birth interval for a woman who breastfeeds in both intervals and who has stopped breastfeeding by the time of interview is given on page 17.



Women may discontinue breastfeeding for two reasons: some women may discontinue immediately because of medical or physical problems; others will continue breastfeeding until some later, perhaps socially prescribed, weaning date. Those in the first group will have very short durations of breastfeeding, shown by the function f_1 in Diagram 3 below; those in the second group will have longer durations, grouped around a second modal value shown by the function f_2. As a consequence, the density of waiting times for all women may be a mixture of these two densities.

DIAGRAM 3 A Two-Fold Mixed Weibull Density Function

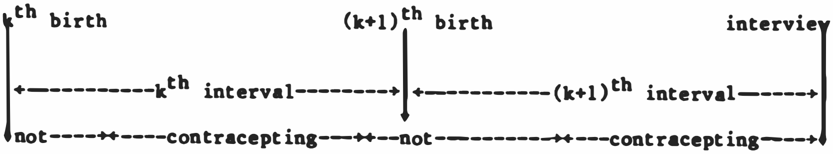


The role of child mortality in relation to breastfeeding is a particularly difficult problem. For some children, death truncates breastfeeding; for others, short breastfeeding may precipitate death; for still others, poor health may result in early termination of breastfeeding, which can in turn result in worse health and possibly death. This poses a severe endogeneity problem. Ideally, breastfeeding and child mortality should be modeled simultaneously as a multi-state process, indicating whether breastfeeding terminated before the child died. Unfortunately, the WFS has grouped the data on date of death into quite large intervals so that it is not possible to tell how long before the child's death breastfeeding was terminated. Even if estimation of such a model were possible, one could not determine without additional information whether breastfeeding was terminated because a child was unhealthy or whether early termination of breastfeeding resulted in a child death. Therefore, from these data, it will be possible to determine only descriptively whether children who survive are breastfed longer than those who do not.

Social and demographic characteristics of the woman and her husband can also be expected to influence duration of breastfeeding. If breastfeeding is being used for family limitation purposes, then its duration should be longer at higher parities, although empirical evidence for this is weak (Jain and Bongaarts, 1980; Butz and DaVanzo, 1978). The greater availability of commercial supplements, as well as better opportunities for women to participate in the labor force in urban areas, may reduce duration of breastfeeding among urban residents. In addition, it is known that women's education and breastfeeding are inversely related (Jain and Bongaarts, 1980). Ideally, a model of breastfeeding would include information on other opportunity costs of a woman's time; unfortunately, such information is not available from the WFS. However, some rudimentary information on the woman's work experience since marriage is included in the model to test its value as a proxy for the opportunity costs of women's time.

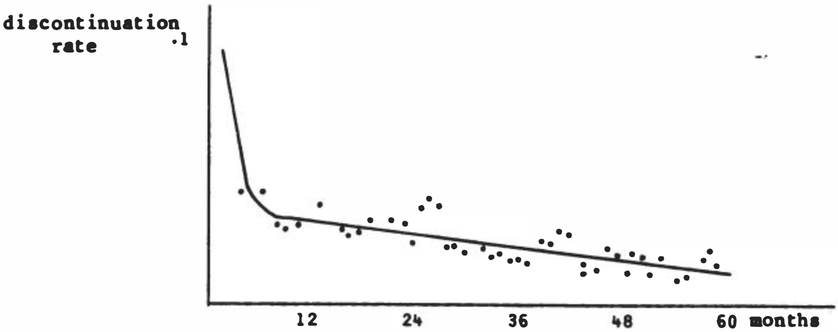
THE CONTRACEPTION EQUATION: MODELING DISCONTINUATION RATES

The family planning module of the WFS questionnaire used in Colombia and Costa Rica includes information on duration of contraceptive use for the last closed and the open interval. These are the only two countries for which such information is available. As in the case of breastfeeding, both the probability of using contraception in either interval and contraceptive discontinuation are modeled. The diagram below gives a schematic representation of contraceptive use in the last closed and the open interval for a woman who contracepts in both intervals and is still contracepting at the time of interview.



Studies of contraceptive discontinuation abound in the literature. One example using a similar methodology is Potter and Phillips (1980). Diagram 4 below gives the estimated hazard rate of discontinuing any method among pill acceptors.

DIAGRAM 4 Observed and Predicted Monthly Probabilities of Discontinuing Any Method Among Pill Acceptors



The hazard function for contraceptive discontinuation should be shaped differently for different methods: users of coitus-dependent methods may be expected to use for shorter periods than users of more modern coitus-independent methods. Women who want an additional child are likely to contracept for shorter durations. In addition, a child death may lead some women to discontinue contraception earlier than they would have otherwise. However, the model of contraceptive discontinuation will not include reasons for discontinuation since these may change with the length of use. It has also been argued that breastfeeding and contraception are competing ways of postponing the next birth. If this is the case, we would expect women who breastfeed not to contracept or to contracept for shorter durations. The concentration of family planning services in urban areas, as well as better availability of supplies and medical care, may make urban women more likely to use and to continue to use contraception. Research has also shown that more-educated women continue contraception longer than do the less-educated (Potter and Phillips, 1980). Participation in the labor force may increase the incentive to contracept for longer periods. Although detailed information on labor force participation is not available, the less-than-ideal data available are included in the model to test their utility as a proxy for opportunities in the labor force.

THE PROBABILITY OF BREASTFEEDING AND THE PROBABILITY OF USING CONTRACEPTION

The prevalence of both breastfeeding and contraception differs quite markedly between Colombia and Costa Rica. For example, 19 percent of Colombian women and 7 percent of Costa Rican women were breastfeeding at the time of the survey; while 52 percent of Colombian women and 78 percent of Costa Rican women were using contraception. Therefore, there is some interest in investigating the determinants of the propensity to breastfeed and the propensity to contracept in either of the last two birth intervals for these two countries. Only the background variables describing social and economic characteristics, taken to be fixed over the last closed and the open interval, are expected to influence these probabilities. It is hypothesized that more-educated women and those with more-educated husbands will be more likely to contracept and less likely to breastfeed; women living in urban areas will be more likely to have access to and therefore use contraception, but may also be less likely to breastfeed; women with experience in the labor force since marriage and those who have worked outside the home may have more "modern" ideas and be more likely to contracept and less likely to breastfeed than women who have not had these experiences.

METHODS

This section of the report has five parts. First, the duration data for fertility, breastfeeding, and contraception are described and evaluated using Kaplan-Meier estimates of the survival functions (Kalbfleisch and Prentice, 1980). Second, the models of conception rates, termination of breastfeeding, and contraceptive discontinuation are analyzed using estimated hazard functions with time-varying covariates. In the next two parts, the sample and variables used are defined. Finally, the equations for the probability of breastfeeding and the probability of using contraception are estimated using logistic regressions.

A DESCRIPTIVE STATISTIC FOR DURATION DATA: THE KAPLAN-MEIER ESTIMATOR OF THE SURVIVOR FUNCTION

The survivor function was defined in the previous section: $\tilde{F}(t)$ is the probability that the event of interest occurs sometime after the time, t, since the preceding event. The events are births (in the case of fertility), termination of breastfeeding, and contraceptive discontinuation. An interval is said to be censored if the respondent was interviewed before it was closed by the next event. Since the information used is from the last closed and the open birth interval, there are at most two intervals for each woman, one of which may be censored. All intervals (even those for the same woman) are treated as if they were independent. The Kaplan-Meier estimator is the nonparametric maximum likelihood estimator of $\tilde{F}$. It is defined as follows, using the example of birth intervals (from Kalbfleisch and Prentice, 1980:11-16). Suppose birth intervals of length

$t_1 < t_2 < \ldots < t_k$ are observed in a sample size N from a homogeneous population with survivor function F(t). Suppose further that there are d_j birth intervals of length t_j $(j=1,\ldots,k)$ and m_j birth intervals are censored by the interview in the interval $[t_j, t_{j+1})$. The number of items at risk just prior to t_j is $n_j = (m_j + d_j) + \ldots + (m_k + d_k)$–the number of birth intervals that have not yet been closed by a birth or censored by the interview. The Kaplan-Meier estimator is now given by

$$\hat{\tilde{F}}(t) = \prod_{j \mid t_j < t} \left(\frac{n_j - d_j}{n_j} \right)$$

It is a step function with jumps at the observed birth interval lengths. It neglects calendar time in that it only uses information on the length of the interval, as if all intervals had a common origin time, t=0. This is also true for duration of breastfeeding and duration of contraceptive use. These estimated survivor functions are used to evaluate the quality of the duration data. Preference in reporting certain interval lengths, particularly troublesome for breastfeeding and for contraception, will be revealed in large jumps in the estimated survivor functions.

A CONTINUOUS-TIME ESTIMATOR OF THE HAZARD FUNCTION WITH TIME-VARYING COVARIATES

The hazard function was defined above, where it was shown to be related to the survivor function by a simple transformation and therefore mathematically equivalent to it. For analysis of a woman's reproductive history, the hazard function is preferred because it allows us to examine the probability of an event, such as a birth conditional on other events or behaviors in the birth interval, such as breastfeeding or contraception. Only a simple specification of the hazard will be considered here. While more elaborate models have been described in the literature (see, for example, Singer and Heckman, 1982), fitting such models can be exceedingly complicated.

The basis for the estimation procedure is to approximate the hazard by a step function, defining subperiods of time from the start of the interval and assuming that the hazard is constant within those subperiods, but shifted proportionately by the covariates. As will be seen in the next section, the estimated survivor functions, which contain the same information as the hazard functions, are quite smooth and change relatively slowly. This implies that the hazard functions will also tend to be smooth, so that the step function approximation probably does not result in the loss of a great deal of information. In its structure, the hazard model resembles an analysis of covariance with interactions. It is given by

$$h_p = \exp(\alpha X + \lambda_p Z_p), \; p = 1, \ldots, P,$$

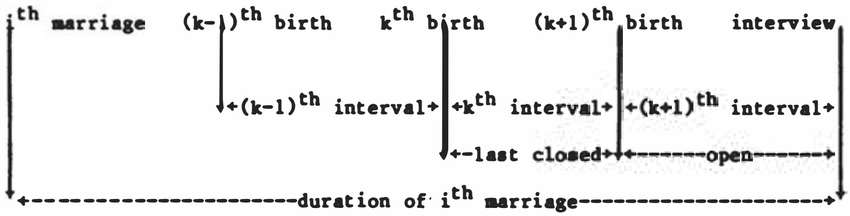
where p indexes subperiods from the start of the interval;

- X is a vector of covariates which are fixed with respect to the interval;
- Z_p is a vector of possibly time-varying covariates;
- α, λ_p are vectors of parameters to be estimated; and
- h_p is the level of the hazard in subperiod p.

The X variables are generally a set of background variables that describe the social and economic characteristics of the woman and her husband. These variables are unchanged over the course of the interval and have the same (proportionate) effect on the hazard at all durations. The Z variables represent the more dynamic aspect of the model and incorporate events or behaviors occurring during the interval of interest that can be expected to modify the fundamental shape of the hazard. Either these variables themselves change over the course of the interval--for example, breastfeeding when births are the dependent variable--or their impact on the dependent variable changes--that is, they are interacted with subperiod. This model is estimated by maximum likelihood using the program RATE (Tuma and Pasta, 1980). In addition to assuming a constant hazard within subperiods which is shifted proportionately by the covariates, the estimation procedure also assumes that all heterogeneity is measured by the covariates X and Z_p, and that all intervals are mutually independent, even those for the same woman. In other words, individuals with the same value of all covariates in subperiod p have exactly the same hazard rate. It should be noted that this is only one of a number of possible specifications; a similar model could have been estimated using a standard package for the analysis of contingency tables (see Laird and Oliver, 1981, or Allison, 1982).

SAMPLE DEFINITION

The analysis here is restricted to women who have been stably married since before the birth of their third-to-last child for the following reasons. Detailed information is restricted to the last closed and the open birth intervals. This means that two intervals are sampled from a woman's reproductive history; the date of interview determines which two are selected. The estimation procedures used here require pooling these two intervals and neglecting their order and calendar time; that is, they only use information on the length of the interval, as if all intervals had a common origin time. Intervals for the same woman are not linked in any way, but are treated as independent observations. This means that the process must be stationary over the intervals sampled. Stably married women are selected to permit treating information on social and economic characteristics of the woman and her husband, collected at the time of the survey, as fixed with respect to both intervals used. Women of parities three and higher were chosen to eliminate intervals between marriage and first birth and to permit the option of using information on infant mortality from the next-to-last closed interval. The sample selection is diagrammed below.



DEFINITION OF VARIABLES USED IN THE HAZARD MODELS

Three dependent variables are considered at each stage of the analysis: duration of the interval from a live birth to the conception of the next live birth, duration of breastfeeding, and duration of contraceptive use. The first variable is so defined because it is assumed that the length of gestation (when the risk of conception is zero) is fixed at 9 months; it is measured by subtracting

9 months from all closed intervals and defining currently pregnant women as having an open interval of length zero (no exposure). This means that the period of gestation has been eliminated from the analysis, thereby defining the hazard as zero duration gestation. Spells of breastfeeding and of contraceptive use in the closed birth interval are always closed; spells from the open birth interval are open only if the woman is still breastfeeding or still contracepting at the time of interview; otherwise they are closed.

The analysis of the hazard models has three stages. The first is descriptive. A model with no covariates is estimated: $h_p = \lambda_p$, $p = 1,\ldots,8$. This model contains much of the same information as the estimates of the survivor function. The eight subperiods are 0-2, 3-5, 6-11, 12-17, 18-23, 24-35, 36-47, and 48+ months. Shorter subperiods are used at the start of the interval because this is where the hazard typically changes most rapidly. These estimates serve as a baseline for comparing the impact of the covariates. For models with covariates, the number of subperiods is reduced to six, where the first five subperiods are the same as before and the sixth subperiod is 24+ months. This is in part to reduce the number of parameters, and in part because there are few observations at the longer durations. When models with eight subperiods were tested, the likelihood ratio statistics for the added parameters were generally not statistically significant.

Table 1 describes the variables used in each of the three analyses. The set of background variables is the same in all three equations. It includes indicators of female labor force participation, urban residence, and years of schooling for the woman and her husband. As already noted, these variables can be expected to influence primarily duration of breastfeeding and duration of contraceptive use, rather than the time to next conception. They are included in the fertility equation so that their direct impact on the time to next live-birth conception apart from their indirect effect through breastfeeding and contraception can be ascertained. Extensive investigation of the functional specification of these variables was not performed here or elsewhere in the analysis, in part because these variables did not perform as well as expected, perhaps due to measurement error. The woman's parity at the start of the birth interval is included in all three equations; it is included in the fertility equation to capture parity-related changes in pregnancy wastage and fecundity not measured elsewhere. The fertility equation also includes indicators of contraceptive method (coitus-dependent or coitus-independent); these are treated as shift factors that are fixed for the interval. Duration of use is a time-varying component that modifies the shape of the hazard. The other time-varying covariates are breastfeeding and child survival (survival of the child whose birth began the interval). All three are treated as indicator variables that are specific to subperiods.

