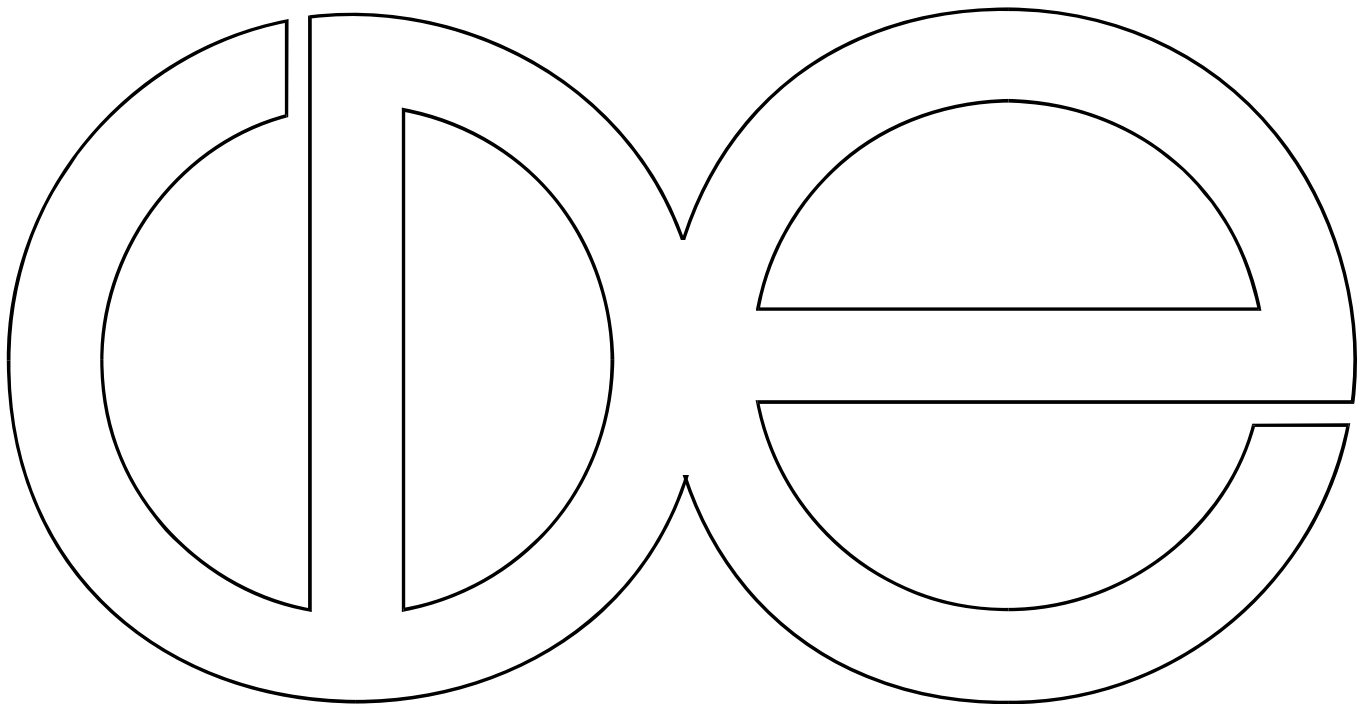


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**Breastfeeding and Postpartum Amenorrhea
among Bolivian Women: A Survival Analysis**

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**BREASTFEEDING AND POSTPARTUM AMENORRHEA
AMONG BOLIVIAN WOMAN: A SURVIVAL ANALYSIS**

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I. INTRODUCTION

The importance of breastfeeding in regulating individual and societal fertility has been matter of general interest for many years, because it tends to increase the average birth interval and therefore to reduce women's fertility over her life span, especially in societies where the use of contraceptive methods is not widespread.

There is substantial evidence that long-term breastfeeding is associated with longer anovulatory periods, and thus with prolonged postpartum amenorrhea, on the one hand, and with reduced fertility even after menses and ovulation have returned, on the other hand. Prolonged lactation suppresses the production of certain types of hormones and thereby extends the postpartum anovulatory period. Moreover, there are different social norms, taboos, and other socioeconomic factors, especially in traditional societies, that reinforce the effect of breastfeeding.

However, many mechanisms by which breastfeeding behavior and other factors produce variability in the length of the anovulatory period, and thus in the resumption of menses across populations as well as within a population in different social and cultural groups, remain either unspecified or unknown. They are probably associated with biological characteristics and specific social structures and implicit or explicit social norms.

In attempting to understand better this process and its demographic significance, the purpose of this study is to investigate the causal relationship between the length of postpartum amenorrhea and breastfeeding variables as well as other demographic and socioeconomic factors that could modify the pace of both postpartum amenorrhea and breastfeeding.

In order to accomplish this objective the following assumptions will guide the entire research and the statistical analysis performed: (1) breastfeeding and postpartum amenorrhea are causally

related, (2) a non-linear model characterizes the relationship between duration of breastfeeding and duration of postpartum amenorrhea, (3) there is a deterministic formulation in this relationship, and (4) the relation between breastfeeding and postpartum amenorrhea is unidirectional, that is breastfeeding affects amenorrhea but amenorrhea does not affect breastfeeding.

The duration of breastfeeding seems to be the most significant variable in explaining the resumption of menses among urban Bolivian women. Although the relationship between breastfeeding and amenorrhea depends heavily on the frequency of nursing, factors such as parity, use of contraception, and especially women's education also play an important role in the return of menses.

To verify these relationships life-table techniques and proportional hazard models are used. First, in order to show the association between amenorrhea and the different covariates we use the median survival time and survival functions. Second, to assess the relative contribution and the direct effects of these variables, a hazard model with time-varying and fixed covariates is used.

In the multivariate analysis the association between postpartum amenorrhea failure time and breastfeeding variables is first analyzed. Later, a set of social and demographic variables such as mother's age at childbirth, parity, use of contraception, infant mortality, women's education, and city of residence are introduced, in order to determine whether the waiting time of amenorrhea varies with these characteristics once breastfeeding variables have been controlled for.

This procedure will allow us to address the problem of confounding influences of social, demographic and biological factors in the mechanisms underlying postpartum infertility, and to capture the heterogeneity of women's behavior about breastfeeding.

The present research is motivated by the importance that this relationship has in understanding the determinants of human fertility and because studies of the effect of breastfeeding on the length of postpartum amenorrhea have not been extensively investigated in Bolivia but other Latin American countries (Delgado, et al., 1982; Rivera et al., 1985; Rodriguez and Diaz, 1988).

II. CONCEPTUAL FRAMEWORK FOR STUDYING THE EFFECTS OF BREASTFEEDING ON FERTILITY

The objective of this section is to review some of the studies about the underlying biological mechanisms in the human reproductive process and its role in the contraceptive effect of breastfeeding, in order to identify the mechanisms that mediate the relation between breastfeeding and post-partum amenorrhea through which lactation affects ovulation, menstruation, and fertility.

THE INTERMEDIATE VARIABLES

The level of fertility in any society is related to a complex network of social, cultural, environmental, and biological variables such as social status, income level, education, breastfeeding behavior, use of contraception, health services, nutrition, women's status, value of the children, etc. Nevertheless, these variables are not the direct determinants of fertility. For instance, the negative relationship between women's education and fertility has been well documented; however a detailed analysis shows that later a marriage pattern and/or the prevalence of contraception are more frequent among women with high levels of education. So, age at union and contraception are factors mediating the association between education and fertility.

Several theoretical and conceptual frameworks have been devised in order to capture the multiplicity of elements that can affect human reproduction. They provide a comprehensive and

coherent list factors that have a direct effect on human fertility and also specify the nature of their interrelation.

Davis and Blake (1956) identified eleven specific biosocial variables or mechanisms directly related to women's fertility, which mediate between fertility and various social, economic, cultural, environmental, and biological variables. These eleven intermediate factors are clustered into three groups: (1) factors that affect the formation and dissolution of unions and those ones that affect exposure to intercourse, such as age of entry into sexual unions, the amount of the reproductive period spent after or between unions, voluntary and involuntary abstinence, and coital frequency; (2) factors that affect exposure to conception, that could be involuntary or voluntary, such as use of contraception; and (3) factors that affect gestation and childbirth, such as fetal mortality from voluntary or involuntary causes.