The variables indicating duration of contraceptive use require some special comment. The WFS for Colombia and Costa Rica provides information on length of use in the closed and the open interval and on current status, but do not give start and stop dates. In order to use this information, one must make some assumptions. It is assumed that women who do not breastfeed begin contracepting immediately postpartum; it is also assumed that women who breastfeed begin contracepting as soon as they stop breastfeeding unless the sum of the duration of breastfeeding and the duration of contraception is greater than the length of the interval from last birth to next conception (or to interview for the open interval); in which case a period of overlap is allowed. However, apparently very few women simultaneously breastfeed and contracept (Pebley et al., 1981). When alternate assignment strategies allowing a delay of 1-3 months between the last birth and the beginning of contraception and between termination of breastfeeding and initiation of contraception were tried, results were not significantly altered. As will be seen when the findings are described, the principal impact of contraception on fertility is through the two variables which indicate use of particular contraceptive methods at any time in the interval. These drastically shift the hazard downward. By comparison, the time-varying covariates produce relatively small rearrangements of the hazard. Poor quality of the data on when contraception was actually used within the interval may account for these findings.

The breastfeeding equation includes the same set of background characteristics and parity. In addition, a dummy variable indicating whether the child in question survived past its second birthday is interacted with subperiod (that is, its estimated coefficient is allowed to vary with duration of breastfeeding and thus modify the shape of the hazard and not just its level) to show

TABLE 1 Variable Definition for the Hazard Models

FERTILITY EQUATION

Dependent Variable: length of interval from birth to next conception.

Fixed covariates (X)

Background Characteristics:

work since marriage: dummy=1 if the woman has worked since marriage.
work away from home: dummy=1 if the woman has worked outside the home.
woman's education: years of schooling.
husband's education: years of schooling.
urban residence: dummy=1 if the woman currently lives in an urban area.

Other Demographic Characteristics

contraceptive method: set of two dummy variables.
coitus-independent contraception: dummy=1 if the woman used the pill, IUD or injections in the birth interval in question.
coitus-dependent contraception: dummy=1 if the woman used a diaphragm, foam, condom or other coitus-dependent method in the inverval in question.

parity: a counter indicating parity at the start of the interval.

Time-Varying Covariates (Z_p)

breastfeeding: a set of six dummies=1 if the woman breastfed her child in subperiod p and previous subperiods.
contraception: a set of six dummies=1 if the woman used contraception in subperiod p.
child survival: a set of six dummies=1 if the child born at the start of the interval survives through subperiod p.

BREASTFEEDING EQUATION

Dependent Variable: duration of breastfeeding.

Fixed Covariates (X)

Background Characteristics: same as in fertility equation.

Other Demographic Characteristics:

parity: same as in fertility equation.

Fixed Covariates that are Interacted with Sub-Period (Z)

child survival: dummy=1 if the child born at the start of the birth interval where breastfeeding occurs survives longer than two years.

TABLE 1 (continued)

CONTRACEPTION EQUATION

Dependent Variable: duration of contraceptive use.

Fixed Covariates (X)

Background Characteristics: Same as in fertility equation.

Other Demographic Characteristics:

parity: same as in fertility equation.
breastfeeding: dummy=1 if the woman breastfed in the birth interval where contraception occurs.
child survival: dummy=1 if the child born at the start of the birth interval where contraception occurs survives longer than two years.

Fixed Covariates that are Interacted with Sub-Period (Z)

desire for an additional child: dummy=1 if the woman stated that she wanted an additional child after the child born at the start of the birth interval where contraception occurs.
contraceptive method: dummy=1 if the woman if the woman used a coitus dependent method (see fertility equation for a more detailed description).

SUBSAMPLES

The equations above have been reestimated for subsamples defined by period to test for non-linearities and to attempt to uncover biases. These results are included in the appendix.

Periods: birth intervals begun since 1960, since 1965, since 1970. Data for all three equations are progressively restricted to intervals from the more recent period.

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in a descriptive way the shorter durations of breastfeeding among women whose children die. Along with the set of background characteristics and parity, the contraception equation also includes indicators for breastfeeding and child survival that are treated as fixed with respect to the interval of use. Variables indicating desire for an additional child and contraceptive method are interacted with subperiod. This specification was chosen because it is not possible to determine the relative timing of events in this portion of the data set. Nevertheless, fertility desires and contraceptive method are expected to influence not only the level of the hazard, but also its shape. Breastfeeding and child survival were retained in the equation since their effect on duration of use is of some interest, but their impact was not sufficient to warrant the estimation of additional parameters required by an interaction model.

The models were estimated for several subgroups of the entire sample selected for this analysis. In light of the concerns expressed earlier that intervals farther away from the survey date are less representative, the period was restricted to the more and more recent past: since 1960, since 1965, since 1970. All three equations were estimated separately for each of these subperiods.

LOGISTIC REGRESSION ANALYSIS OF THE PROBABILITY OF BREASTFEEDING AND THE PROBABILITY OF USING CONTRACEPTION

The decision to breastfeed or to contracept may be determined by factors other than those related to the duration of lactation and contraceptive use. As a first step in understanding what determines the propensity to breastfeed or to contracept, two dichotomous variables were defined which indicate whether the woman ever breast-fed and whether she ever used contraception in either the last closed or the open interval. The predictor variables for both of these dependent variables are the same set of background covariates defined for the fertility equation in Table 1. The estimation procedure used is logistic regression analysis.

DESCRIPTIVE RESULTS

In this section, the distributions of the variables to be used in the final set of analyses in the next section are given and the quality of the data evaluated, with particular attention paid to the dependent variables.

THE PROPENSITY TO BREASTFEED AND THE PROPENSITY TO CONTRACEPT

Recall that the dependent variable for the analysis of the propensity to breastfeed and the propensity to contracept is in each case an indicator variable; the first is defined to be one if the woman breastfeeds in either the open or the closed birth interval and to be zero otherwise, while the other is defined to be one if the woman contracepted in either the open or the closed birth interval and to be zero otherwise. This variable definition was chosen to avoid any biases that might arise from using information from the open interval only thereby eliminating currently pregnant women. The results below show that behavior in the closed interval is a good predictor of behavior in the open interval.

Table 2 gives cross-tabulations of breastfeeding and contraceptive use for the last closed and the open birth intervals for Colombia and Costa Rica. The top panel shows that in each of the last closed and the open birth intervals, 91 percent of Colombian women breastfed. In Costa Rica, 77 percent reported breastfeeding in the last closed birth interval and 81 percent in the open interval. Women who breastfed in one interval are likely to do so in the next: in Colombia, 95 percent of women who reported breastfeeding in the closed interval also reported breastfeeding in the open interval; in Costa

TABLE 2 Cross-Tabulation of Breastfeeding and of Contraceptive Use for the Last Closed and the Open Interval

BREASTFEEDING

		Colombia: Open Interval yes	Colombia: Open Interval no			Costa Rica: Open Interval yes	Costa Rica: Open Interval no	
Closed Interval	yes	1220	64	91%	yes	898	52	77%
	no	56	67	9%	no	114	174	23%
		91%	9%	1407		81%	19%	1243

CONTRACEPTION

		Colombia: Open Interval yes	Colombia: Open Interval no			Costa Rica: Open Interval yes	Costa Rica: Open Interval no	
Closed Interval	yes	391	65	31%	yes	518	51	43%
	no	461	556	69%	no	535	232	57%
		58%	42%	1473		79%	21%	1336

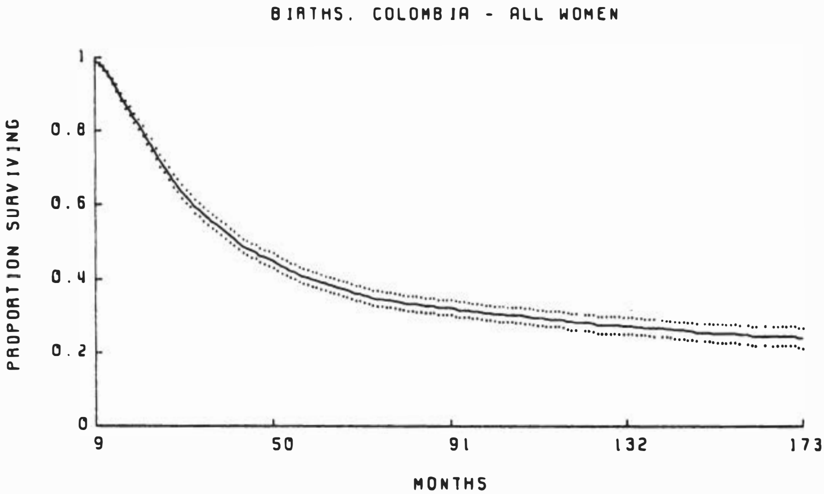
Rica, the figure was 94 percent. The lower panel shows that, although the prevalence of contraception is considerably greater in Costa Rica, contraceptive use is nearly twice as likely in the open as in the closed birth interval in both countries. Even so, behavior in the closed interval is quite a good predictor of behavior in the open interval: in Colombia, 86 percent of women who used in the closed also used in the open; in Costa Rica, 91 percent did so.

SURVIVOR FUNCTIONS FOR BIRTH INTERVALS, DURATION OF BREASTFEEDING, AND DURATION OF CONTRACEPTIVE USE

The survivor function was formally defined earlier: for birth intervals, at any time t after the last birth, it is the proportion of women who have not yet had a next conception. Figure 3 gives the survivor function for birth intervals for Colombia in the upper panel, and for Costa Rica in the lower panel. The dotted lines show 95 percent confidence bands. Notice that the survivor functions are quite smooth, which suggests that there are no strong preferences for reporting particular birth dates in either country. If the two graphs were superimposed, the survivor function for Costa Rica would lie above that for Colombia, and the 95 percent confidence bands for the two countries would not overlap after intervals about two years long, suggesting somewhat longer birth intervals in Costa Rica than in Colombia. Figure 4 gives the survivor functions for breastfeeding for the two countries. Both show relatively sharp drops at 12, 18, and 24 months, probably reflecting a combination of digit preference and actual behavior resulting from social norms dictating how long a child ought to be breastfed. The survivor function for Colombia lies above that for Costa Rica, except for very long durations. The estimates at these long durations are somewhat suspect since they rely on a very small number of cases, particularly in Costa Rica. Figure 5 gives the survivor functions for contraceptive use for the two countries. These, like the survivor functions for births, are quite smooth, although some jumps at multiples of 12 months are evident. The survivor function for Costa Rica is far above that for Colombia, revealing considerably longer periods of use in the former country.

MEANS AND VARIANCES OF THE INDEPENDENT VARIABLES USED IN THE ANALYSIS

Table 3 gives descriptive statistics for some of the independent variables used in the analysis. Colombian and Costa Rican women are about equally likely to have worked since they were married or to have worked outside the home. In both countries the women have slightly less education than their husbands, but educational achievement is considerably higher in Costa Rica than in Colombia. However, the Colombian women are more likely than the Costa Rican women to be living in an urban area. As already noted, the level of fertility is about the same in both countries, possibly slightly higher in Colombia than in Costa Rica. Infant mortality is also somewhat higher in Colombia than in Costa Rica. The incidence of contraceptive use, particularly for coitus-dependent



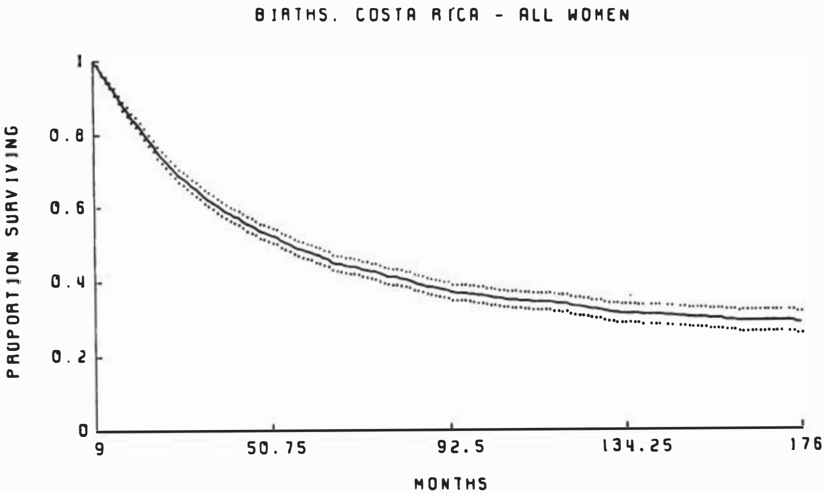
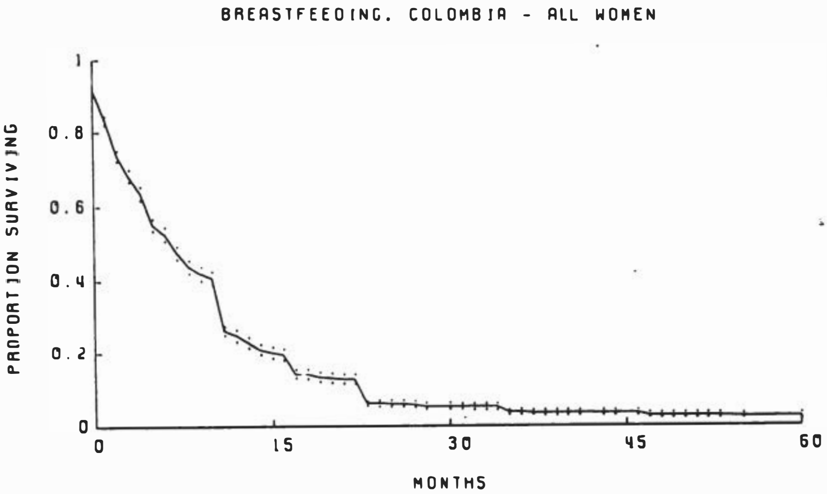


FIGURE 3 Survivor Functions for Time to Next Live-Birth Conception



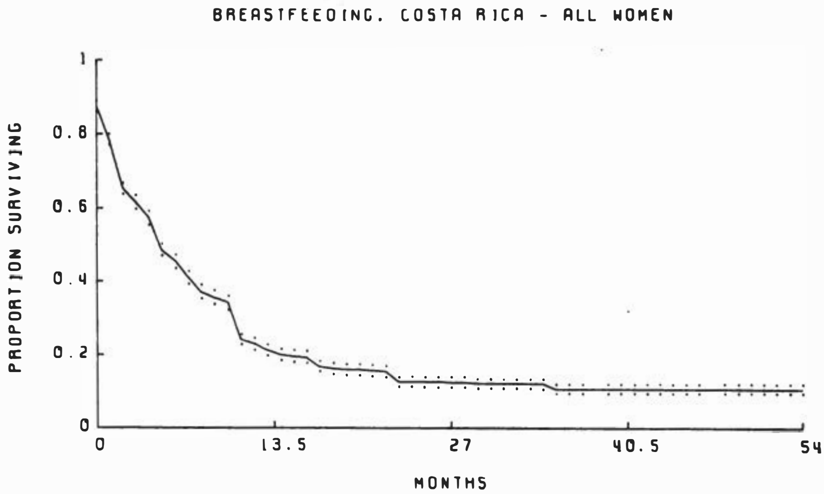
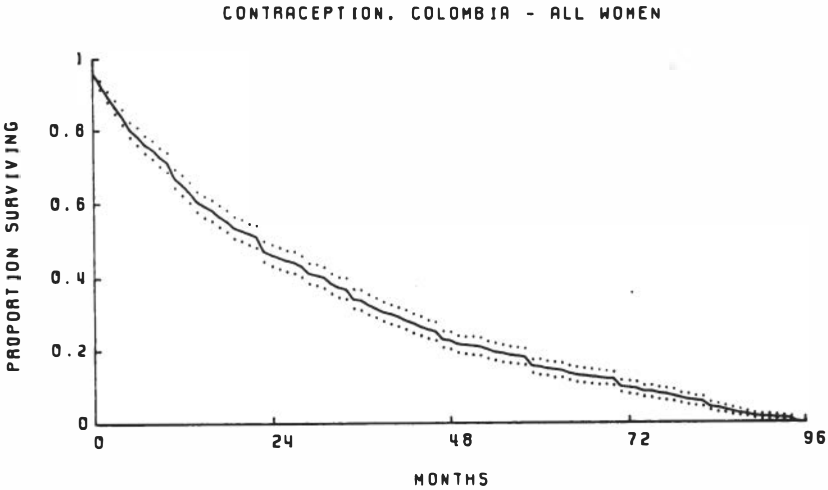


FIGURE 4 Survivor Functions for Duration of Breastfeeding



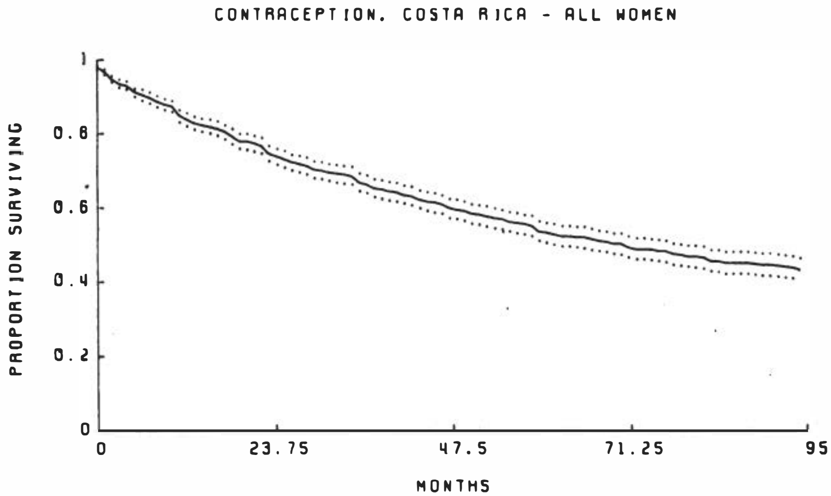


FIGURE 5 Survivor Functions for Duration of Contraceptive Use

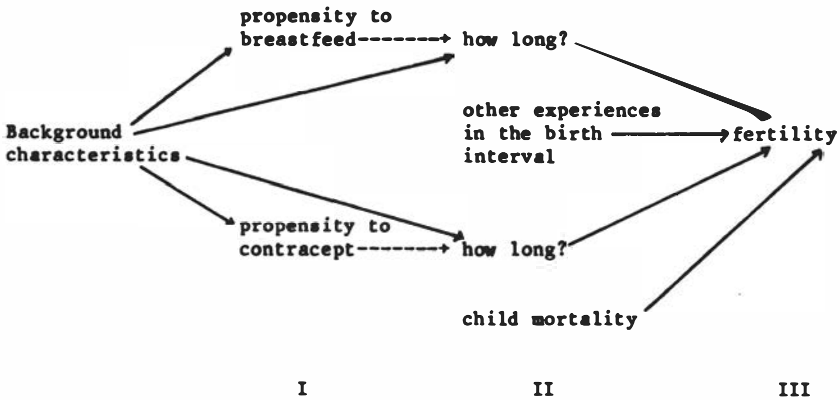
TABLE 3 Means and Variances of Some Independent Variables Used in the Analysis

	Colombia		Costa Rica	
	mean	standard deviation	mean	standard deviation
work since marriage	.34	.48	.36	.48
work away from home	.18	.39	.24	.43
woman's education	3.2	2.7	4.6	3.6
husband's education	3.5	3.1	4.8	4.1
urban residence	.58	.49	.43	.49
parity	5.7	3.0	5.6	3.1
births surviving to age one	.94	.24	.95	.22
coitus independent contraception in a birth interval	.21	.41	.24	.43
coitus dependent contraception in a birth interval	.20	.40	.32	.47
births surviving to age one among children who are breastfed	.97	.18	.98	.15

methods, is higher in Costa Rica. Finally, the last figure in the table provides information on infant mortality among children who are breastfed. A comparison with the same figure for all births shows lower infant mortality among this group; however, this difference cannot be attributed to breastfeeding since breastfeeding might never be started if a child is in poor health or dying.

FINAL RESULTS

This section first examines models for the propensity to breastfeed and for the propensity to contracept. Second, among women who breastfeed and among women who contracept, information about other experiences in the birth interval is incorporated, and models of termination rates for breastfeeding and for contraception, respectively, are examined. Finally, factors affecting conception rates are examined using information about the timing of breastfeeding, contraception, and child mortality. The scheme for the analysis is given by the diagram below.



The details of the variables included in each equation were given in Table 1.

LOGISTIC REGRESSION MODELS FOR THE PROPENSITY TO BREASTFEED AND FOR THE PROPENSITY TO CONTRACEPT

These two equations use background characteristics to predict the probability of breastfeeding and the probability of using contraception in either the last closed or the open birth interval. Colombia and Costa Rica have quite different distributions of the two dependent variables. Nearly all women breastfeed in Colombia; in Costa Rica, although breastfeeding is very common, it is not universal. In contrast, many more women contracept in Costa Rica than in Colombia. Table 4 gives the results of the analysis. Since breastfeeding is nearly universal in Colombia (only 6 percent of women did not breastfeed in either of the two birth intervals sampled), the best prediction is that all women will breastfeed. Under these circumstances, the model is not very informative. Even though there is more variability in the dependent variable in Costa Rica, the model does not perform much better. Thus, the measured characteristics indicating social and economic status do not distinguish well between a woman who will breastfeed and one who will not.

The analysis of the propensity to use contraception is somewhat more successful. Although contraceptive usage is much higher in Costa Rica, the impact of the social and economic variables is much larger in Colombia. In Colombia, the probability of use increases with the education of both the woman and her husband, and is higher for urban than for rural residents. In Costa Rica, only the woman's education and urban residence have an impact, and the effects are much smaller. This confirms that contraceptive use is both more extensive and less restricted to particular social and economic groups in Costa Rica than in Colombia. It is interesting that, although breastfeeding is less widespread in Costa Rica than in Colombia, it is not any more restricted to particular social and economic groups in one country than in the other. The analysis by period in the appendix shows that these results are not significantly altered as births from progressively earlier time periods are eliminated, suggesting that these results are not solely attributable to changing practices.

TABLE 4 Logistic Regression for Probability of Breastfeeding and for Probability of Using Contraception in Last Closed or Open Birth Interval

	Colombia		Costa Rica	
	Breastfeeding	Contraception	Breastfeeding	Contraception
constant	3.626 (.2344)	-.9816 (.1051)	1.637 (.1248)	.8288 (.1221)
work since marriage[a]	.0227 (.3011)	.1362 (.1552)	.4303 (.2543)	-.0605 (.2050)
work away from home[a]	-.2051 (.3420)	-.2262 (.1964)	-.4640 (.2848)	.1716 (.2519)
woman's education	-.0545 (.0481)	.2032* (.0308)	.0241 (.0275)	.0900 (.0300)
husband's education	-.0627 (.0402)	.1222* (.0279)	-.0439 (.0236)	.0118 (.0262)
urban residence[a]	-.5516* (.2676)	.7413* (.1214)	-.0375 (.1626)	.4441* (.1674)
Model χ^2	27.35	303.5	8.70	47.24
d.f.	5	5	5	5
predictive accuracy	.684	.164	.335	.318
% not using	6.0	39.7	17.5	19.2
N	1643	1643	1449	1449

Notes: [a] Indicator variable; 1=yes.
Standard errors are in parentheses.
* indicates significance at the .05 level.

HAZARD MODELS FOR TERMINATION OF BREASTFEEDING AND CONTRACEPTIVE DISCONTINUATION

Figure 6 shows the estimated hazard functions for termination of breastfeeding (top panel) and contraceptive discontinuation (bottom panel). These hazards have been estimated without covariates and contain the same information as the survivor functions discussed earlier. The horizontal lines show the result of assuming constant exponential discontinuation rates; the jagged lines show the estimated hazards when they are allowed to vary over the eight subperiods defined earlier; the solid lines represent estimates for Colombia and the dashed lines those for Costa Rica. First examine the estimated hazard functions for termination of breast-

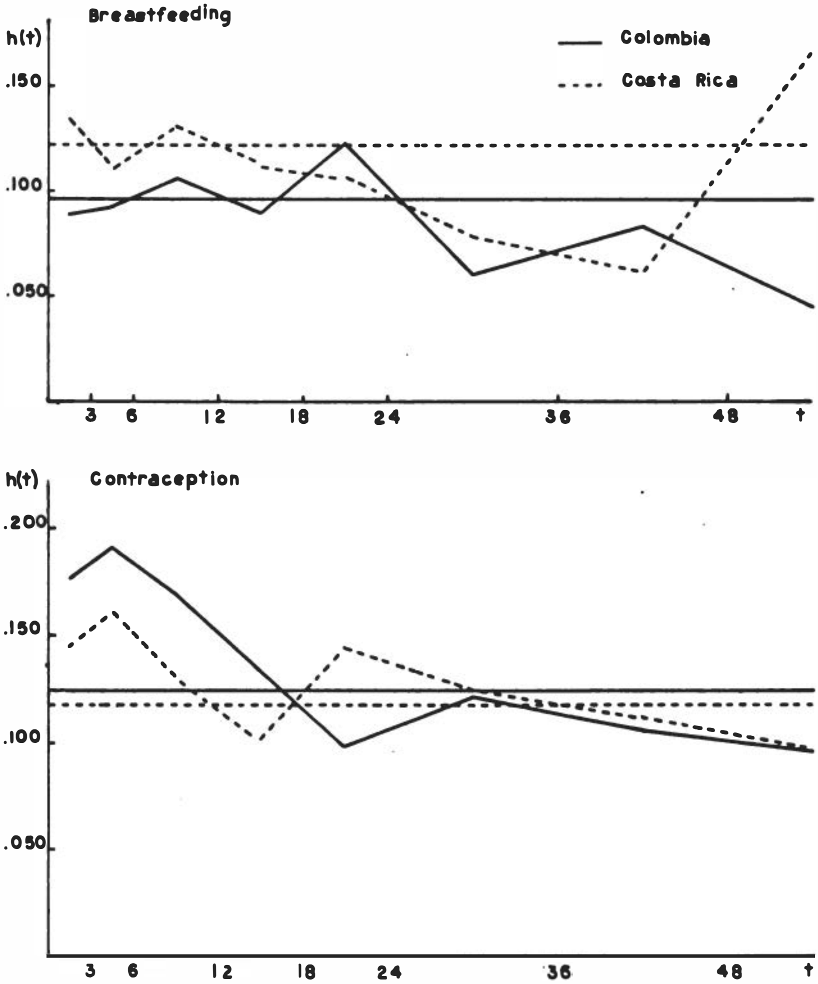


FIGURE 6 Hazard Functions for Termination of Breastfeeding and for Contraceptive Discontinuation

feeding in the top panel. The horizontal lines show that termination rates are higher in Costa Rica than in Colombia. Colombia shows a pattern of moderate discontinuation rates for durations of breastfeeding under 18 months, followed by a marked peak in discontinuation rates between 18 and 23 months, suggesting that the socially prescribed weaning time may fall within this interval. The pattern for Costa Rica shows much higher discontinuation rates at short durations, with one group of women discontinuing before 3 months have elapsed and a second group discontinuing after 6 to 11 months. Turning to the estimated hazard functions for contraceptive discontinuation in the lower panel, the horizonal lines show that on average, discontinuation rates are only somewhat higher in Colombia than in Costa Rica. However, the time pattern of discontinuation is quite different. Colombia shows much higher discontinuation rates at shorter durations, and the two curves tend to converge after durations of use longer than two years. The curves for Costa Rica show two peaks of discontinuation, one at short durations, the other at durations of 18 to 23 months. As discussed below, these differences are primarily accounted for by differences in the pattern of discontinuation of coitus-dependent methods in the two countries, while the pattern of discontinuation of coitus-independent methods is more similar.