Any specific mention about the influence of breastfeeding on fertility, or equivalently the fact that postpartum amenorrhea depends on breastfeeding is absent in the framework described above. However, this relationship was emphasized by Henry (1953, 1961, 1979) and later by Bongaarts (1978, 1983). Henry identified four inhibiting intermediate variables: (1) the post-partum infecundable period. After childbearing each woman experiences a period of temporary infecundability, called anovulatory period, in which normal ovulation and menstruation are absent. The amenorrheic period does not last as long as the anovulatory period. However, since the amenorrhea period is easier to observe than anovulation, the waiting time of postpartum amenorrhea is commonly used as an indicator of the postpartum infecundable period.

(2) The waiting time to conception (called fecundable or ovulatory interval). This period follows immediately the postpartum infecundable interval. During this period, a woman is at risk of conceiving if she ovulates regularly and if she engages in intercourse.

(3) Intrauterine mortality. When the waiting time to conception ends with a pregnancy, it could terminate prematurely due to spontaneous intrauterine mortality.

(4) Permanent sterility. At older ages or when some diseases are prevalent in a society, the proportion of couples with at least one spouse permanently sterile may rise in a way that could affect the levels of fertility observed.

These four proximate determinants are in turn influenced by other factors such as breastfeeding, which appears to be the main biological determinant of variations in the length of postpartum amenorrhea, frequency of intercourse, and the length of the fertile period during a woman's menstrual cycle, which affect the duration of the waiting time to conception.

Recent studies about the determinants of fertility have identified a similar set of variables (Bongaarts, 1978; World Fertility Survey, 1977). For instance, Bongaarts (1978, 1983) grouped the intermediate fertility variables described by Davis and Blake (1956) and Henry (1953, 1961) into eight basic factors called proximate determinants. He found that the bulk of the variability in the levels of fertility is basically due to: (1) exposure factors (age at marriage, and proportion of women non-married), (2) natural marital fertility control factors (the period of lactation that follows childbirth, spontaneous fetal wastage, sterility, etc.), and (3) deliberate marital fertility control factors (prevalence of induced fetal wastage and prevalence of contraceptive practices).

Bongaarts (1978) also observed that the levels of fertility in non-contracepting less developed societies could increase substantially if the process of modernization leads to abandonment of

traditional practices such as lactation and postpartum abstinence. In a numerical illustration, he found that when breastfeeding is reduced, a high prevalence of contraceptive use is required to maintain the same levels of fertility. Bongaarts (1983) suggests that actual fertility changes in any society are more frequently due to four factors: (1) the proportion of married women, (2) the effectiveness of contraception, (3) the prevalence of induced abortion, and (4) the duration of postpartum infecundity.

Therefore in order to assess properly the influence of the various social, cultural, and environmental variables on fertility changes, it has to account for the mechanisms by which intermediate factors such breastfeeding, contraceptive practice, etc., affect the levels of fertility.

All the concepts reviewed so far are related to biosocial factors associated with the woman's reproductive cycle and the timing of significant reproductive events, such as the age at menarche, pregnancy, menopause and death. These factors affect the length of her menstrual cycle and the duration of postpartum amenorrhea.

BIRTH INTERVALS AND THEIR COMPONENTS

A birth interval is frequently defined as the length of time elapsed between two live births, and it can be divided into four additive components (Potter, 1963; Potter et al., 1965; Menken and Bongaarts, 1978; Srinivasan, 1980): (1) The period of postpartum amenorrhea that follows the birth of a child. That is, the length of time from birth to the first postpartum menstruation, called lactational infertility; (2) the total duration of menstruation intervals between two births. That is, the time elapsed from the first postpartum menses to conception; (3) the period of pregnancy and amenorrhea due to abortions and still births that may occur between two live births; and (4) the period of pregnancy associated with the last live birth. The birth of any child is always followed by a

period of amenorrhea, which is usually much longer for lactating women than for non-lactating. During this period conception is impossible due to the absence of ovulation, which is affected by both woman's health conditions and breastfeeding practices.

The second component is the sum of the waiting times to conceptions that can occur between two live births. The factor that determines the length of a menstruating interval is the fecundability or the monthly probability of conception, which in turn depends on the fecundity of a woman (biological capacity to conceive), the frequency and timing of sexual unions, contraceptive practices, and health status of the couple. On the other hand, the number of menstruating intervals depends on the number of fetal losses, which is affected by the probability that a conception will end in a live birth. This probability is determined by the incidence of still births, induced abortions, and spontaneous abortions.

The third component of a birth interval is the specific contribution of fetal losses as they occur to the woman between two live births. This reproductive 'wastage' (abortions and still births) operates directly to widen the interval. The gestational length of pregnancy in which these losses take place and the subsequent amenorrheic period that follows the early termination of pregnancy along with the frequency of these terminations are important components of the reproductive history of the woman.

Finally, the fourth component, the duration of pregnancy associated with a live birth is the less variable part of the interval. On average, a full term pregnancy lasts about nine months.

Both the intermediate variables and birth intervals have common underlying mechanisms, which are related to specific biological, demographic, and social processes in the woman's reproductive life span. For instance, postpartum infertility as an intermediate variable and as a component of

the birth interval is a consequence of the action of several factors, including breastfeeding. But at the same time breastfeeding is related to a set of demographic and socioeconomic factors.

It is known that lactation may offer nearly total fertility control during the first six months after childbirth because ovulation is suppressed and that this protection diminishes gradually in the follow 12 months or so. The latter period, of lowered fecundity, occurs after the ovulation has resumed and it is variable from one woman to another. Women who menstruate within the six months that follows a birth will usually do it before the first postpartum ovulation. In these cases the first menses are the result of an estrogen withdrawal bleed due to follicular development. But those who remain amenorrheic beyond the sixth month are more likely to menstruate after the first postpartum ovulation (McNeilly, 1988).

As we can see, the relationship between breastfeeding and postpartum amenorrhea, in particular, and breastfeeding and fertility, in general, highlights the complexity of the mechanisms by which breastfeeding delays normal ovulation and menstruation. Therefore, it is necessary to describe briefly what are the demographic, socioeconomic and biological mechanisms underlying such processes.

POST-PARTUM AMENORRHEA AND BREASTFEEDING

There is a large body of literature showing evidence for the positive association between duration of breastfeeding and the length of postpartum amenorrhea (as indicator of duration of infecundity). Some of this literature is based on aggregate cross-sectional demographic analysis (Bongaarts and Potter, 1983); other relies on clinical studies (Howie and McNeilly, 1982; Rodriguez and Diaz, 1988), small biosocial studies (Delgado et al., 1978; Lunn et al., 1984), and longitudinal studies (Jones, 1988; Huffman et al., 1987; Santow, 1987; Pinto et al., 1998). Many of these studies

are important attempts to investigate how breastfeeding patterns affect postpartum infecundity.

Other authors are more interested in the relationship between hormonal factors, breastfeeding and the return of menses.

The most consistent conclusion drawn from these studies is that long-term breastfeeding is associated with longer periods of post-partum amenorrhea, ovarian inactivity, and reduced fertility (Knodel, 1977; van Ginneken, 1978; Pinto et al., 1998).

The socio-demographic evidence

Demographic and social research has shown that in the absence of breastfeeding, the average amenorrheic period lasts between one and three months. When lactation is initiated just after childbirth, duration of amenorrhea increases systematically with the duration of breastfeeding but at progressively slower rates (Santow, 1978; Corsini, 1979; Bongaarts, 1983). Further, when breastfeeding is intensive and prolonged, the average postpartum amenorrhea may last from one to two years (Huffman, 1978; Cantrelle and Ferry, 1979).

On the other hand, there are many studies that have reported contradictory findings about average duration of postpartum amenorrhea and breastfeeding. For instance, in Senegal the average duration of breastfeeding was 24.3 months and the mean duration of amenorrhea was only 10.8 months (Cantrelle and Leridon, 1971). In Taiwan, breastfeeding lasted on average 17.7 months while amenorrhea continued for only 11.4 months (Jain et al., 1969). Similarly, in Bangladesh the average duration of lactation was 24 months and the average amenorrhea post-partum 18.7 months (Chen et al., 1974), and in India women reported 21 months of average duration of lactation and only 11.7 months of amenorrhea (Potter et al., 1965).

Several social, cultural, biological, and environmental factors contribute to such variations, but it seems that the major contributor is related to duration, frequency, and intensity of breastfeeding. For example, women who fully breastfeed their children tend to have much longer amenorrheic periods than those who partially breastfeed them (Perez et al., 1971; Huffman et al., 1978; Jones, 1988; Rodriguez and Diaz, 1988).