Tables 5 and 6 give the estimated coefficients, their standard errors, and the antilogs for the equation with covariates predicting termination of breastfeeding. These results are displayed graphically in Figure 7. The strategy used in this and the other analyses of duration is first to examine the impact of the background variables alone (Model 1), then to add the covariates describing other demographic characteristics (Model 2), and finally to add the covariates that describe other events or behaviors that occur in the interval (Model 3). The log-likelihood for each model is given at the bottom of the tables so that likelihood-ratio statistics can be computed to determine the statistical significance of the added covariates. First consider the effects of the background covariates alone. In Colombia, as in Costa Rica, the woman's education, her husband's education, and urban residence are all statistically significant, and the estimated coefficients are nearly of the same magnitude. In both countries, these three variables are all associated with shorter durations of breastfeeding. Model 2 adds parity, which is also statistically significant and of nearly the same order of magnitude. In both countries, higher parity is associated with longer durations of breastfeeding. Some of this may be a cohort effect since average parity at the start of the last closed interval increases by approximately one for each five-year cohort of women between ages 20 and 45. Because the number of observations is small, the model

TABLE 5 Coefficient Estimates for Termination of Breastfeeding: Colombia

	Model 1		Model 2		Model 3	
	coeff.	antilog	coeff.	antilog	coeff.	antilog
work since marriage[a]	-.0557 (.0629)	.9458	-.0562 (.0629)	.9454	-.0616 (.0628)	.9403
work away from home[a]	.0021 (.0765)	1.002	.0012 (.0764)	1.001	.0084 (.0765)	1.008
woman's education	.0766* (.0110)	1.080	.0722* (.0112)	1.075	.0720* (.0111)	1.075
husband's education	.0111 (.0095)	1.011	.0074 (.0096)	1.007	.0093 (.0096)	1.009
urban residence[a]	.2343* (.0516)	1.264	.2339* (.0517)	1.264	.2327* (.0516)	1.262
parity			-.0234* (.0082)	.9769	-.0245 (.0082)	.9758*
child survival[a]					-.4022* (.0922)	.6688
Period 1 (0-2 months)						
constant	-2.854* (.0585)	.0576	-2.693* (.0808)	.0676	-2.316* (.1176)	.0987
Period 2 (3-5 months)						
constant	-2.787* (.0617)	.0616	-2.624* (.0835)	.0725	-2.245* (.1199)	.1060
Period 3 (6-11 months)						
constant	-2.579* (.0524)	.0758	-2.414* (.0776)	.0895	-2.032* (.1162)	.1316
Period 4 (12-17 months)						
constant	-2.661* (.0739)	.0699	-2.491* (.0945)	.0828	-2.102* (.1294)	.1222
Period 5 (18-23 months)						
constant	-2.429* (.0910)	.0881	-2.261* (.1080)	.1042	-1.866* (.1406)	.1547
Period 6 (24+ months)						
constant	-3.130* (.1452)	.0437	-2.964* (.1562)	.0516	-2.561* (.1815)	.0772
loglikelihood	-6594.		-6590.		-6582.	
N = 2264						

Notes:
a Indicator variable: 1=yes.
Standard errors are in parentheses.
* indicates significance at the .05 level.

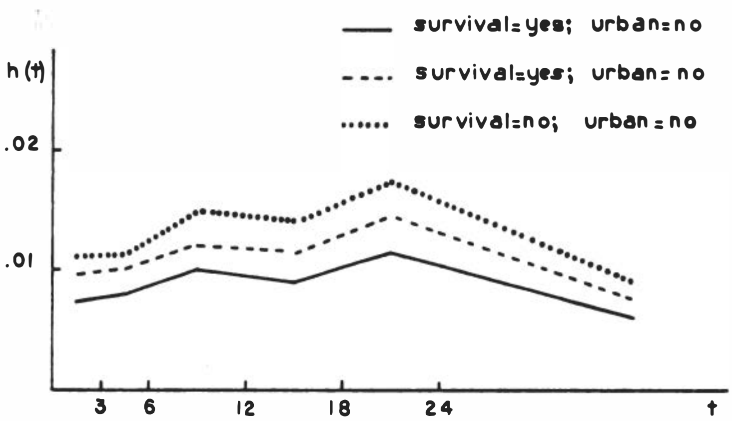
TABLE 6 Coefficient Estimates for Termination of Breastfeeding: Costa Rica

	Model 1		Model 2		Model 3	
	coeff.	antilog	coeff.	antilog	coeff.	antilog
work since marriage[a]	-.0826 (.0742)	.9208	-.0627 (.0744)	.9392	-.0640 (.0744)	.9379
work away from home[a]	.0942 (.0881)	1.099	.08102 (.0881)	1.084	.0847 (.0881)	1.088
woman's education	.0439* (.0095)	1.045	.0371* (.0098)	1.038	.0368* (.0098)	1.038
husband's education	.0131 (.0088)	1.013	.0099 (.0088)	1.010	.0118 (.0088)	1.012
urban residence[a]	.1426* (.0556)	1.153	.1342* (.0557)	1.144	.1412* (.0558)	1.152
parity			-.0289* (.0089)	.9715	-.0301* (.0089)	.9703
child survival[a]					-.5909* (.1296)	.5538
Period 1 (0-2 months)						
constant	-2.371* (.0561)	.0934	-2.160* (.0846)	.1153	-1.597* (.1484)	.2025
Period 2 (3-5 months)						
constant	-2.511* (.0640)	.0812	-2.297* (.0908)	.1005	-1.727* (.1535)	.1778
Period 3 (6-11 months)						
constant	-2.285* (.0552)	.1018	-2.071* (.0848)	.1260	-1.496* (.1513)	.2241
Period 4 (12-17 months)						
constant	-2.418* (.0876)	.0891	-2.205* (.1086)	.1102	-1.627* (.1664)	.1966
Period 5 (18-23 months)						
constant	-2.465* (.1226)	.0850	-2.238* (.1403)	.1066	-1.657* (.1893)	.1908
Period 6 (24+ months)						
constant	-2.791* (.1719)	.0613	-2.562* (.1853)	.0772	-1.973* (.2258)	.1391
loglikelihood	-5524.		-5519.		-5510.	
N = 1908						

Notes:

a Indicator variable: 1=yes.
Standard errors are in parentheses.
* indicates significance at the .05 level.

Colombia



Costa Rica

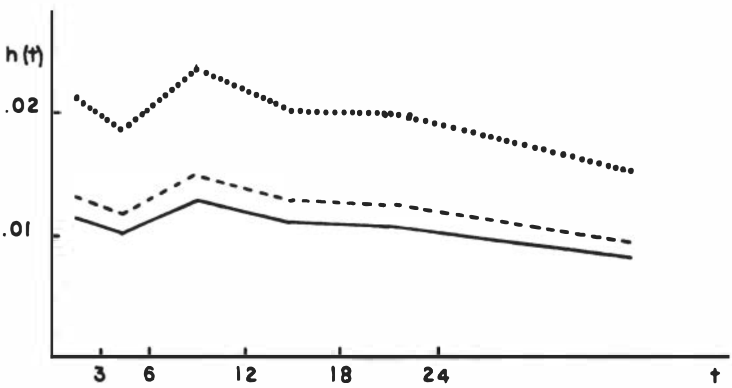


FIGURE 7 Hazard Functions with Covariates for Termination of Breastfeeding

could not be reestimated for each cohort of women, and the statistical package used does not permit age to be treated properly as a time-varying covariate. The issue therefore remains unresolved.

Model 3 adds a dummy variable indicating whether the child survived past age two. The coefficients of this variable are of the same sign and are statistically significant in both countries, but the estimate for Costa Rica is nearly 50 percent greater than that for Colombia. The corresponding hazards are shown in Figure 7. The top panel in the figure graphs the results for Colombia, and the bottom those for Costa Rica. The scale has been adjusted for the mean parity and mean education of the woman and her husband. The solid line gives the hazard for women whose child survives past age two--that is, well past the usual weaning time--and who do not live in an urban area. When we compare the two countries, there is a tendency among women who have not yet stopped breast-feeding to stop between 18 and 23 months in Colombia and between 6 and 11 months in Costa Rica. The dashed line shows the estimated hazard for women who live in urban areas and whose children survive. The dotted line shows the hazard for women whose children do not survive. Clearly, breastfeeding durations are much shorter for these children in Costa Rica, where durations of breast-feeding are already relatively short. It was not possible to obtain more detailed information on the interactions of child mortality and breastfeeding from these data, for reasons already cited; however, in both countries, child mortality is lower among children who are breastfed than among all children, even in Costa Rica, where mortality in general is quite low.

Tables 7 and 8 give the estimated coefficients for the equation predicting contraceptive discontinuation. These results are displayed graphically in Figure 8. Model 1 includes the effects of the background covariates alone. Husband's education is statistically significant in both countries, while urban residence is significant only in Colombia. This is no longer the case when other covari-ates are added (Models 2 and 3). In the larger models, husband's education is no longer significant; urban residence becomes significant in Colombia, reaches borderline significance in Costa Rica, and is associated with longer durations of use. This last effect is larger in Colombia than in Costa Rica, possibly due to the greater concentration of family planning efforts in urban areas in Colombia. Model 2 adds parity, desire for an additional child, and contraceptive method. All three variables are statistically significant in both countries. Higher parities are associated with longer duration of use in both countries, and the coefficients are about the same size. Women who desire an additional child and those who use a coitus-dependent method tend to use for shorter durations; these effects are somewhat larger in Costa Rica than in Colombia. When breastfeeding and child survival were added, neither variable was statistically significant in either country.

Model 4 contains terms for the interaction of desire for an additional child and method of contraception with subperiod to see how the shape of the hazard is modified by each of these covariates. These results are presented graphically in Figure 8. As before, the results for Colombia are given by the top panel and those for Costa Rica by the bottom panel. The scale for Costa Rica has been expanded to show the detail; the level of discontinuation is therefore considerably higher in Colombia. The shape of the discontinuation curves is quite different for the two countries. The solid line gives the estimated hazard function for women who use coitus-independent contraception and who do not desire additional children. In Colombia, high discontinuation rates for these women are concentrated in the first 3 to 5 months of use. In Costa Rica, the curve is not only lower, but much flatter, although somewhat higher discontinuation rates can be found in the first year of use. The line of dashes and dots shows the estimated hazard for women who use a coitus-dependent method and who do not want an additional child. In Colombia, discontinuation rates are relatively higher for durations of use under 18 months, then drop to join those for the coitus-independent methods. In Costa Rica, the discontinuation rates are relatively high at rather short durations of use, moderate at intermediate durations, and quite high for durations longer than 18 months. The two dashed lines give the estimated hazards for each of the two classes of methods for women who desire an additional child. In Colombia, the principal effect of this variable is to shift the curve upward by about the same amount at all durations. In Costa Rica, for each set of methods, it is only after durations of use of one year or more that the discontinuation curve for women who desire an additional child consistently diverges from that of women who do not. This suggests that in Costa Rica, for durations of use of one year, women who want an additional child are as likely

TABLE 7 Estimates for Contraceptive Discontinuation: Colombia

	Model 1		Model 2		Model 3		Model 4	
	coeff.	antilog	coeff.	antilog	coeff.	antilog	coeff.	antilog
work since marriage[a]	.0597 (.1140)	1.061	.0132 (.1145)	1.013	.0243 (.1147)	1.025	.0210 (.1147)	1.021
work away from home[a]	-.0234 (.1337)	.9769	-.0380 (.1344)	.9627	-.0508 (.1347)	.9505	-.0464 (.1347)	.9547
woman's education	-.0081 (.0204)	.9919	-.0340 (.0211)	.9665	-.0363 (.0212)	.9644	-.0367 (.0212)	.9640
husband's education	.0071 (.0166)	1.007	-.0039 (.0169)	.9961	-.0039 (.0170)	.9962	-.0023 (.0170)	.9977
urban residence[a]	-.3065* (.1029)	.7360	-.2953* (.1031)	.7443	-.2964* (.1031)	.7435	-.2865* (.1030)	.7509
parity			-.1026* (.0199)	.9025	-.1020* (.0199)	.9030	-.1031* (.0199)	.9021
desire additional children[a]			.4304* (.0199)	1.538	.4395* (.0123)	1.552		
coitus-dependent contraception[a]			.3975* (.0852)	1.488	.3929* (.0853)	1.481		

breastfeeding[a]					−.2323 (.1453)	.7927	−.2277 (.1454)	.7963
child survival past age two[a]					−.0180 (.1773)	.9822	−.0220 (.1774)	.9782
Period 1 (0-2 months)								
constant	−3.845* (.1496)	.0214	−3.537* (.2049)	.0291	−3.305* (.2841)	.0367	−3.273* (.3384)	.0379
desire additional children[a]							−.0995 (.2830)	.9053
coitus-dependent contraception							.6445* (.2761)	1.905
Period 2 (3-5 months)								
constant	−3.766* (.1512)	.0232	−3.452* (.2063)	.0317	−3.219 (.2855)	.0400	−3.054* (.3277)	.0472
desire additional children[a]							.2750 (.2678)	1.317
coitus-dependent contraception[a]							.1957 (.2587)	1.216

TABLE 7 (continued)

	Model 1		Model 2		Model 3		Model 4	
	coeff.	antilog	coeff.	antilog	coeff.	antilog	coeff.	antilog
Period 3 (6-11 months)								
constant	-3.888* (.1306)	.0205	-3.566* (.1928)	.0283	-3.334* (.2758)	.0356	-3.346* (.3081)	.0352
desire additional children[a]							.3411 (.2138)	1.407
coitus dependent contraception[a]							.4707* (.2098)	1.601
Period 4 (12-17 months)								
constant	-4.109* (.1503)	.0164	-3.769* (.2073)	.0231	-3.537* (.2859)	.0291	-3.799* (.3747)	.0224
desire additional children[a]							.3026 (.2618)	1.353
coitus-dependent contraception[a]							.9025* (.2677)	2.466
Period 5 (18-23 months)								
constant	-4.406* (.1770)	.0122	-4.058* (.2277)	.0173	-3.827* (.3009)	.0218	-3.817* (.3622)	.0220

desire additional children[a]							.6460* (.3148)	1.908
coitus-dependent contraception[a]							.1820 (.3128)	1.200
<u>Period 6 (24+ months)</u>								
constant	-4.325* (.1104)	.0132	-3.913* (.1819)	.0200	-3.677* (.2694)	.0253	-3.692* (.2756)	.0249
desire additional children[a]							.6532* (.1340)	1.922
coitus-dependent contraception[a]							.2572 (.1275)	1.293
log likelihood	-3027.		-2982.		-2981.		-2973.	
N = 1186								

<u>Notes:</u>

a Indicator variable: 1 = yes.
Standard errors in parentheses.
* indicates significance at the .05 level.

TABLE 8 Estimates for Contraceptive Discontinuation: Costa Rica

	Model 1		Model 2		Model 3		Model 4	
	coeff.	antilog	coeff.	antilog	coeff.	antilog	coeff.	antilog
work since marriage[a]	-.0168 (.1457)	.9833	.0821 (.1460)	1.086	.0728 (.1465)	1.076	.0701 (.1464)	1.073
work away from home[a]	.0790 (.1591)	1.082	.0669 (.1580)	1.069	.0841 (.1590)	1.088	.0805 (.1589)	1.084
woman's education	.0065 (.0148)	1.007	-.0382* (.0153)	.9625	-.0385 (.0153)	.9622	-.0390* (.0153)	.9618
husband's education	.0284* (.0128)	1.029	.0184 (.0130)	1.019	.0183 (.0131)	1.019	.0206 (.0130)	1.021
urban residence[a]	-.0899 (.0940)	.9140	-.1750 (.0940)	.8395	-.1731 (.0941)	.8411	-.1720 (.0938)	.8420
parity			-.1244* (.0215)	.8830	-.1252* (.0215)	.8823	-.1267* (.0216)	.8810
desire additional children[a]			.6169* (.0861)	1.853	.6233* (.0861)	1.865		
coitus-dependent contraception[a]			.7006 (.0898)	2.015	.7046* (.0900)	2.023		

breastfeeding[a]					.1503	1.162	.1615	1.175
					(.1084)		(.1086)	
child survival past age two[a]					-.1648	.8481	-.2032	.8161
					(.2111)		(.2116)	
Period 1 (0-2 months)								
constant	-4.391*	.0124	-3.604*	.0272	-4.274*	.0139	-3.989*	.0185
	(.1504)		(.2089)		(.2872)		(.3856)	
desire additional children[a]							-.0440	.9569
							(.2687)	
coitus-dependent contraception							.8623*	2.369
							(.3092)	
Period 2 (3-5 months)								
constant	-4.300	.0136	-3.504*	.0300	-4.174*	.0154	-3.959*	.0191
	(.1495)		(.2088)		(.2876)		(.3792)	
desire additional children[a]							.3407	1.406
							(.2695)	
coitus dependent contraception[a]							.6796*	1.973
							(.2902)	

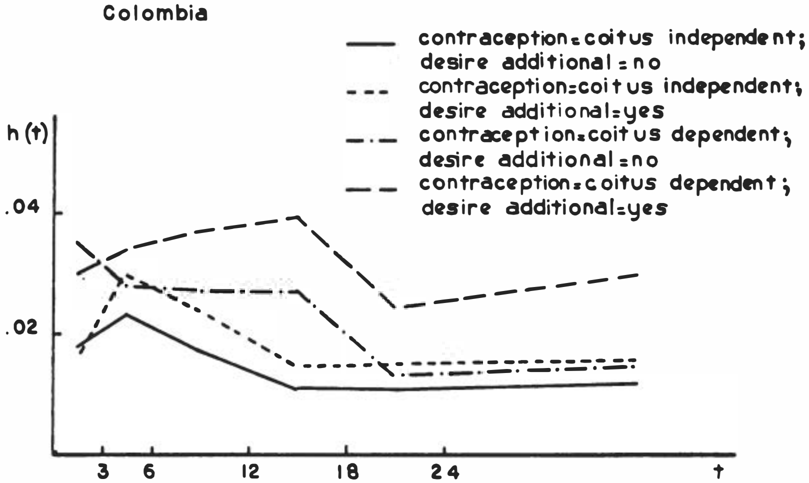
TABLE 8 (continued)

	Model 1		Model 2		Model 3		Model 4	
	coeff.	antilog	coeff.	antilog	coeff.	antilog	coeff.	antilog
Period 3 (6-11 months)								
constant	-4.505* (.1295)	.0110	-3.699* (.1954)	.0247	-4.369* (.2776)	.0127	-3.968* (.3305)	.0189
desire additional children[a]							.1748 (.2203)	1.191
coitus dependent contraception[a]							.5389* (.2322)	1.714
Period 4 (12-17 months)								
constant	-4.762* (.1499)	.0085	-3.951* (.2101)	.0192	-4.620* (.2882)	.0098	-4.359* (.3704)	.0128
desire additional children[a]							.4941 (.2732)	1.639
coitus dependent contraception[a]							.4734 (.2783)	1.605
Period 5 (18-23 months)								
constant	-4.393* (.1367)	.0124	-3.574* (.2013)	.0280	-4.242* (.2813)	.0144	-4.380* (.3712)	.0125

desire additional children[a]							.5256* (.2420)	1.691
coitus dependent contraception[a]							1.013* (.2726)	2.753
Period 6 (24+ months)								
constant	-4.717* (.0929)	.0089	-3.818* (.1729)	.0220	-4.483* (.2610)	.0113	-4.690* (.2759)	.0092
desire additional children[a]							.9903* (.1250)	2.692
coitus dependent contraception[a]							.7252* (.1288)	2.065
log likelihood	-3330.		-3238.		-3237.		-3225.	
N = 1302								

Notes:

a Indicator variable: 1 = yes.
Standard errors in parentheses.
* indicates significance at the .05 level.



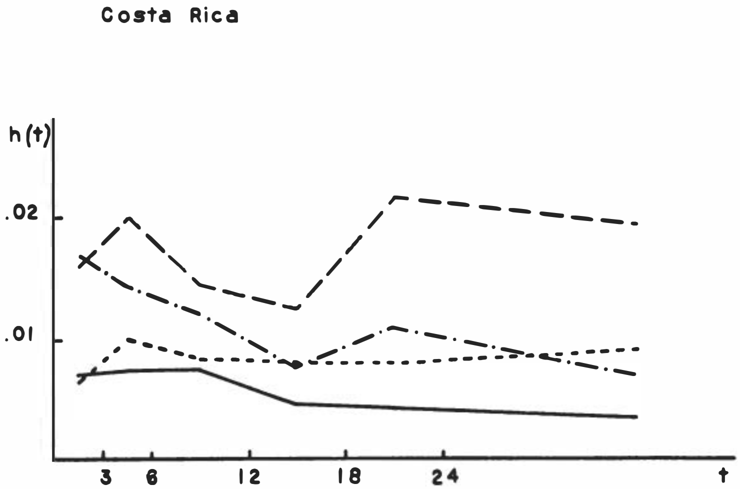


FIGURE 8 Hazard Functions with Covariates for Contraceptive Discontinuation

to discontinue as other women and may use contraception for spacing purposes. This is not the case in Colombia, where those who want an additional child are more likely than other women to discontinue at all durations. Thus the pattern of contraceptive use is quite different in the two countries.

HAZARD MODELS FOR CONCEPTION

Figure 9 displays the estimated hazard functions for conceptions for Colombia and Costa Rica. These hazards have been estimated without covariates and contain the same information as the survivor functions discussed earlier. The horizontal line shows the results of assuming a constant hazard over the entire birth interval; the curved lines show the estimated hazards when they are allowed to vary over the eight subperiods defined earlier; the solid lines represent estimates for Colombia, and the dashed lines those for Costa Rica. The horizontal lines suggest that the interval from birth to next conception is slightly shorter in Colombia than in Costa Rica. The curved lines reveal that, although the conception rate is slightly higher for very short interval lengths in Costa Rica, it is somewhat lower at longer interval lengths, and the two curves converge after 36 months. In general, however, the estimated curves for the two countries are quite similar.

Tables 9 and 10 give the estimated coefficients for the equation predicting conception rates. These results are displayed graphically in Figure 10. As before, the analysis proceeds with the progressive addition of variables. Recall that demographic variables such as parity and behavioral variables such as contraceptive method, duration of use, and duration of breastfeeding are expected to have the greatest impact on conception rates. The background variables, which describe social and economic status, are expected to have little impact apart from their influence on the intermediate variables. Model 1 shows the effect of the background variables alone. In both countries, only urban residence is statistically significant, and the two estimated coefficients, along with their standard errors, have nearly the same value in both countries. Our previous results would suggest that this effect is operating primarily through contraception or breastfeeding practices. However, subsequent models show that it persists even after these

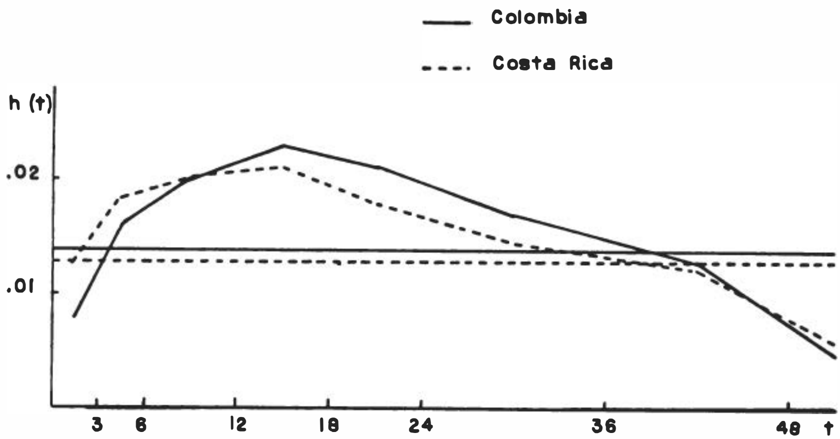


FIGURE 9 Hazard Functions for Live-Birth Conceptions

other variables are added. Model 2 adds contraceptive method and parity. Use of either coitus-dependent or coitus-independent contraception lengthens the time to next conception. The impact of coitus-independent contraception is nearly twice that of coitus-dependent contraception in both countries, but the impact of either set of methods is greater in Costa Rica than in Colombia. This result holds when other variables are added to the model, suggesting that contraceptive efficacy may be greater in Costa Rica (see Goldman et al., 1982). Higher parities are associated with longer intervals in both countries, and the estimated coefficients are close in value.

Model 3 removes the background covariates and adds the full set of time-varying intermediate variables. Model 4 returns the background variables to the model. Likelihood ratio tests show that, although the effect of the background variables is small, it is statistically significant. A comparison of Models 3 and 4 reveals that few coefficients change when the background variables are added. As already noted, among the background variables, only urban residence is statistically significant. Figure 10 displays the impact of the time-varying covariates from Model 4. The results for Colombia are in the upper panel and those for Costa Rica in the lower panel. The solid line gives the estimated hazard for women who do not breastfeed and do not contracept; this corresponds to the "natural fertility" line in Diagram 2 with gestation subtracted from all intervals. Although the shapes of the hazards for the two countries accord moderately well, that for Costa Rica suggests an unexpected rise in the interval 3 to 5 months. As expected from previous biometric research reviewed earlier, the impact of breastfeeding is more marked at durations of less than one year, after which the two curves converge, while the largest impact is for durations of under 3 months. The dotted line, which shows the case where the child does not survive, is most useful for comparison. For example, if a child were breastfed for 6 months and then died, the risk of conception for its mother would be the dashed line for the first 6 months and the dotted line thereafter. The estimated effects of this variable are rather larger than expected, particularly at very short durations. Some of this effect may be due to the tendency of short birth intervals and high infant mortality to be mutually reinforcing in a manner that is not completely captured by either breastfeeding or contraceptive behavior. The two lowest lines in each panel show the conception rates for women who contracept. The variable indicating contraceptive method shifts the hazard to a very low level in both countries; the time-varying covariates act principally to rearrange the shape of the hazard slightly so that the effect of contraception is not a simple proportional shift of the solid line. This is particularly noticeable in the last subperiod (24+ months), where the hazard for contracepting women levels off from its downward course.

The similarity of these results for the fertility equation in the two countries is striking, particularly in light of the behavioral differences shown by the models of breastfeeding and contraception discussed earlier: not only are the signs on many of the coefficients the same but many of the coefficients are close in magnitude. Although different propensities and durations of breastfeeding and contraception are used to obtain close to the same level of fertility, the impact of a particular behavior is nearly the same. This reinforces the idea expressed earlier that this portion of the model accesses fundamental biometric aspects of fertility, whereas the other portions of the model are more behavioral in nature.

TABLE 9 Coefficient Estimates for the Fertility Equation: Colombia

	Model 1		Model 2		Model 3		Model 4	
	coeff.	antilog	coeff.	antilog	coeff.	antilog	coeff.	antilog
work since marriage[a]	-.0095	.9906	-.0210	.9792			-.0394	.9614
	(.0701)		(.0702)				(.0703)	
work away from home[a]	-.0036	.9964	.0088	1.009			.0273	1.028
	(.0860)		(.0860)				(.0861)	
woman's education	-.0111	.9890	.0031	1.003			.0006	1.001
	(.0128)		(.0132)				(.0133)	
husband's education	-.0092	.9909	-.0089	.9911			-.0121	.9879
	(.0113)		(.0117)				(.0118)	
urban residence[a]	-.2375*	.7886	-.1503*	.8605			-.1519*	.8591
	(.0583)		(.0587)				(.0593)	
coitus-independent contraception[a]			-1.138*	.3204	-1.189*	.3045	-1.141*	.3196
			(.0790)		(.1328)		(.1337)	
coitus-dependent contraception[a]			-.5672*	.5671	-.6337*	.5306	-.5819*	.5589
			(.0694)		(.1271)		(.1285)	
parity			-.1041*	.9011	-.1008*	.9041	-.1068*	.8987
			(.0098)		(.0095)		(.0098)	
Period 1 (0-2 months)								
constant	-4.601*	.0100	-3.860*	.0211	-2.156*	.1158	-2.010*	.1340
	(.1236)		(.1365)		(.2976)		(.3005)	

breastfeeding[b]					-.9047*	.4047	-.9354*	.3924
					(.3248)		(.3255)	
contraception[c]					.1747	1.191	.1820	1.200
					(.3603)		(.3602)	
child survival[b]					-1.180*	.3074	-1.151*	.3163
					(.3659)		(.3668)	
<u>Period 2 (3-5 months)</u>								
constant	-3.807*	.0222	-3.056*	.0471	-2.474*	.0842	-2.337*	.0966
	(.0895)		(.1067)		(.2861)		(.2891)	
breastfeeding[b]					-.1379	.8712	-1.723	.8417
					(.2126)		(.2129)	
contraception[c]					.1670	1.182	.1679	1.183
					(.2387)		(.2387)	
child survival[b]					-.6545*	.5197	-.6168	.5396
					(.3252)		(.3256)	

TABLE 9 (continued)

	Model 1		Model 2		Model 3		Model 4	
	coeff.	antilog	coeff.	antilog	coeff.	antilog	coeff.	antilog
Period 3 (6-11 months)								
constant	-3.607* (.0666)	.0271	-2.830* (.0890)	.0590	-2.493* (.2062)	.0826	-2.352* (.2107)	.0952
breastfeeding[b]					-.2135 (.1238)	.8077	-.2539* (.1245)	.7758
contraception[c]					-.0041 (.1801)	.9959	-.0092 (.1801)	.9908
child survival[b]					-.3311 (.2138)	.7182	-.2951 (.2145)	.7445
Period 4 (12-17 months)								
constant	-3.483 (.0690)	.0307	-2.675 (.0914)	.0689	-2.706 (.2179)	.0668	-2.566* (.2219)	.0768
breastfeeding[b]					.0614 (.1229)	1.063	.0147 (.1239)	1.015
contraception[c]					-.0004 (.1802)	.9996	-.0073 (.1803)	.9928
child survival[b]					-.1149 (.2217)	.8915	-.0783 (.2222)	.9247
Period 5 (18-23 months)								
constant	-3.566 (.0775)	.0283	-2.722* (.0987)	.0657	-2.810* (.2736)	.0602	-2.676* (.2764)	.0688

breastfeeding[b]					.0285	1.029	-.0012	.9988
					(.1606)		(.1611)	
contraception[c]					-.7241*	.4847	-.7254*	.4842
					(.2203)		(.2204)	
child survival[b]					.1299	1.139	.1581	1.171
					(.2790)		(.2794)	
Period 6 (24+ months)								
constant	-4.437	.0118	-3.583*	.0278	-4.000*	.0183	-3.875*	.0208
	(.0592)		(.0855)		(.1623)		(.1666)	
breastfeeding[b]					-.2638	.7681	-.2707*	.7628
					(.1323)		(.1328)	
contraception[c]					.1562	1.169	.1654	1.180
					(.1476)		(.1478)	
child survival[b]					.2990	1.348	.3467*	1.414
					(.1607)		(.1614)	
loglikelihood	-8248.		-8061.		-8026.		-8019.	
N = 2925								

Notes:
a Indicator variable: 1=yes.
b Time-varying indicator variable: 1=yes in period p and all previous periods, p=1,...,6.
c Time-varying indicator variable: 1=yes in period p, p=1,...,6.
Standard errors are in parentheses.
* indicates significance at the .05 level.