Supplementation seems to be the most important factor that explains why prolonged duration of breastfeeding does not always extend the average time of amenorrhea beyond 18 or 20 months. In fact, children over one year are more likely to receive significant amounts of supplementary food (liquid and solid).

In a longitudinal study in Indonesia (Jones, 1988), the association between breastfeeding (number of feedings during the day and during the night, and the number of minutes per nursing), maternal age, and resumption of post-partum menses was investigated. Using proportional hazard models, the author found that age and the three breastfeeding variables were all significantly related to resumption of menses. The results show that low intensity breastfeeding (measured by three or fewer feedings at night, six or fewer feedings during the day, lasting six minutes or less per nursing), and younger age of mothers, all increase the risk of early resumption of menses.

In a follow-up study carried out in Santiago, Chile (Rodriguez and Diaz, 1988) life tables and hazard models were used in order to assess the impact of duration of breastfeeding, frequency of suckling (during the day and night), and supplementation on the duration of post-partum amenorrhea. The final estimates show that (1) the effects of duration of lactation on return of menstruation are rather modest, because most of the effect of duration is captured by breastfeeding patterns, (2) partial breastfeeding leads to important increases in the risk of resumption of menses,

even after adjusting for frequency of suckling, and (3) high frequency of suckling reduces the risk of return to menses under both full and partial breastfeeding.

In Bangladesh (Chen et al., 1974) it was found that women who were breastfeeding and amenorrheic at 17 to 25 months post-partum at the beginning of the study reported long average duration of postpartum amenorrhea and high average of suckling frequency. Many of their children were breastfed from five to six times in an eight-hour period. The authors estimated that the total time the children suckled was more than two hours in a 24 hours period. Further, they observed a reduction in this frequency during harvesting season, when mothers were busy in the crop activities. This result was found to be independent of children's age.

In the Kivu region of Zaire, Delvoye and associates (1977) observed the persistence of serum prolactin for 15 to 18 months post-partum in rural women who had breastfed for two years or longer. The prevalence of amenorrhea and prolactin declined concurrently over a two year period. In contrast, in an urban area from the same region (Delvoye et al., 1978; Delvoye and Robyn, 1980) it was found that prolactin levels remained unchanged during the first 12 postpartum months in the high nursing frequency group, decreased with time (but not significantly) in the intermediate group, and decreased rapidly in the low nursing frequency group.

In rural Mexico (north-central region) a study of breastfeeding women (Rivera et al., 1985) compared the average number of suckling episodes of ovulatory and non-ovulatory women. Among the ovulatory women the average number of suckling episodes at the time of first ovulation was nine per 24 hours; and for those mothers who did not ovulate during the investigation, the average suckling frequency at the time they left the follow-up was 12 episodes in a 24-hour period. Finally,

they found that low frequency had greater predictive power of earlier onset of ovulation, menses, and conception than early or late supplementation.

In a one-year longitudinal study of Scottish women (McNeilly et al., 1982, 1983; Howie et al., 1982) it was found that a suckling frequency of more than 5 times and duration of more than 65 minutes every day was enough to maintain almost complete suppression of ovarian activity. They also observed that reductions below these levels were associated with changes in breastfeeding behavior, such as less frequent night nursing and introduction of supplementary food.

Lactational amenorrhea and breastfeeding practices were studied in middle-class American women in Boston (Elias et al., 1986). The women under study were divided into two clusters according to whether they nursed their children on average more or less than eight times per day during the period of breastfeeding without any supplementation. They found that those mothers who breastfed more frequently also nursed significantly more hours during both day and night than their less frequent nursing counterparts. Further, they observed that women who nursed more frequently had significantly longer duration of amenorrhea (13.1 months) compared with less frequent nursers (8 months). Also, when duration of amenorrhea was regressed on the breastfeeding variables, duration of exclusive nursing and frequency of night-time nursing were powerful predictors of resumption of menses.

In a study of Orissa, India, Srinivasan and co-workers (1988) used a proportional hazard model for a multivariate analysis, and found that duration of breastfeeding and eight socioeconomic variables had significant influence on the duration of post-partum amenorrhea. For instance, they found that the risk of resuming menses for urban women was 1.77 times higher than for rural

women. They also found significant differences in the risk of returning to menses by education, mother's age, and caste.

The association between duration of breastfeeding and the length of postpartum amenorrhea observed in these studies could be explained mainly by the endocrine factors that underlie the reproductive process and regulate ovulation and menstruation, which are strongly related to lactation.

The biological evidence

The contemporary menstrual patterns of consecutive fertile cycles are a relatively recent evolutionary development. Throughout the evolutionary history the majority of a woman's reproductive years were spent in a succession of pregnancy and breastfeeding states. Therefore, the mechanisms that control ovulation did not evolve in a context of many consecutive unfertilized menstrual cycles but rather in a hormonal and environmental context of birth, lactation and nursing. Thus, the regulatory mechanisms of the reproductive cycle depend on both neuro-hormonal and external factors which are functionally related to pregnancy and breastfeeding (McClintock, 1981).

The female reproductive cycle, less accurately called the menstrual cycle, refers to the rhythmic fluctuations of the hormones in the hypothalamus, anterior pituitary, and ovaries and the morphological changes that occur in the ovaries and endometrium of the uterus. The female reproductive cycle is maintained by hormones released by the ovaries. These hormones depend in turn on pituitary hormones, which require a releasing of hormones produced by the hypothalamus. When both the ovarian and pituitary hormones have reached specific levels they inhibit the production of neurosecretions in the hypothalamus, completing in this way a feedback mechanism (Knobil, 1980).

The hypothalamus, a collection of highly specialized brain cells, produces certain types of hormones (neurosecretions) which control the release of female sex hormones. The hypothalamus is known to produce more than six releasing inhibiting hormones directly into the bloodstream to be transported elsewhere in the body to regulate, for instance, the pituitary secretions. The pituitary gland, located below the hypothalamus, manufactures eight hormones. Three of them are of fundamental importance: follicle-stimulating hormone (FHS), which stimulates the growth and development of the primary follicles and results in hormone production in the ovaries; luteinizing hormone (LH), responsible for ovulation, corpus luteum formation, and hormone production in the ovaries.

The physiological mechanism which underlies the process of return of postpartum fecundity and fertility is found in the hypothalamus of the human brain. This is the area of the brain where central regulation of reproduction is mediated by the activity of an endogenous hypothalamic pulse generator (HPG). Here during a normal menstrual cycle hypothalamic nuclei release gonadotropin-releasing hormone (GnRH) in a pulsatile manner, which in turn, results in the pulsatile secretion of the pituitary gonadotropins, follicle stimulating hormone (FSH) and luteinizing hormone (LH). The integrity of this endogenous system is necessary for normal ovarian function (Knobil, 1980).

Following birth and with the initiation of breastfeeding, stimulation of the mother's nipple by the nursing infant provides the controlling signal that suppresses postpartum fertility in normally nourished, healthy women. Nursing sets up a neuroendocrine reflex from the breast to the hypothalamus which disrupts the ability of the HPG to maintain a normal pattern of GnRH/LH pulsatile secretion. FSH concentrations return to near normal levels within approximately 30 days postpartum in spite of the continued disruption of GnRH signals by nursing. As a consequence, FSH

levels are sufficient to begin to induce follicle growth. However, in the majority of nursing mothers, the continued suckling induced disruption of the pulsatile GnRH/LH signal results in GnRH-secreting neurons being hypersensitive to estradiol negative feedback. Reduced estradiol production by the FSH stimulated follicles inhibits the normal positive ovarian feedback of estradiol to the hypothalamus. Disruption of LH signals continues until the suckling stimulus declines sufficiently to allow for the generation of a normal preovulatory LH surge. Only then can ovulation take place with the formation of normal corpus luteum (Glasier et al., 1984; McNeilly et al., 1985; Tay et al., 1993; McNeilly et al., 1994; McNeilly, 2001).

A physiological mechanism for postpartum amenorrhea involving the pituitary hormone prolactin (PRL) has been proposed. Under this model, the authors assumed that recurrence of postpartum menstrual bleeding occurs when the plasma level of the key hormone PRL drops below a threshold value. As we have seen above, however, the mechanism of postpartum lactational infertility does not involve PRL directly, nor does it involve dopamine or endogenous opioids such as beta-endorphin which have in the past been proposed to be responsible for the amenorrhea of nursing women (Tay et al., 1993; 1996). Instead it is the direct suckling induced failure of the central mechanisms of the HPG and pituitary to secrete GnRH/LH in normal frequencies that is directly responsible for postpartum lactational infertility (McNeilly et al., 1994; McNeilly, 2001). Nonetheless, by simply substituting a critical suckling threshold (some measure of suckling frequency such as the total duration of sucking during any 24-hour period that we use in this study) for a critical PRL threshold above which menstruation and/or ovulation cannot occur.