TABLE 10 Coefficient Estimates for the Fertility Equation: Costa Rica

	Model 1		Model 2		Model 3		Model 4	
	coeff.	antilog	coeff.	antilog	coeff.	antilog	coeff.	antilog
work since marriage[a]	.0194 (.0849)	1.020	.0527 (.0851)	1.054			.0625 (.0853)	1.064
work away from home[a]	-.0855 (.0980)	.9181	-.0764 (.0976)	.9265			-.0786 (.0979)	.9244
woman's education	.0041 (.0108)	1.004	.0020 (.0112)	1.002			.0021 (.0112)	1.002
husband's education	-.0042 (.0095)	.9958	-.0122 (.0096)	.9879			-.0113 (.0096)	.9888
urban residence[a]	-.2213* (.0623)	.8015	-.2344* (.0632)	.7910			-.2455* (.0636)	.7823
coitus-independent contraception[a]			-1.348* (.0807)	.2596	-1.468* (.1302)	.2304	-1.456* (.1304)	.2331
coitus-dependent contraception[a]			-.7193* (.0628)	.4871	-.9014* (.1209)	.4060	-.8307 (.1217)	.4358
parity			-.0934* (.0103)	.9108	-.0810* (.0097)	.9222	-.0941* (.0103)	.9102
<u>Period 1 (0-2 months)</u>								
constant	-4.356* (.1149)	.0128	-3.386* (.1331)	.0338	-2.830* (.5071)	.0590	-2.687* (.5090)	.0681

breastfeeding[b]					-.9281*	.3953	-.9459*	.3883
					(.2294)		(.2295)	
contraception[c]					-.4360	.6466	-.4353	.6471
					(.3386)		(.3387)	
child survival[b]					.0329	1.033	.0884	1.092
					(.5238)		(.5239)	
<u>Period 2 (3-5 months)</u>								
constant	-3.894*	.0204	-2.899*	.0551	-2.318*	.0985	-2.174*	.1137
	(.0965)		(.1181)		(.3241)		(.3273)	
breastfeeding[b]					-.6132*	.5416	-.6481*	.5230
					(.1841)		(.1844)	
contraception[c]					-.2412	.7857	-.2435	.7839
					(.2418)		(.2418)	
child survival[b]					-.3448	.7084	-.2780	.7573
					(.3402)		(.3407)	

TABLE 10 (continued)

	Model 1		Model 2		Model 3		Model 4	
	coeff.	antilog	coeff.	antilog	coeff.	antilog	coeff.	antilog
Period 3 (6-11 months								
constant	-3.799* (.0742)	.0224	-2.769* (.1014)	.0627	-2.461* (.2524)	.0854	-2.305* (.2567)	.0998
breastfeeding[b]					-.1083 (.1314)	.8974	-.1613 (.1319)	.8511
contraception[c]					-.1041 (.1781)	.9011	-.1158 (.1782)	.8907
child survival[b]					.3955 (.2570)	.6733	-.3325 (.2574)	.7171
Period 4 (12-17 months)								
constant	-3.740* (.0772)	.0238	-2.668* (.1043)	.0694	-2.529* (.2765)	.0797	-2.372* (.2802)	.0933
breastfeeding[b]					.2470 (.1447)	1.280	.1844 (.1455)	1.202
contraception[c]					-.3492 (.1863)	.7052	-.3637 (.1864)	.6951
child survival[b]					-.2689 (.2788)	.7642	-.2091 (.2792)	.8113

Period 5 (18-23 months)								
constant	-3.908*	.0201	-2.804*	.0606	-2.829*	.0591	-2.685*	.0682
	(.0880)		(.1132)		(.3414)		(.3442)	
breastfeeding[b]					.1920	1.212	.1314	1.140
					(.2307)		(.2311)	
contraception[c]					-.0238	.9765	-.0385	.9622
					(.1954)		(.1955)	
child survival[b]					-.1467	.8636	-.0766	.9262
					(.3448)		(.3451)	
Period 6 (24+ months)								
constant	-4.571*	.0104	-3.458*	.0315	-3.931*	.0196	-3.779*	.0228
	(.0587)		(.0928)		(.2008)		(.2061)	
breastfeeding[b]					.0301	1.031	-.0413	.9596
					(.1710)		(.1717)	
contraception[c]					.4922*	1.636	.4825*	1.620
					(.1394)		(.1395)	
child survival[b]					.0668	1.069	.1452	1.156
					(.1917)		(.1921)	
log likelihood	-7607.		-7397.		-7371.		-7358.	
N = 2472								

Notes:
a Indicator variable: 1=yes.
b Time-varying indicator variable: 1=yes in period p and all previous periods, p=1,...,6.
c Time-varying indicator variable: 1=yes in period p, p=1,...,6.
Standard errors are in parentheses.
* indicates significance at the .05 level.

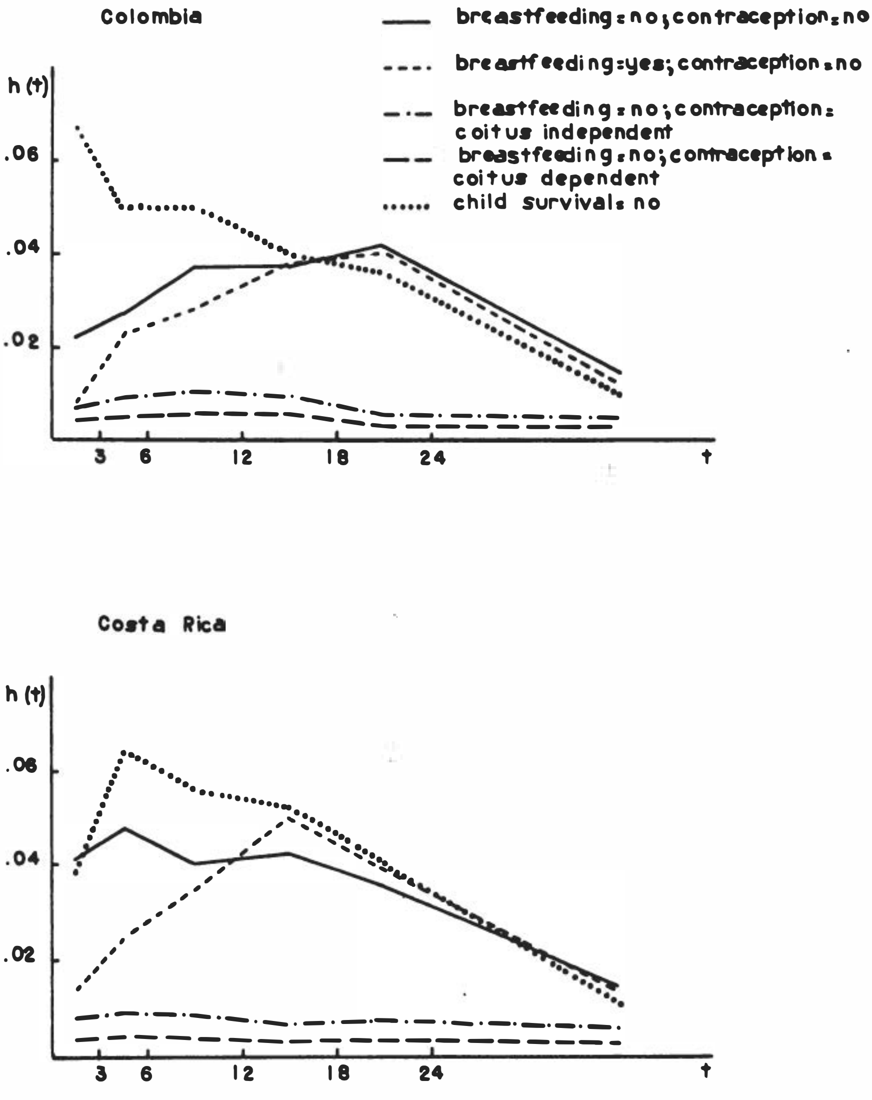


FIGURE 10 Hazard Functions with Covariates for Live-Birth Conceptions

SUMMARY OF RESULTS

Although the level of fertility is quite similar in Colombia and Costa Rica, contraceptive prevalence is greater and duration of use longer in Costa Rica, while breastfeeding is more common and durations longer in Colombia. Moreover, mortality is lower in Costa Rica than in Colombia. In addition, the social and economic climates of the two countries differ in some respects: Colombia is somewhat more urbanized, but educational attainment for both men and women is higher in Costa Rica, while female labor force participation appears to be about the same in both countries. The analysis described in this paper has three stages: first, social and economic characteristics of the woman and her husband are used to predict the propensity to breastfeed and the propensity to contracept; second, dynamic models of the duration of breastfeeding and the duration of contraceptive use, incorporating information about other experiences in the birth interval, are estimated; finally, conception rates are modeled using information about the timing of breastfeeding, contraception, and child mortality.

Although breastfeeding is nearly universal in Colombia, and common but not universal in Costa Rica, in neither country do the social and economic variables describing education, place of residence, or experience in the labor force serve as good predictors of whether or not a woman will breastfeed. Such background characteristics are more successful in predicing the propensity to use contraception. Although contraceptive prevalence is considerably higher in Costa Rica than in Colombia, the impact of social and economic variables is much greater in the latter country; this is consistent with the idea that the success of the Costa Rican family planning effort has not been confined to particular social or economic strata. Nevertheless, in both countries, better-educated and urban women are more likely to use contraception.

The models of duration of breastfeeding and duration of contraceptive use reveal important regularities as well as behavioral differences between Colombia and Costa Rica. As noted earlier, durations of breastfeeding are longer and durations of contraceptive use shorter in Colombia than in Costa Rica. Nevertheless, in both countries, higher education of the woman or of her husband and urban residence are associated with shorter durations of breastfeeding. Child survival is associated with longer durations of breastfeeding, but the impact of a child death is much greater in Costa Rica, where durations of breastfeeding are relatively short. As for contraceptive use, not only are durations longer in Costa Rica, but also the pattern of use is quite different, suggesting differences in the decision-making process. There are some similarities; in both countries, for example, better-educated and urban women contracept longer. These longer durations of use by urban women are particularly marked in Colombia, which may be due to a greater concentration of family planning efforts in urban areas. The differences become more apparent when method and desire for an additional child are considered. In both countries, women who use coitus-dependent methods and those who desire an additional child have higher discontinuation rates than other women. Among women using coitus-independent methods, in Colombia, discontinuation rates are higher and concentrated in the first 3 to 5 months of use; in Costa Rica, these rates are much lower, and peak discontinuation is spread over the first year of use. Similarly, in Colombia, women using coitus-dependent methods show relatively high rates of discontinuation in the first year and a half of use, whereas in Costa Rica, discontinuation rates for these methods are higher for short and for very long durations of use. In Costa Rica, discontinuation rates for women who desire an additional child do not diverge significantly from those of women who do not until after 18 months of use; in Colombia, discontinuation rates are shifted upward for women desiring an additional child for all durations of use greater than 3 months. This suggests that in Costa Rica, women who desire additional children may use contraception for spacing purposes, whereas in Colombia, spacing between births is obtained through near-universal breastfeeding, although perhaps not intentionally.

In spite of these striking differences in breastfeeding and contraceptive behavior, the impact of each of these two variables on conception rates is remarkably similar in the two countries, and generally agrees with expectations based on previous biometric research. Use of contraception drastically shifts the conception rate downward. The impact of breastfeeding on conception rates is most marked at short durations and diminishes as expected. In addition, background characteristics, with the exception of urban residence, have little impact on fertility except through contraceptive use. However, although child mortality should influence fertility by altering breastfeeding and contraceptive behavior, we find that it continues to have a considerable impact on conception rates, particularly at short interval lengths. This suggests that infant mortality and short birth intervals are mutually reinforcing in ways not captured by the variables included in the model. Thus, the model developed here is capable of revealing behavioral differences in breastfeeding and contraception, as well as describing biometric regularities in their impact on fertility. It shows the details of how two quite different countries have attained close to the same level of fertility through quite different behavioral mechanisms.

APPENDIX
RESULTS FOR PERIOD SUBGROUPS

The models described in the final results were reestimated for subgroups of the entire sample selected for the analysis. Because intervals farther away from the survey date are less and less representative, the period was restricted to the more and more recent past: intervals begun since 1960, since 1965, and since 1970. All equations were reestimated for these periods.