III. DATA AND METHODS

The objective of this section is to describe and set the methodological issues in which this study rests. First, a review of the most important characteristics of the data collection is presented. Second, the variables considered in the research are defined. And third, a brief discussion of the demographic and statistical procedures used to analyze the data is presented.

THE SOURCE OF DATA

The baseline data used for this research come from the "Woman's Economic Activity and Human Reproduction Survey" (WEAHR) carried out during November and December of 1986 by the National Population Council of Bolivia (CONAPO), with the financial assistance from the Pathfinder Fund.

The survey covered the three largest cities of Bolivia: La Paz, Cochabamba, and Santa Cruz de la Sierra, which are in the western, central, and eastern part of the country, respectively. Together, these three cities make up 57 percent of the urban population and almost 25 percent of the national population.

A two-stage sample design was used to select 2,600 households in these three cities. The sample size by cities totals 1,000 households in La Paz, 850 in Santa Cruz, and 750 in Cochabamba. Regardless of their marital status, 3,011 women aged 15-49, who slept the previous night in the selected household, became eligible for the individual survey. In La Paz city 1,132 women were interviewed, in Santa Cruz City 1,024, and in Cochabamba City 855. The survey in those places was carried out on a house-by-house interview and the average rate of response was about 96 percent.

The main objective of the survey was to obtain more reliable information on the relationship between fertility and working patterns among urban Bolivian women. Demographic and

socioeconomic factors which might account for this relation were also included in the core questionnaire.

The questionnaire was made up of three parts: (1) a household schedule, used to list the members of the household and their basic demographic and social characteristics, (2) an individual questionnaire for detailed interviews with females aged 15-49 years who were previously identified in the household schedule. This part contained the following sections: respondent's demographic and social background, marriage history, current economic activity, maternity history, and contraceptive knowledge and use; and (3) a second individual questionnaire for detailed interviews with women between 20 and 39 years old about occupational and reproductive histories.

The maternity history section included retrospective information on variables related to the woman's reproductive variables, such as the timing of occurrence of births, number of live births, still births, fetal wastage, infant and child mortality, and duration of postpartum variables to the date of the interview. Therefore, the survey provides incomplete and truncated histories for some of these characteristics. The basic questions about breastfeeding and amenorrhea were restricted to every woman's two most recent live births (last two children).

Quality of the data

According to an evaluation made by CONAPO, the survey is a reliable source of information. In the final report released by this institution (CONAPO, 1989) a comparison of the data from the household questionnaire with the last population census data (1976), for the three cities under study, shows no significant differences. Similar results were obtained for various demographic and socioeconomic variables included in the survey.

Since the information contained in the maternity history files was obtained in a retrospective fashion, the quality of reporting depends basically on the respondent's capacity and willingness to recall the actual occurrence of each event and the date they occurred. When the individual fails to remember certain dates, they tend to assign values in relation to other vital or social events. This phenomenon often produces dramatic peaks in the distribution of the events considered. Therefore, incorrect report of dates is one of the sources that produce important distortions in the study of retrospective events. Finally, the respondent may also misidentify the occurrence of the event, such as in the case of resumption of menstruation.

Reporting duration of breastfeeding

In different studies, duration of breastfeeding shows a heaping pattern at multiples of six months (Lesthaeghe and Page, 1980). A similar phenomenon can be found in the Bolivian case.

The basic questions about breastfeeding in the core questionnaire were: "Did you breastfeed your last/next-to-the-last children? and, if yes, For how many months did you breastfeed him/her?" The last question was probably interpreted by women in different ways. For instance, for some women who were still breastfeeding their last children, may have responded in terms of the actual number of months rather than saying they had not yet weaned their children by the time of the interview. Although it is hard to assess the dimension of this problem in these data, at first glance it seems to be rare. In effect, less than two percent of the women reported duration of breastfeeding equal to or longer than the recorded age of the child in question. As in many other studies (Lesthaeghe and Page, 1980; Page et al., 1982), the date of the birth could also be the source of such inconsistency.

In Figure 1 we can see that the duration of breastfeeding reported for children who have been weaned by the date of the interview exhibit peaks at 3, 6, 9, 12, 18, and 24 months. However, in Bolivia there are cultural preferences and social norms that induce the weaning of the child at 6, 12 and 18 months. Such variations could also be caused by the heterogeneity in breastfeeding practices. So, if one allows some room for these cultural preferences and practices the pattern observed in that figure may reflect genuine durations rather than being an artifact of preferences of certain digits.

Reporting duration of amenorrhea

The endpoint of amenorrhea is often easy to define but for many women it is hard to recall and recognize it adequately. In the WEAHR survey this problem is reflected in the form of the question that retrieves this information: "Approximately how many months after having your last child did your menstruation resume?" As one can see from Figure 2 the lack of precision in measuring this episode affects the shape of its distribution.

Like in other studies (Huffman et al., 1987; Potter and Kobrin, 1981) there are early peaks, especially during the initial months, probably because the identification of the first menses after childbirth is not always straightforward, and many women tend to confound it with postpartum bleeding (Lesthaeghe and Page, 1980; Page et al., 1982). On the other hand, the heaping observed at 12 months could be associated either with breastfeeding or with the effect of rounding. Very often, if women are not able to recall the precise number of months after delivery when their first menstrual discharge resumed, they may have chosen rounded durations.

Finally, all other source of distortion may come when postpartum amenorrhea shades into menopause. In these cases, whether amenorrhea has ended is not too clear for older women.

However, this problem only affects censored observations corresponding to very few women older than 45 who reported childbirth.

DEFINITION OF THE VARIABLES

Since the purpose of this research is to evaluate the existence of a causal connection between the length of the infertility period and breastfeeding. We now define the variables that are considered to have direct causal influence: breastfeeding, parity, mother's age at birth, infant and child mortality, use of contraception, mother's education, and city of residence, and provide an operational definition of the dependent variable (postpartum anovulatory period).

The dependent variable

Because the "Woman's Economic Activity and Human Reproduction Survey" did not collect hormonal data, the duration of postpartum anovulation cannot be detected directly. Thus, despite the fact that the duration of postpartum amenorrhea and anovulation are not perfectly correlated, we use the interval from birth to the first postpartum menstruation as a proxy for the return of postpartum fecundity. That is, direct measurements of the postpartum anovulatory period are not available in large scale surveys because of the difficulty in observing ovulation. Instead we are forced to rely on a better defined event: the resumption of menses after birth. Thus, in this study resumption of postpartum menses is used to indicate return of fecundity.

Since most women have their first episode of ovulation within a few weeks before or after the first postpartum menses, duration of postpartum amenorrhea (or the waiting time between the last delivery and resumption of menses) is a good indicator of the duration of the anovulatory period. Although the indicator is accurate when is applied at the population level, it is always subject to errors at the individual level. Therefore, the dependent variable in this study is defined as the

interval-in months-between parturition and the first incidence of menstruation. In the multivariate analysis this waiting time of postpartum amenorrhea is treated as a continuous variable.

The independent variables

Eight independent variables, or covariates, are included in the analysis. They are classified into three groups: breastfeeding variables, demographic variables, and socioeconomic variables.

As we have seen in the previous chapter, the main determinant of amenorrhea postpartum is breastfeeding. However, the inhibiting effect of lactation on ovulation and menstruation is produced not only by the duration of breastfeeding but also by the type and intensity of breastfeeding. The data collected by the WEAHR survey do not allow us to make any distinction between full and partial breastfeeding nor to measure the average time per nursing suckling period that is the intensity of every episode of nursing. Because of this restriction only two measures are used, the total number of months and the number of times a day the child was breastfed to the date of the interview. The first measure is a good indicator of the duration of breastfeeding, while the second one measures the frequency of nursing (used as a proxy of intensity). The latter is divided into three categories: (1) from one to five episodes of lactation a day, (2) from six to twelve times a day, and (3) on demand (more than 12 times per day), which means high intensity of suckling and maybe total absence of supplementary food. The duration variable is treated as continuous and time dependent variable in the hazard model and the frequency as categorical and fixed covariate.