LOGISTIC REGRESSION MODELS FOR THE PROPENSITY TO BREASTFEED AND FOR THE PROPENSITY TO USE CONTRACEPTION: ESTIMATES BY PERIOD

Tables A1 and A2 give the results for the propensity to breastfeed and the propensity to contracept, respectively, with models estimated for birth intervals from progressively restricted calendar periods. These results should be compared to Table 4 in the main text. Information on breastfeeding and contraception is restricted to the last closed and the open birth intervals. These intervals are spread over the period from 1960 to 1976. Since it is likely that breastfeeding was declining and contraception increasing in both countries over this period, there is some concern that results using all intervals may not be representative. Indeed, the next-to-last row of Table A1 shows that, as the period of analysis is restricted to the progressively more recent past, a larger fraction of women are breastfeeding in neither the last closed nor the open interval in both Colombia and Costa Rica, but the changes are relatively small. The results for contraception are much less clear. This is in part due to the fact that only information from the last closed and open birth interval is used. Contraception is

TABLE A.1 Logistic Regression for Probability of Breastfeeding by Period

	COLOMBIA			COSTA RICA		
	since 1960	since 1965	since 1970	since 1960	since 1965	since 1970
constant	3.667* (.2457)	3.826* (.2672)	3.845* (.3053)	1.680* (.1313)	1.560* (.1392)	1.769* (.1913)
work since marriage[a]	-.0280 (.3116)	-.0964 (.3378)	-.3809 (.3802)	.4022 (.2684)	.4753 (.2848)	.1859 (.3720)
work away from home[a]	-.0174 (.3530)	-.3059 (.3762)	.1066 (.4529)	-.4039 (.3009)	-.3984 (.3257)	.0642 (.4464)
woman's education	-.0409 (.0499)	-.0324 (.0522)	-.0377 (.0627)	.0169 (.0288)	.0188 (.0308)	.0391 (.0429)
husband's education	-.0707 (.0413)	-.0979* (.0431)	-.1166* (.0527)	-.0424 (.0248)	-.0334 (.0268)	-.1153* (.0369)
urban residence[a]	-.6302* (.2772)	-.7153* (.2949)	-.8630* (.3329)	-.0765 (.1713)	-.1750 (.1845)	-.1746 (.2614)
Model χ^2	27.17	36.27	32.87	8.42	7.55	16.72
df	5	5	5	5	5	5
predictive accuracy	.683	.683	.671	.337	.315	.303
% not breastfeeding	6.0	6.2	6.7	17.4	18.5	19.8
N	1538	1334	877	1319	1099	565

Notes: a Indicator variable: 1=yes.
Standard errors are in parentheses.
* indicates statistical significance at the .05 level.

concentrated in the open interval, and the use of contraception markedly lengthens these intervals. Thus the longer intervals that started in the earlier period tend to be associated with contraceptive use; conversely, short intervals will have begun more recently and will not be associated with contraceptive use. Therefore, there is no clear trend in the propensity to use contraception in the intervals examined.

In spite of the slight decline in breastfeeding and the absence of trends in contraception, the coefficient estimates in Tables A1 and A2 show remarkably little change as the period of analysis is restricted. In the case of breastfeeding, two changes are apparent, and these apply only to the most restricted case (since 1970): in Colombia, the coefficient on urban residence becomes significant; in both Colombia and Costa Rica, the coefficient on husband's education becomes significant.

TABLE A.2 Logistic Regression for Probability of Using Contraception by Period

	COLOMBIA			COSTA RICA		
	since 1960	since 1965	since 1970	since 1960	since 1965	since 1970
constant	-.9791* (.1097)	-.8794* (.1155)	-.9237* (.1348)	.8288* (.1311)	.8832* (.1460)	.8340* (.2018)
work since marriage[a]	.1372 (.1632)	.0409 (.1722)	.0589 (.2014)	.0556 (.2234)	.0235 (.2366)	-.1062 (.3208)
work away from home[a]	-.2555 (.2067)	-.2253 (.2219)	-.1585 (.2698)	.0534 (.2741)	.5566 (.3213)	.6924 (.4652)
woman's education	.2195* (.0329)	.2037* (.0348)	.1505* (.0411)	.0885* (.0324)	.0813* (.0362)	.0885* (.0503)
husband's education	.1223* (.0295)	.1142* (.0312)	.1228* (.0371)	.0182 (.0283)	.0131 (.0312)	-.0040 (.0440)
urban residence	.8114* (.1262)	.8583* (.1329)	.7507* (.1576)	.5700* (.1845)	.4931* (.2101)	.8402* (.3260)
Model χ^2 df	299.67 5	236.19 5	120.05 5	49.45 5	43.81 5	30.72 5
predictive accuracy	.180	.165	.103	.341	.352	.339
% not contracepting	38.4	38.8	46.0	18.3	17.8	18.9
N	1538	1334	877	1319	1099	565

Notes: a Indicator variable: 1=yes.
Standard errors are in parentheses.
* Indicates statistical significance at the .05 level.

Thus in the more recent period, there are larger social and economic differentials in breastfeeding behavior than are indicated by the full sample results. In the case of contraception, the coefficient on women's education drops from being statistically significant at the .05 level to being of borderline significance, but the change in the size of the standard error is small and may be attributable to the reduced sample size.

HAZARD MODELS FOR TERMIANTION OF BREASTFEEDING AND CONTRACEPTIVE DISCONTINUATION: ESTIMATION BY PERIOD

Tables A3 through A6 gave the estimated coefficients for the hazard models for duration of breastfeeding and duration of contraceptive use. These results should be compared to the final column in Tables 5 and 6 in the main text. Again, the results are remarkably robust to the elimination of intervals from the increasingly distant

TABLE A.3 Coefficient Estimates for Termination of Breastfeeding by Period: Colombia

	since 1960		since 1965		since 1970	
	coeff.	antilog	coeff.	antilog	coeff.	antilog
work since marriage[a]	-.0594 (.0652)	.9423	-.0595 (.0714)	.9423	.0519 (.0951)	1.053
work away from home[a]	-.0030 (.0792)	.9970	.0159 (.0885)	1.016	-.1571 (.1266)	.8546
women's education	.0679* (.0116)	1.070	.0603* (.0127)	1.062	.0490* (.0164)	1.050
husband's education	.0132 (.0099)	1.013	.0184 (.0108)	1.019	.0462* (.0144)	1.047
urban residence[a]	.2572* (.0527)	1.293	.2926* (.0560)	1.340	.3099* (.0727)	1.363
parity	-.0265* (.0084)	.9738	-.0293* (.0090)	.9711	-.0488* (.0127)	.9524
child survival past age two[a]	-.4407* (.0946)	.6436	-.4577* (.1041)	.6327	-.4457* (.1314)	.6404
Period 1 (0-2 months)						
constant	-2.278* (.1207)	.1025	-2.234* (.1317)	.1071	-2.267* (.1670)	.1036
Period 2 (3-5 months)						
constant	-2.194* (.1223)	.1114	-2.187* (.1349)	.1122	-2.214* (.1708)	.1092
Period 3 (6-11 months)						
constant	-1.993* (.1198)	.1363	-1.981* (.1308)	.1379	-2.001* (.1653)	.1352
Period 4 (12-17 months)						
constant	-2.053* (.1332)	.1284	-2.025* (.1458)	.1320	-1.890* (.1831)	.1511
Period 5 (18-23 months)						
constant	-1.831* (.1449)	.1603	-1.830* (.1595)	.1604	-1.643* (.2034)	.1934
Period 6 (24+ months)						
constant	-2.513* (.1853)	.0810	-2.514* (.2034)	.0809	-1.967* (.3162)	.1398
loglikelihood	-6225.		-5259.		-3000.	
N	2154		1854		1145	

Notes: a Indicator variable: 1=yes.
Standard errors are in parentheses.
* indicates statistical significance at the .05 level.

TABLE A.4 Coefficient Estimates for Termination of Breastfeeding by Period: Costa Rica

	since 1960		since 1965		since 1970	
	coeff.	antilog	coeff.	antilog	coeff.	antilog
work since marriage[a]	-.0630 (.0769)	.9389	-.0328 (.0841)	.9677	-.0217 (.1279)	.9785
work away from home[a]	.0833 (.0916)	1.087	.0846 (.1033)	1.088	.1540 (.1625)	1.166
woman's education	.0395* (.1019)	1.040	.0360* (.0112)	1.037	.0222 (.0176)	1.023
husband's education	.0125 (.0093)	1.013	.0160 (.0103)	1.016	.0273 (.0160)	1.028
urban residence[a]	.1390* (.0583)	1.149	.1091 (.0657)	1.115	.0546 (.1081)	1.056
parity	-.0286* (.0091)	.9718	-.0275* (.0100)	.9729	-.0580* (.0150)	.9437
child survival past age two[a]	-.5683* (.1328)	.5665	-.5468* (.1455)	.5788	-.7595* (.2201)	.4679
Period 1 (0-2 months)						
constant	-1.636* (.1528)	.1947	-1.632* (.1682)	.1955	-1.263* (.2514)	.2828
Period 2 (3-5 months)						
constant	-1.764* (.1580)	.1713	-1.813* (.1747)	.1632	-1.394* (.2615)	.2482
Period 3 (6-11 months)						
constant	-1.528* (.1555)	.2169	-1.566* (.1708)	.2089	-1.206* (.2579)	.2994
Period 4 (12-17 months)						
constant	-1.672* (.1717)	.1878	-1.727* (.1889)	.1778	-1.076* (.2769)	.3410
Period 5 (18-23 months)						
constant	-1.686* (.1944)	.1853	-1.679* (.2117)	.1866	-1.028* (.3210)	.3579
Period 6 (24+ months)						
constant	-2.024* (.2342)	.1322	-2.080* (.2712)	.1250	-1.361* (.5724)	.2564
log likelihood	-5116.		-4082.		-1871.	
N	1777		1434		697	

Notes: a Indicator for variable: 1=yes.
Standard errors are in parentheses.
* indicates statistical significance at the .05 level.

past: although the shape of the hazard is necessarily modified as the longer intervals are eliminated, the signs, magnitude, and statistical significance of the coefficients remain remarkably stable. Tables A3 and A4 give the results for duration of breastfeeding. Among those variables which are statistically significant for the full sample, only urban residence passes into insignificance, and that only in Costa Rica in the most recent period. Tables A5 and A6 give the results for duration of contraceptive use. In Colombia, the coefficient on urban residence is not significant in the most recent period, whereas it is significant when the full sample is analyzed. In Costa Rica, it is no longer significant once the longest intervals (those which began before 1960) have been eliminated. The coefficients on the variable indicating desire for additional children, which are allowed to vary with subperiod of the interval of use, become somewhat unstable as the period is restricted. The coefficients on the variable indicating that the method used is coitus-dependent increase in absolute value as the period is restricted, partly because the longer intervals in the earlier periods may be the result of long and effective use of these methods, as already noted in the main text.

HAZARD MODELS FOR LIVE-BIRTH CONCEPTIONS: ESTIMATES BY PERIOD

Tables A7 and A8 give the estimated coefficients for the model of conception rates. These results should be compared to the final column in Tables 9 and 10 in the main text. As with the results already discussed in this appendix, there are few notable changes as the sample is progressively restricted. The shape of the hazard necessarily changes as longer intervals are eliminated; however, the signs, magnitude, and statistical significance of the coefficients generally remain stable. In Colombia, urban residence is no longer significant when the longest intervals are removed and only those begun since 1960 are examined; in Costa Rica, this is the case when those begun before 1965 are eliminated. This suggests that the longest intervals from the earliest period are associated with births to urban women. The impact of use of contraception diminishes as the period is restricted; however, as noted earlier, this may be an artifact of longer intervals from earlier periods being the result of efficient use. This is more marked for coitus-dependent than for coitus-independent methods. Similarly, and probably for the same reasons, the impact of breastfeeding diminishes as intervals are restricted to the more recent past. In contrast, the coefficients on the time-varying aspect of contraception increase as the period of analysis is restricted, perhaps because of respondents' better recall of the more recent past. The coefficients indicating child survival show no consistent pattern of change in either country, despite considerable mortality decline over the period.

TABLE A.5 Coefficient Estimates for Contraceptive Discontinuation by Period: Colombia

	since 1960		since 1965		since 1970	
	coeff.	antilog	coeff.	antilog	coeff.	antilog
work since marriage[a]	.0120 (.1165)	1.012	.0205 (.1268)	1.021	-.0669 (.1668)	.9353
work away from home[a]	-.0266 (.1382)	.9737	.0294 (.1516)	1.030	.2224 (.2040)	1.249
women's education	-.0364 (.0218)	.9643	-.0241 (.0230)	.9762	.0348 (.0284)	1.035
husband's education	-.0014 (.0173)	.9986	-.0080 (.0186)	.9920	-.0356 (.0250)	.9650
urban residence[a]	-.2384* (.1033)	.7879	-.2567* (.1070)	.7736	-.1779 (.1325)	.8370
parity	-.1055* (.0200)	.8998	-.1147* (.0209)	.8917	-.0920* (.0286)	.9121
breastfeeding[a]	-.1840 (.1472)	.8320	-.2306 (.1569)	.7941	.0144 (.1965)	1.015
child survival past age two[a]	-.0010 (.1774)	.9990	-.0066 (.1893)	.9935	-.3750 (.2491)	.6873
<u>Period 1 (0-2 months)</u>						
constant	-3.363* (.3422)	.0346	-3.142* (.3567)	.0432	-3.252* (.4815)	.0387
desire additional children[a]	-.0599 (.2850)	.9419	-.1922 (.2985)	.8251	-.1593 (.3594)	.8527
coitus-dependent contraception[a]	.6331* (.2697)	1.883	.5791* (.2744)	1.784	.6605 (.3491)	1.936
<u>Period 2 (3-5 months)</u>						
constant	-3.130* (.3308)	.0437	-2.952* (.3483)	.0523	-2.744* (.4521)	.0643
desire additional children[a]	.2701 (.2679)	1.310	.1858 (.2789)	1.204	.1412 (.3263)	1.152
coitus-dependent contraception[a]	.2377 (.2588)	1.268	.2173 (.2680)	1.243	.0023 (.3200)	1.002

TABLE A.5 (continued)

	since 1960		since 1965		since 1970	
	coeff.	antilog	coeff.	antilog	coeff.	antilog
Period 3 (6-11 months)						
constant	-3.430* (.3118)	.0324	-3.320* (.3325)	.0361	-3.048* (.4391)	.0475
desire additional children[a]	.3564 (.2146)	1.428	.3498 (.2228)	1.419	.0347 (.2813)	1.035
coitus-dependent contraception[a]	.5010* (.2107)	1.650	.5561* (.2193)	1.744	.3763 (.2717)	1.457
Period 4 (12-17 months)						
constant	-3.840* (.3498)	.0215	-3.648* (.3680)	.0260	-3.143* (.4685)	.0431
desire additional children[a]	.2148 (.2689)	1.240	.1175 (.2804)	1.125	-.3177 (.3233)	.7278
coitus-dependent contraception[a]	.9053* (.2700)	2.473	.9490* (.2783)	2.583	1.004* (.3173)	2.730
Period 5 (18-23 months)						
constant	-3.863* (.3643)	.0210	-3.781* (.3949)	.0228	-3.524* (.5331)	.0295
desire additional children[a]	.5825 (.3194)	1.790	.5247 (.3514)	1.690	.3666 (.4416)	1.443
coitus-dependent contraception[a]	.1910 (.3170)	1.210	.2069 (.3501)	1.230	.3044 (.4384)	1.356
Period 6 (24+ months)						
constant	-3.774* (.2796)	.0230	-3.490* (.2976)	.0305	-2.626* (.4146)	.0724
desire additional children[a]	.6464* (.1371)	1.909	.5167* (.1521)	1.676	.0148 (.2242)	1.015
coitus-dependent contraception[a]	.3513* (.1306)	1.421	.3410* (.1443)	1.406	.4315 (.2194)	1.539
log likelihood	-2865.		-2456.		-1298.	
N	1151		1006		571	

Notes: a Indicator variable: 1=yes.
Standard errors are in parentheses.
* indicates statistical significance at the .05 level.