The variable "duration of breastfeeding" was coded as a dummy variable: 1 if the woman breastfed her children and 0 if she was still breastfeeding him when the survey occurred. For frequency of breastfeeding we used two dummy variables: the first one was coded as 1 if the woman

breastfed her child between 1 and 5 times a day, and 0 otherwise. The second dummy variable was coded 1 if the mother breastfed her children between 6 and 12 times a day, and 0 otherwise.

Among the demographic covariates we have considered parity, age of the mother at birth, use of contraceptive methods, and infant mortality. Parity is defined as the number of live births a woman has had to the date of the survey, which is the birth order of the child under study. The categories are women with only one child, with two, three, or four children, and women with five children or more. The second demographic covariate is the age of the mother at birth of the child under study. Two groups of women are considered, mothers who were less than 30 years at childbirth and those who were 30 years or more. The use of contraceptive methods is defined as the use of any means of contraception after having the last child. Only two categories are taken into account: "yes" if woman had used any method, and "no" if she had not. These three variables are treated as categorical and fixed covariates.

Finally among the demographic variables, infant mortality is defined as the month at which the death of the child occurs. This covariate is included in the analysis because when an infant dies, the anovulatory period ends through the termination of breastfeeding.

Two social factors are included in this study: mother's education and the city of residence of the woman. Both variables are strongly associated with cultural and economic differences, and they could modify the pace of postpartum variables. Education was defined as the number of years she spent in school. So, we cluster them into two groups: women with low education (less than seven years of formal instruction, or primary education), and high education (seven years or more of formal education, or beyond primary education). Since the survey was carried out in only three cities, the place of residence is La Paz, Cochabamba, or Santa Cruz, that is, the city where she was

interviewed. These two socioeconomic characteristics are considered as categorical and fixed covariates in the life-table and hazard analysis.

STATISTICAL PROCEDURES

A distinction is frequently made between procedures used for descriptive and explanatory purposes. In the use of descriptive techniques the focus is posed on describing the sample or the population from which the sample was drawn, through concrete measures about the average or typical respondent in the sample (means, modes, medians, etc.). On the other hand, explanatory analyses can be carried out by different statistical procedures designed to evaluate a causal relationship among different variables. In this case, the effort is focused on assessing the causal effect of one or more variables, called independent variables, on another one, called the dependent variable. There exist many standard techniques that handle this type of analysis: linear regression models, analysis of variance, analysis of covariance, path analysis, etc.

The incomplete nature of the data used in this study imposes serious restrictions in the use of such standard techniques. Two problems are present in these data: selectivity and censoring. The first one occurs when a portion of individuals under study tend to be selected by certain characteristics and therefore they are not representative of the whole population in the categories in which they have been classified. The second, censoring, basically means a curtailment of exposure by some cut-off point of reference (i.e., the date of the interview), and it introduces certain ambiguities in the definition and measurement of the variables used. For instance, when duration of postpartum amenorrhea is the dependent variable in a linear regression model, only those women who have resumed menses are considered in the study, because the value of this variable is not measured for women who have not yet resumed menstruation by the time of the interview (censored

observations). Therefore, they must be excluded. Also, if the period of analysis is relatively short, the omission of women with long waiting times could result in an underestimation of the mean duration of the dependent variable. Finally, conventional linear models do not have room for time-varying covariates, that is, independent variables whose values change throughout the period of analysis. Nevertheless, these methodological problems can be avoided through the use of life-table techniques and hazard models. For example, selectivity can be handled by introducing proper controls in a multivariate hazard model or constructing separate life tables for each category of the variable under study.

Life-table technique

Many problems presented by linear regression models in the study of waiting times may be avoided through the use of life tables. Such is the case of censored observations. For instance, in the WEAHR survey women were interviewed at one point of time (date of the interview); therefore some of them had not yet resumed menses by the time of the interview, but they could have menstruation later in their life. This right censoring means that if we compute the rate of resumption of menses as the number of women who have already had resumed menses divided by the total number of women in the sample under study; we will underestimate the rate of return to menses for women with incomplete information. If we exclude women with incomplete information in the denominator of the estimated rate, and thus include only those women who were actually exposed to the risk of having menses resumed, we measure only the duration of time they were actually exposed to that risk.

Therefore the life-table technique is an efficient tool through which the problem of right censoring can be handled. This technique treats a sample of women of different ages at any point in time as if they were representing a single cohort, aging over time.

However, the inclusion of censored observations could yield biased estimates for waiting times, such as the duration of postpartum amenorrhea. For example, the inclusion in the life table of women who will never have menses again biases the estimation of the mean waiting time to menses towards a large number. In this case, amenorrheic women will appear in the study as women still waiting to return of menstruation at the longest durations of observation.

Another limitation associated with this technique is its univariate nature. As the number of covariates taken into account increases, the number of life tables describing the relations among variables increases rapidly and large sample sizes are needed to get significant results.

Because the tabular representation of a life table is rather cumbersome, we will use two statistics. First, the median survival time (median duration) for all the categories of the independent covariates is considered. These values are the result of independent life-tables, calculated one at a time. Second, some survival functions are presented graphically for the most important covariates with their respective categories.

Proportional hazard model

The limitations of the simple univariate life table and the lack of ability that linear models have to handle censored observations can be avoided by using hazard models, that is, non linear regression models in which the dependent variable is the risk of experiencing the event under study (Allison, 1982; Trussell and Hammerslough, 1983). In the present study our focus is on the risk of the resumption of the first postpartum menses.

The proportional hazard model represents the individual instantaneous probability of failing at any duration. It can be written as the product of the underlying hazard at time t and of an exponential linear combination of a set of covariates, which could be fixed or time-varying. The model provides a regression model that incorporates the ideas underlying the life-table technique. So, it permits the risk of the resumption of menses to depend on a set of individual characteristics represented by any set of covariates. The general functional form could be expressed as:

$$\mu(t|z) = \mu_0(t) \exp(\beta z + \alpha z(t))$$

Where $\mu_0(t)$ is the baseline, βz is the fixed component and $\alpha z(t)$ is the time-varying component.

In the model specified, the monthly probability of returning of menses is the dependent variable. The unit of observation is the woman-month of exposure to resumption of menses. A binary variable denotes whether or not menses resumes in any given month of observation. For instance, a woman who has resumed menstruation in the fourth month after delivery is represented in the record by four observations, one for every month. In the first three observations, the binary variable takes the value zero and in the fourth one it takes the value 1. When the woman is censored in the fourth month then the binary variable is equal to zero in all four observations. So, censored observations are easily included in the hazard model.

Since in the hazard model there exists a separate observation for each month for every woman who is actually exposed to the risk of resuming menses, the inclusion of time dependent-covariates is rather simple. For example, a woman who has weaned her last child in the fifth month and resumed menses in the seventh month after delivery is classified as lactating woman in the first five months and as non-lactating in the remaining two months.

Cox's model is non-parametric because the underlying hazard has no any specific functional form but is determined essentially by a product-limit life table. The assumptions in which the model rest are that heterogeneity is captured by the set of covariates considered in the analysis and that the relative risks remain constant over the duration of the amenorrheic interval. The latter assumption means that while the hazard rates in the various groups differ, the differences are proportional to one another.

IV. RESULTS AND DISCUSSION

The statistical-demographic analysis that follows is restricted to those women who had at least one live birth within the four years preceding the date of the survey. Further, data used here refer only to the last child ever born during this period. By restricting the information to this interval and these children, we have tried to minimize the effects of recalling biases and of truncation on the report of duration of amenorrhea and breastfeeding.

In the study, the basic unit of analysis is a woman-birth; and each one is considered independent of all others. From 3,011 women interviewed in the survey, 1,079 were selected initially on the basis of the restrictions imposed above. But, because the study is concerned with the effect of the duration of breastfeeding on the resumption of menses, women who did not breastfeed their children after birth were also removed from the sample. Thus, the analysis is based on 1,001 cases. In this data, 312 women reported still breastfeeding and 216 as being amenorrheic at the time of the interview.

For duration of breastfeeding three common situations were identified for every woman who had her last child before the date of the interview: (1) she may report that she stopped breastfeeding

at a certain duration and the child was still alive, (2) the woman was breastfeeding but stopped because of unexpected causes, such as the death of the child, her own illness, etc., and (3) the woman was still breastfeeding when the survey occurred.

In considering the data for duration of amenorrhea, a woman who had not yet resumed menses after the last childbirth by the time of the interview is considered censored observation on the waiting time to postpartum amenorrhea.