TABLE A.6 Coefficient Estimates for Contraceptive Discontinuation by Period: Costa Rica

	since 1960		since 1965		since 1970	
	coeff.	antilog	coeff.	antilog	coeff.	antilog
work since marriage[a]	.0437 (.1519)	1.045	.0955 (.1647)	1.100	.2058 (.2315)	1.228
work away from home[a]	.0947 (.1655)	1.099	.0862 (.1809)	1.090	.0393 (.2582)	1.040
women's education	-.0394* (.0159)	.9614	-.0444* (.0173)	.9655	-.0747* (.0242)	.9280
husband's education	.0136 (.0136)	1.014	.0043 (.0144)	1.004	.0346 (.0200)	1.035
urban residence[a]	-.1100 (.0968)	.8958	.0403 (.1043)	1.041	.0978 (.1492)	1.103
parity	-.1374* (.0221)	.8716	-.1259* (.0227)	.8817	-.1316* (.0324)	.8767
breastfeeding[a]	.1735 (.1126)	1.189	.0813 (.1183)	1.085	.0641 (.1546)	1.066
child survival past age two[a]	-.1937 (.2203)	.8239	-.0828 (.2299)	.9205	-.9334* (.2931)	.3932
Period 1 (0-2 months)						
constant	-3.921* (.3920)	.0198	-3.928* (.4015)	.0197	-2.965* (.5077)	.0516
desire additional children[a]	-.0575 (.2688)	.9441	-.0440 (.2817)	.9570	.1515 (.3312)	1.164
coitus-dependent contraception[a]	.9584* (.3092)	2.607	.9867* (.3146)	2.682	1.093* (.3692)	2.984
Period 2 (3-5 months)						
constant	-3.918* (.3879)	.0199	-3.866* (.3985)	.0209	-2.586* (.4812)	.0753
desire additional children[a]	.3693 (.2730)	1.447	.1807 (.2899)	1.198	.0772 (.3266)	1.080
coitus-dependent contraception[a]	.7666* (.2914)	2.153	.8206* (.3056)	2.272	.9023* (.3140)	2.465

TABLE A.6 (continued)

	since 1960		since 1965		since 1970	
	coeff.	antilog	coeff.	antilog	coeff.	antilog
Period 3 (6-11 months)						
constant	-3.861* (.3383)	.0210	-3.899* (.3503)	.0203	-2.827* (.4548)	.0592
desire additional children[a]	.0922 (.2298)	1.097	.1114 (.2399)	1.118	-.1202 (.3074)	.8867
coitus-dependent contraception[a]	.5213* (.2378)	1.684	.6369* (.2456)	1.891	.9004* (.3145)	2.461
Period 4 (12-17 months)						
constant	-4.263* (.3766)	.0141	-4.278* (.3923)	.0139	-2.747* (.4750)	.0641
desire additional children[a]	.4370 (.2749)	1.548	.4017 (.2946)	1.494	-.1095 (.3591)	.8963
coitus-dependent contraception[a]	.5689* (.2798)	1.766	.6375* (.2944)	1.892	.6814 (.3574)	1.977
Period 5 (18-23 months						
constant	-4.216* (.3764)	.0148	-4.181* (.3854)	.0153	-2.877* (.5128)	.0563
desire additional children	.3652 (.2479)	1.441	.3431 (.2548)	1.409	-.0965 (.3471)	.9080
coitus-dependent contraception	1.042* (.2761)	2.835	1.206* (.2789)	3.340	1.456* (.3753)	4.290
Period 6 (24+ months)						
constant	-4.636* (.2869)	.0097	-4.582* (.3010)	.0102	-2.573* (.4189)	.0763
desire additional children	1.009* (.1337)	2.744	.9991* (.1528)	2.716	.5420* (.2498)	1.719
coitus-dependent contraception[a]	.7505* (.1331)	2.118	.8154* (.1473)	2.260	.8104* (.2282)	2.249
log likelihood	-2970.		-2474.		-1198.	
N	1225		1035		536	

Notes: a Indicator variable: 1=yes.
Standard errors are in parentheses.
* indicates statistical significance at the .05 level.

TABLE A.7 Coefficient Estimates on the Fertility Equation by Period: Colombia

	since 1960		since 1965		since 1970	
	coeff.	antilog	coeff.	antilog	coeff.	antilog
work since marriage[a]	-.0237 (.0721)	.9766	-.0426 (.0773)	.9582	-.0633 (.0949)	.9387
work away from home[a]	-.0420 (.0884)	.9589	-.0346 (.0965)	.9660	.0858 (.1243)	1.090
women's education	.0025 (.0138)	1.002	-.0002 (.0144)	.9998	.0010 (.0179)	1.001
husband's education	-.0057 (.0120)	.9943	-.0138 (.0125)	.9863	-.0051 (.0163)	.9949
urban residence[a]	-.0935 (.0598)	.9107	-.0970 (.0627)	.9076	.0776 (.0765)	.9253
coitus-independent contraception[a]	-1.201* (.1345)	.3008	-1.054* (.1368)	.3485	-.8760* (.1698)	.4164
coitus-dependent contraception[a]	-.5984* (.1295)	.5497	-.4388* (.1334)	.6448	-.3078 (.1671)	.7351
parity	-.1245* (.0099)	.8829	-.1274* (.0104)	.8804	-.0866* (.0132)	.9171
Period 1 (0-2 months)						
constant	-1.858* (.3018)	.1559	-1.687* (.3260)	.1851	-1.903* (.3824)	.1491
breastfeeding[b]	-.9460* (.3233)	.3883	-1.094* (.3317)	.3350	-.9414* (.3977)	.3901
contraception[c]	.1407 (.3609)	1.151	-.0804 (.3786)	.9227	-.4389 (.4950)	.6448
child survival[b]	-1.201* (.3639)	.3009	-1.114* (.3887)	.3283	-1.190* (.4631)	.3042
Period 2 (3-5 months)						
constant	-2.204* (.2899)	.1104	-2.259* (.3466)	.1045	-2.247* (.3959)	.1057
breastfeeding[b]	-.1370 (.2194)	.8720	-.1638 (.2252)	.8489	-.4077 (.2577)	.6652
contraception[c]	.1273 (.2427)	1.136	-.0679 (.2510)	.9344	-.1771 (.3061)	.8377
child survival[b]	-.7057* (.3276)	.4938	-.4699 (.3773)	.6251	-.4972 (.4311)	.6082

TABLE A.7 (continued)

	since 1960		since 1965		since 1970	
	coeff.	antilog	coeff.	antilog	coeff.	antilog
Period 3 (6-11 months)						
constant	-2.243*	.1062	-2.143*	.1174	-2.524*	.0801
	(.2149)		(.2403)		(.3217)	
breastfeeding[b]	-.2935*	.7457	-.4103*	.6635	-.5242*	.5920
	(.1253)		(.1322)		(.1588)	
contraception[c]	-.0665	.9356	-.2765	.7584	-.4491	.6382
	(.1811)		(.1894)		(.2362)	
child survival[b]	-.2627	.7690	-.1755	.8390	.1491	1.161
	(.2178)		(.2407)		(.3193)	
Period 4 (12-27 months)						
constant	-2.467	.8049	-2.134	.1184	-2.015	.1334
	(.2315)		(.2351)		(.2543)	
breastfeeding[b]	-.0172	.9829	-.0530	.9484	-.1280	.8799
	(.1259)		(.1316)		(.1547)	
contraception[c]	-.1048	.9005	-.2726	.7614	-.2781	.7573
	(.1825)		(.1879)		(.2268)	
child survival[b]	-.0246	.9757	-.1832	.8326	-.3295	.7193
	(.2318)		(.2327)		(.2486)	
Period 5 (18-23 months)						
constant	-2.469*	.0847	-2.081*	.1248	-2.229*	.1076
	(.2769)		(.2897)		(.3685)	
breastfeeding[b]	-.0291	.9713	-.0102	.9899	-.0118	.9882
	(.1651)		(.1742)		(.2036)	
contraception[c]	-.8796*	.4150	-1.096*	.3341	-.9894*	.3718
	(.2255)		(.2364)		(.2854)	
child survival[b]	.1183	1.126	-.9066	.9080	-.0250	.9753
	(.2795)		(.2920)		(.3723)	
Period 6 (24+ months)						
constant	-3.451*	.0317	-2.981*	.0507	-2.328*	.0975
	(.1729)		(.2036)		(.2715)	
breastfeeding[b]	-.1949	.8229	-2.162	.8055	-.0941	.9102
	(.1358)		(.1489)		(.1874)	
contraception[c]	-.0212	.9790	-.3014	.7398	-.1881	.8285
	(.1494)		(.1551)		(.1985)	
child survival[b]	.2639	1.302	.2642	1.302	-.0307	.9698
	(.1646)		(.1906)		(.2623)	
log likelihood	-7502.		-6319.		-3805.	
N	2780		2407		1534	

Notes:

a Indicator variable: 1=yes.
b Time-varying indicator variable: 1=yes in period p and all previous periods, p=1,...,6.
c Ti -varying indicator variable: 1=yes in period p, p=1,...,6.
Standard errors are in parentheses.
* indicates statistical significance at the .05 level.

TABLE A.8 Coefficient Estimates on the Fertility Equation by Period: Costa Rica

	since 1960		since 1965		since 1970	
	coeff.	antilog	coeff.	antilog	coeff.	antilog
work since marriage[a]	.0327 (.0880)	1.033	.0878 (.0948)	1.092	-.0254 (.1360)	.9749
work away from home[a]	-.0843 (.1024)	.9191	.0351 (.1136)	1.036	.3290 (.1727)	1.390
women's education	.0019 (.0115)	1.002	-.0186 (.0124))	.9815	-.0349 (.0179)	.9657
husband's education	-.0154 (.0100)	.9847	-.0113 (.0108)	.9888	-.0004 (.0160)	.9996
urban residence[a]	-.1332* (.0662)	.8753	-.0583* (.0722)	.9434	-.0349* (.1060)	.9657
coitus-independent contraception[a]	-1.434* (.1318)	.2383	-1.391* (.1388)	.2489	-1.345* (.1853)	.2604
coitus-dependent contraception[a]	-.7364* (.1226)	.4788	-.5702* (.1312)	.5654	-.4081* (.1736)	.6649
parity	-.1081* (.0105)	.8975	-.1131* (.0110)	.8930	-.1106* (.0157)	.8953
<u>Period 1 (0-2 months)</u>						
constant	-2.597* (.5091)	.0745	-2.710* (.5866)	.0666	-2.973* (1.013)	.0511
breastfeeding[b]	-.9430* (.2306)	.3894	-1.001* (.2411)	.3676	-1.179* (.3112)	.3077
contraception[c]	-.5209 (.3389)	.5940	-.5917 (.3433)	.5534	-.6029 (.4157)	.5472
child survival[b]	.1164 (.5246)	1.123	.3683 (.6010)	1.445	.8381 (1.022)	2.312
<u>Period 2 (3-5 months)</u>						
constant	-2.077* (.3280)	.1252	-2.208* (.3897)	.1099	-1.723* (.4661)	.1786
breastfeeding[b]	-.6335* (.1882)	.5307	-.6381* (.1991)	.5283	-.6984* (.2496)	.4974
contraception[c]	-.2912 (.2430)	.7474	-.4738 (.2550)	.6226	-.5087 (.3020)	.6013
child survival[b]	-.2909 (.3414)	.7476	-.0092 (.4020)	.9909	-.1906 (.4809)	.8265

TABLE A.8 (continued)

	since 1960		since 1965		since 1970	
	coeff.	antilog	coeff.	antilog	coeff.	antilog
Period 3 (6-11 months)						
constant	-2.301* (.2718)	.1002	-2.143* (.2930)	.1173	-1.923* (.3979)	.1462
breastfeeding[b]	-.2100 (.1362)	.8106	-.2754 (.1457)	.7593	-.4862* (.1930)	.6150
contraception[c]	-.2970 (.1841)	.7430	-.5073* (.1957)	.6021	-.6274* (.2491)	.5340
child survival[b]	-.1935 (.2729)	.8240	-.1589 (.2927)	.8531	.0001 (.3992)	1.000
Period 4 (12-27 months)						
constant	-2.258* (.2803)	.1045	-2.140* (.3041)	.1177	-2.007* (.4637)	.1343
breastfeeding[b]	.1820 (.1467)	1.200	.2337 (.1554)	1.263	-.1213 (.2124)	.8858
contraception[c]	-.4958* (.1882)	.6091	-.7185* (.2009)	.4875	-.8608* (.2510)	.4228
child survival[b]	-.1561 (.2796)	.8555	-.0957 (.3013)	.9087	.3096 (.4614)	1.363
Period 5 (18-23 months)						
constant	-2.560* (.3442)	.0773	-2.394* (.3672)	.0913	-1.745* (.4689)	.1747
breastfeeding[b]	.1868 (.2323)	1.205	.2022 (.2455)	1.224	.1011 (.3007)	1.106
contraception[c]	-.1723 (.2001)	.8418	-2.455 (.2144)	.7823	-.4817 (.2770)	.6177
child survival[b]	-.0671 (.3463)	.9351	-.1215 (.3683)	.8856	-.1927 (.4679)	.8248
Period 6 (24+ months)						
constant	-3.659* (.2127)	.0258	-3.242* (.2271)	.0391	-1.166* (.3300)	.3117
breastfeeding[b]	.0988 (.1765)	1.104	.0740 (.1906)	1.077	.5309 (.2878)	1.700
contraception[c]	.2967* (.1420)	1.345	.1413 (.1510)	1.152	-.0033 (.2208)	.9967
child survival[b]	.3360 (.1993)	1.399	.2826 (.2123)	1.327	-.9579* (.3058)	.3837
log likelihood	-6744.		-5416.		-2478.	
N	2309		1908		956	

Notes:

a Indicator variable: 1=yes.
b Time-varying indicator variable: 1=yes in period p and all previous periods, p=1,...,6.
c Time-varying indicator variable: 1=yes in period p, p=1,...,6.
Standard errors are in parentheses.
* indicates statistical significance at the .05 level.

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