LIFE-TABLE ESTIMATES

Two types of indicators are used to describe the life table: the median survival time, or median duration, and the survival functions of amenorrhea postpartum for all women and for the different sub-populations considered in the study.

Using the life-table technique, the monthly failure probabilities at every duration at which menstruation returned have been estimated as the ratio of the number of women that have resumed menses divided by the number of women still at risk of returning to the menstruating state. Therefore, the survival function calculated from these probabilities is an estimate of the proportion of women who had not yet menstruated at different durations after childbirth. As we will see in the different figures, the survival function always takes the shape of a monotonically decreasing function at every distinct duration at which menses has returned. The decreasing stepped pattern observed in many survival functions reflects the heaping of the duration of amenorrhea reported on multiples of six months. The median duration is the estimate of length of time at which half of the women have resumed menstruation.

Table 1 provides the median durations for postpartum amenorrhea as well as for breastfeeding. These estimates were calculated using both complete and censored data simultaneously. According

to these estimates, the median duration of amenorrhea postpartum in the population under study is 6.73 months and the median for breastfeeding is 12.41 months. In this particular case the median survival time for lactation is substantially longer than the median for amenorrhea. This means that the end of the amenorrheic state among urban women in Bolivia occurs while they are still breastfeeding their children, a very common situation at the individual level when longer duration of breastfeeding is accompanied with supplemental food, such as fluids by bottle and solids. Clearly, lactation cannot be a reliable contraceptive method for every individual woman.

In the same table, the breastfeeding variables show that women who weaned their last child resume menses earlier than women who were still breastfeeding them at the time of the survey. The estimated waiting times for these cases are 6.03 and 11.91 months, respectively. On the other hand, the higher the frequency of breastfeeding, the longer median duration of amenorrhea. The median duration of amenorrhea among mothers who breastfed on demand (13 or more times a day) is almost four months longer than among women who did five or less times a day. We found that in mothers with the lowest frequency of lactation a day the anovulatory period lasts approximately 8.02 months; while in mothers with the highest frequency this period tends to last 12.69 months. The duration of breastfeeding also increases as the frequency of nursing increases. Therefore, in women with the longest total duration of breastfeeding, the periods of intense lactation that cause prolonged anovulatory periods tend also to be longest.

Figure 3 illustrates the patterns for resumption of menstruation and weaning for all women in the study. As we can see, the survival function for amenorrhea lags many months behind the survival function of breastfeeding. That is, the proportion of women who has not yet weaned is greater than

the corresponding proportion of women that has not yet menstruated at every monthly duration at least during the first 24 months.

In Figure 4, the survival functions for amenorrhea are shown for women who weaned and were still breastfeeding by the time of the interview. As we expected, the functions also decrease steadily over time and women who weaned resume menses faster than those still breastfeeding. For instance, 75 percent of those women who were still breastfeeding resumed menses by the sixth month, 50 percent by the eleventh month, and only 25 percent by the nineteenth month. Among women who had completed weaning before the date of the survey, these quartiles are reached in second, fifth, and twelfth months.

In Figure 5 the effects of frequency of breastfeeding on the duration of amenorrhea are shown. Women who had breastfed their children less frequently have the fastest resumption of menses during the first three months; after that point the rate of increases of the survival function tends to slow down considerably. In the other extreme, women who breastfed on demand resumed menses more slowly, and the rates of returning to menstruation are lower than those in the other two curves. The lowest quartile is reached by month 7 among women with low frequency of breastfeeding, by month 11 among intermediate frequency, and by month 12 among high frequency. In the upper quartile the differences in terms of duration are small among the three groups. However, the survival functions for low and high frequency breastfeeding women are completely different between the first and eleventh month, and they present a similar pattern in the remaining months. It is a remarkable fact that by month 22 there are no women still amenorrheic among those who breastfed less frequently.

Thus, it seems that the association between lactation and prolonged amenorrhea is due not only to the direct effect of duration of breastfeeding but to the correlation between frequency of breastfeeding in the early months and its overall duration.

Demographic covariates

From Table 1, we also can see that the duration of postpartum amenorrhea varies according to specific demographic and socioeconomic characteristics of the women under study.

As expected and observed in other studies, increasing parity and age of the mother at birth are associated with increasing durations of amenorrhea. The median duration for women with only one child is about 5.31 months; when the woman has from two to four children the median duration is 6.68 months; while for women with five or more children the duration is 9.24 months. The median survival time among younger women (under age 30) is 6.71 months and for the older ones (30 years or above) is 7.76 months.

No significant variation was found in the duration of amenorrhea postpartum for infant mortality. Whether the child was alive or dead by the time of the survey makes little difference in the resumption of menses; in this particular case, despite the important differences found in the duration of breastfeeding: 12.51 months for children alive and 6.37 for those who were dead. This lack of variability in amenorrhea can be verified by looking at Figure 6. Here, the amenorrhea survival functions have almost the same shape and several points of intersection; that is, they are not clearly differentiated.

Finally, whether the woman uses contraception affects the length of the amenorrhea postpartum. Those who have used any contraceptive method after having their last child tend to have shorter amenorrheic periods than women who never used it. As we can see in Table 1, non users

resume menses 6.99 months after childbirth, while users do after 3.92 months. In Figure 7, the amenorrhea survival functions for groups of women are quite different from each other, and it is clear that women who used contraception have, in fact, faster resumption of menstruation.

Socioeconomic covariates

The median duration of amenorrhea post-partum for women with lower education (six or less years at school) is 9.66 months, compared to 5.03 months for women with higher levels of education (seven or more years of formal education). This differential may suggest that mothers with low education who could be in poorer economic and nutritional conditions and continuous episodes of intense breastfeeding resume menses later than women in better social and economic conditions. Figure 9 shows that more highly educated women have more rapid return of menses than the less educated ones at every duration post-partum. The most important differences are produced during the first 18 months.

The second socioeconomic variable included in the analysis is the city where the woman was living during the five years before the survey. As we can see in Table 1, women who live in La Paz city have the longest duration of amenorrhea post-partum (9.26 months), followed by women who lived in Cochabamba city (6.73 months) and by those resident in Santa Cruz city (4.04 months). The survival functions (Figure 9) reflect these differences between the first and eleventh months of duration. After the seventeenth month, the curves for women in Cochabamba and Santa Cruz have intersected and the survival function of Santa Cruz remains slightly higher than Cochabamba.

Bolivia is divided into three large and distinct ecological regions, with striking economic, cultural, racial, and climatic diversity. The core region is the high plain (Altiplano) situated within the Andean Mountains at heights over 12,500 feet. The largest city in this region is La Paz. Towards

the east, one descends into another region of semitropical valleys, with Cochabamba as the most important city. Continuing east, Bolivia spreads out into the lowlands (Llanos) of the Amazon basin. In this region Santa Cruz is the largest city.

Despite the ecological differences among these three regions, economic, demographic, and cultural differences are even more important. La Paz has been characterized as a traditional society, and Santa Cruz as a modern one. Cochabamba lies between these two types. Santa Cruz has, for example, the highest level of fertility, the lowest levels of infant mortality, marital unions begin earlier, educational level are higher, sexual relations resume a few months after childbirth, women use modern contraceptive methods more extensively, they have better jobs, and, in general women's status has improved as a result of the economic success that the region has attained. La Paz is exactly the opposite, with more traditional characteristics, and Cochabamba lies between the two.

Therefore, in Santa Cruz city breastfeeding traditions have been eroded among the younger and most modernized segments of this population. Thus the length of amenorrhea is more likely to decrease as modernization proceeds.

To conclude, as we expected, there are clear differences in the duration of postpartum amenorrhea and breastfeeding for each variable considered in the analysis. That is, women with longer waiting times of lactation have greater periods of amenorrhea after childbirth. Therefore, there appears to be associations among these biodemographic events.

PROPORTIONAL HAZARD ESTIMATES

The simultaneous and independent effects that the covariates considered in the analysis have on the resumption of menses can be assessed through the proportional hazard regression model. The coefficients associated with the covariates describe the relationship between them and the risk of

resuming menses at every time t . Their interpretation as a value is rather difficult, but their signs give us sufficient information about the direction in which the risk is changing. A positive coefficient indicates an increase in the risk of resuming menses, and a negative one means a decrease in the risk. Further, by exponentiating these regression coefficients we are able to calculate the relative risks associated with the covariate in question. Values greater than one mean that the relative risk of returning to menses postpartum is greater for this group when compared with the reference group. Values less than one indicate the risk is lower for the group being analyzed when compared with the baseline group.

For example, in Table 2 for the variable "frequency" of breastfeeding the baseline group is the third one, high frequency of breastfeeding, and the relative risk of resuming menses in any given month for the first category is 1.6096, after controlling for all covariates included in the model. This means that the risk of returning menses is 1.61 times higher for women with less frequency of breastfeeding (1 to 5 times a day) than those women with high frequency (more than 12 times a day). That is women who breastfed less frequently have a 60 percent higher risk of resuming menses than those who breastfed more frequently.

Five proportional hazard models were fitted, each one with additive effects among their independent variables. In the first one (Table 2), the main effects of the two breastfeeding variables (duration and frequency of lactation) are considered simultaneously. The second model (Table 3) considers in addition several demographic covariates. The third model (Table 4) includes both lactational and socioeconomic variables. The fourth model (Table 5) includes both demographic and socioeconomic variables simultaneously. Finally, the fifth model (Table 6) is estimated with all the variables defined in the study. Various models with interactions among the independent variables

were fitted, but since the results were not statistically significant, they are not included in the analysis.

This strategy is followed in order to evaluate the strength of the relationship between the duration of postpartum amenorrhea and breastfeeding patterns under two different situations, with and without controlling for the demographic and socioeconomic individual variability. At the same time, it allows us to determine the independent effect that socioeconomic variables have on the waiting time of amenorrhea once breastfeeding variables have been controlled

Model 1: The effects of breastfeeding variables

The regression results for the main effects of breastfeeding variables are given in Table 2. As we can see, the strongest effects on the time to the first menses after childbirth are the duration of breastfeeding (the end of lactation). At every different failure time the instantaneous hazard of the return of menses for a non-lactating woman, at the time of the survey, is 2.09 times greater than for a woman who was still breastfeeding at the time of the survey, controlling for the frequency of nursing.

As we expected, the frequency of breastfeeding variables also have significant effects on the dependent variable. At each postpartum duration, women who breastfed their children no more than five times a day experienced a significantly earlier resumption of menstruation than those who nursed them either between 6 and 12 times a day or on demand (more than 12 times a day). The effect of infrequent feeding on the risk of menstruation after childbirth in any given month is 1.61 times the risk of those mothers who breastfed their offspring with the highest frequency. For the intermediate group the risk is only 1.25 times that of the reference group. In other words: the higher

the frequency of nursing episodes per day, the lower the risk of earlier return of menses. Therefore, the frequency of breastfeeding is inversely related to the hazard of resuming postpartum menses.

These results are in general agreement with those found in other studies. They show that the effect of duration of breastfeeding and the frequency of nursing are important in delaying the resumption of ovulation, and thus the return of menses postpartum for the urban Bolivian mothers under study.

A higher frequency of nursing episodes per day means that the suckling by the infant stimulates more frequently the neural receptors located in the breast nipple, initiating a chain of neuroendocrine stimulation which disrupts the ability of HPG to maintain a normal pattern of GnRH and LH secretions. As the frequency and intensity of lactation decrease, the average levels of FSH are sufficient to begin to induce follicle growth and allow for the generation of the normal preovulatory LH surge, which varies from woman to woman. Only then can ovulation take place, with the formation a normal corpus luteum, and menstruation resume.

It has been found that a suckling frequency of more than 5 times a day and a duration of 10 minutes per feed each day were sufficient to sustain total suppression of ovarian activity for almost one year (Howie and McNeilly, 1982). These authors believe that such suppression could continue indefinitely if high frequent and intense suckling are maintained.

On the other hand, lower frequencies of breastfeeding are strongly associated with the introduction of supplementary food (solid or liquid). This implies a reduction in the nursing episodes per day as well as in the duration of each one, and consequently a reduction in the suckling frequency. Thus, an early return to ovulation and menses are more likely to occur.

Having found that the median duration of breastfeeding is greater than the median duration of amenorrhea, in the Bolivian case, we could easily conclude that prolonged lactation does not guarantee longer amenorrheic periods. Such a situation probably emerges when women supplement breastfeeding with bottle-feeding. Under that condition, the ovulatory suppressing effect of breastfeeding is weakened because the infant on mixed feeding tends to suckle less frequently and intensely. Thus, either partial or total introduction of supplementary food reduces the length of the amenorrheic period through the frequency of nursing.

Consequently, while duration of breastfeeding is highly associated with the duration of amenorrhea, the frequency of nursing is very important in sustaining postpartum amenorrhea. That is, the period of lactational amenorrhea depends on the duration of the breastfeeding as well as on the suckling frequency. And the introduction of supplements too early is detrimental for amenorrhea duration.

However, there are various factors that could modify weaning and suckling patterns in different ways and therefore, the resumption of menses. Socioeconomic, cultural, and behavioral factors influence a woman's decision to initiate and terminate breastfeeding. For instance, mothers who are too young are more likely than older women to wean their children early because of the lack of experience in bearing a child or because they frequently resume their sexual relations earlier. Educated women tend to use bottles and pacifiers more often than women with lower education, probably because they work far from their homes or they have more modern attitudes towards lactation. Educational processes, through formal schooling or media consumption may weaken traditions and customs to create a "modern" perspective on the world in which people expect more

behavioral changes. Those mothers with higher education become aware of greater personal opportunities, and have more access to health services and modern forms of contraception.

Malnourished mothers produce smaller quantities of milk, thus their hungrier children will suckle more frequently. These mothers are also unable to afford supplemental feeding. Cultural practices may also influence weaning time when, for example, the infant is walking, or when his/her first tooth appears, and so on. Therefore, such socioeconomic factors have to be included in the analysis to avoid spurious relations and confounding effects.

Model 2: Breastfeeding and demographic variables

The results of the regression performed with lactational and demographic variables simultaneously are presented in Table 3. As we can see, the improvement in the fit attributable to the demographic covariates is significant. The global chi-square increases from 70.80 in the first model to 100.26 in the second one.

First, the strongest determinant of the time to first menstruation is still the duration of breastfeeding. At each failure time the instantaneous hazard of resuming menses for a woman who weaned her children before the date of the survey is 2.07 times higher the hazard for a woman who was still breastfeeding by the time of the interview.

The risk for a low frequency nursing woman is 1.51 times as large as the risk for a high frequency nursing woman, while the intermediate frequency category has a risk 1.23 times higher than the baseline one. However, if we compare these values with those found in the first model, controlling for demographic variables has produced a slight reduction in the relative risk associated with these breastfeeding factors. The most important change can be observed in the lower frequency nursing group.

Second, all breastfeeding factors are still highly significant after introducing the demographic covariates, despite changes observed in the size of the coefficients. These changes suggest that the role of the breastfeeding variables in the resumption of menses may mediate the effect of the demographic covariates.

All parity levels have significant independent effects on the instantaneous probability of resuming menses in this model. In fact, mothers with only one child have a risk of resumption of menses which is 66.20 percent higher than mothers with five children or more, while the risk of menstruation for mothers with two, three, or four children is 32.70 percent higher than the risk observed for mothers in the baseline group for parity. This relation was also found in other studies (Huffman, 1978; Pinto et al., 1998). That is, high parity levels are associated with longer amenorrhea. This relation could be reflecting the effect of some biological factors, unrelated to lactation, which may be present in the hormonal mechanism responsible for menstruation and ovulation. For example, women who have a birth for the first time are subject to irregular and fluctuating menstrual cycles, and menstrual bleeding for few days after childbirth is very common among them. Also primiparous women are more likely to be young.

The second demographic covariate included in the model is the age of the mother at birth. This variable was found not to be statistically significant at the usual levels of significance. However, this does not mean that age's mother has no effect on the length of postpartum amenorrhea. Probably we need other categories for this variable. The contradictory result found shows that younger age (less than 30 years) reduces the risk of resumption of menses. In other words, amenorrhea resumed much faster in older women. Different studies have found that older age decreases the risk of earlier return

to menses (Jones, 1988; Huffman, 1978). Therefore, the independent effect of age was probably captured in part by socioeconomic factors, not included in Model 2.

The effect of infant mortality is not significant at all, because its biological effect on the length of amenorrhea postpartum operates through the premature termination of breastfeeding. The statistic used to perform the correspondent test of significance is quite small (0.4203). This relation has been reviewed, modeled, and estimated by different authors. They found that the effects of a child death on subsequent fertility are very important (Potter, 1963; Sheps and Perrin, 1964; Cochrane and Zachariah, 1983; Pinto, 1994).

Finally, women who used contraception after the reference live birth were found to be subject to a hazard of resumption of menstruation 1.39 larger than those women who never used any contraceptive method. Similar effects were found in a study in central Java (Santow, 1987).

There are two ways the use of contraception may affect the resumption of menses. The first one is an indirect biological effect through breastfeeding. During the period of gestation, despite the high levels of prolactin, little or no breast milk is formed until delivery occurs. This absence of milk during pregnancy is due to the inhibiting effect of the estrogen hormone, which blocks the action of prolactin in the breast. This inhibiting effect is only removed when the estrogen levels decline after childbirth, thus allowing the initiation of lactation (McNeilly, 1977). Therefore, synthetic estrogens as those contained in many contraceptives would reduce drastically the output milk in a lactating woman and thus suppress lactation. The second one is the independent effect, which is associated with other biological mechanisms not well understood.

The association between contraception and amenorrhea can also be explained in a different way. The use of any contraceptive method is a good indicator of the resumption of normal sexual

relations, especially if women want protection against a subsequent pregnancy. However, when this occurs in many traditional societies children begin to be weaned and therefore the intensity of nursing decreases notably. That is, the erosion of postpartum sexual abstinence may really produce shorter durations of breastfeeding and earlier resumption of menses, and not the use of contraception. Since we are not controlling for socioeconomic factors, some of its effect may be confounded with those effects associated with socioeconomic covariates.

Model 3: Breastfeeding and socioeconomic covariates

Along with breastfeeding variables, two socioeconomic covariates are taken into account in the third model (Table 4). The improvement of fit is considerable, the global chi-square increases from 70.80 in model 1 to 121.97. The socioeconomic covariates included (mother's education and city of residence) are all highly significant, according to the respective test of significance.

We can see that when education and city of residence of the mother are added to our baseline model (Model 1), the breastfeeding variables reduce their net effects on the resumption of menses. The coefficient estimated in the third model is smaller than those found in the first model. The most important reductions occurred in the frequency of nursing and not in breastfeeding duration. Although there are observed reductions in the effects of breastfeeding variables, they are still significant but at lower levels.

The changes observed in the relative risk due to breastfeeding variables after controlling for socioeconomic covariates suggest that the effects of lactational variables on the resumption of menses may mediate the effect of mother's education and the city of residence, which could reflect the socioeconomic status of the mother and different cultural backgrounds that affect suckling pattern and norms about the timing of weaning.

In Model 3 (Table 4), the second important effect on the return of menses is related to mother's education. Women with low formal education experienced a significantly later return of menstruation than women with at least some secondary schooling. At any given month, women with lower education were subject to a hazard 0.66 as great as were women with high education, other characteristics being the same. That is, the risk of resumption of menses for mothers with 6 or less years of education is 34.2 percent lower than the risk observed in women with high education.

The fact that increasing education increases the risk of resuming menstruation earlier may reflect both cultural practices and the economic condition of the woman, such as women's work status, and family income (not considered among the socioeconomic variables). In general, for the Bolivian case, women with low education tend to have the worse economic and nutritional conditions. Malnourished mothers produce less breast milk than normal women, so their children need to suckle more frequently to satisfy their basic requirements. This situation is commonly reinforced by the poor economic condition of the mother and her family, which does not allow them to afford supplementary feeding (not included among the breastfeeding variables). The result is a much longer period of postpartum amenorrhea.

Finally, the city of residence was found to have a significant independent effect on the risk of resumption of menses among urban women in Bolivia. The mechanisms underlying this effect are not clear at all. As we can see in Table 4, women who live in La Paz and Cochabamba city have a relative risk of resuming menses 0.66 and 0.81 as great as their counterparts in Santa Cruz, respectively. Stated in other terms, the risk of returning earlier to menses at any given month for woman in La Paz is about 34 percent lower than the risk experienced by a woman in Santa Cruz city.

For women who live in Cochabamba the risk of first menstruation after birth is about 20 percent lower than the risk experienced by women in Santa Cruz.

Model 4 and Model 5: Breastfeeding, demographic, and socioeconomic covariates

The results of the regression performed with all covariates simultaneously are presented in Table 5. As we can see, there is a noticeable improvement in the fit. The global chi-square is now 138.81, which is highly significant.

First, the most important determinant of the time to the first menstruation is still the duration of breastfeeding. In fact, at every failure time the hazard rate of resuming menses for non-breastfeeding women is about 91 percent higher than the hazard for women who were still nursing their off-spring, after controlling for all the other demographic and socioeconomic factors. However, in the baseline model this value is about 108.7 percent (Model 1, in Table 2).

The frequency of nursing factors also remain significant but at lower levels. The relative risk for low frequency breastfeeding women is 1.3314, after controlling for the different factors. In Model 1, without such controls, the relative risk is 1.6096, always in relation to the higher frequency. For the intermediate group, the changes go from 1.2498 in Model 1 to 1.1361 in the Model 4.

The observed reduction in the coefficients of the breastfeeding variables, after adjusting for other variables, means that some demographic and socioeconomic covariates are actually confounding variables.

Among the demographic covariates, parity and use of contraception are significant. Infant mortality still remains without any independent effect on the resumption of menses, and mother's age varies again indirectly with the risk of early return to menses (Table 5). After controlling for all the

other socioeconomic and lactational variables, the demographic variables show a reduction in their respective regression coefficients, in comparison with Model 2.

In Model 4, socioeconomic factors seem to have captured most of the effect lost by breastfeeding variables. In fact, mother's education and city of residence still have significant effects on the risk to return of menstruation after controlling for the breastfeeding variables, and they have changed very little. This can be seen by comparing the change in their respective coefficient when are compared with those estimated in Model 5 (Table 6). However, not only the socioeconomic factors have independent effects on the resumption menses but also parity and use of contraception, after controlling for all the variables defined in this work.

The effects of parity and conception are clearly biological; however the independent effects of the socioeconomic covariates are due to the lack of specification of other social factors, such as woman's work status, family income, etc., and/or other breastfeeding variables, such as intensity of lactation, duration of full breastfeeding, etc. Errors in the measurement of the lactational variables may also be an important cause for the existence of independent effects among socioeconomic variables on the resumption of menses.

The effect of maternal education may act through the intervening variables such as women's employment status, family income, and socio-cultural factors. There are many factors that could affect the relationship between female employment and the prevalence of breastfeeding: place of the work, type of the work, and the existence of alternatives for child care. The place and type of work influence lactation by affecting the access to the infant as well as the time available with him. It seems that breastfeeding is more compatible with part-time work or work that has much flexibility in scheduling adequately the hours of work, for instance, when women work at home or can easily

alternate household activities with her formal work. In a country like Bolivia, one could expect little conflict between work and lactation because of the small proportion of women involved in formal activities. More than a half of the female labor force in urban areas is incorporated in the informal sector.

Formal education in Bolivia during the last two decades has been one of the major agents of socialization beyond the family and has changed traditional beliefs and values, especially in the urban areas. For instance, in these areas the supporting social network that promotes breastfeeding is not available as it is in rural areas. Additionally, it seems that changes in breastfeeding behavior, as that produced by modernization, are caused by social, cultural, and economic influences on parental attitudes.

On the other hand, women in rural areas are more likely to initiate lactation and breastfeed their offspring for longer durations than women in urban areas. However, the reasons why the level of urbanization is strongly associated with lower prevalence of lactation remain unclear.

V. CONCLUSIONS

Both theoretical and empirical evidence indicates that longer and more frequent breastfeeding may increase the length of the anovulatory period, and therefore the waiting time to resumption of menses. The biological evidence shows that prolonged lactation suppresses the production of certain types of hormones and thereby extends postpartum anovulatory periods. On the other hand, different demographic, socioeconomic, and cultural factors reinforce the effect of breastfeeding on the resumption of menses.

By large, in this study, our findings are in agreement with those found in other studies in both developed and developing countries.

First, duration of breastfeeding along with the frequency of nursing is the major determinant of prolonged anovulation and post-partum amenorrhea in urban Bolivian women. The effect of both variables remains significant before and after controlling for different demographic and socioeconomic covariates. With all other factors being equal, women who wean their children or nurse them a few times a day, increase their risk of early resumption of menses in comparison with those who were still breastfeeding and nursing their offspring more frequently.

Therefore, it is clear that breastfeeding and amenorrhea are highly correlated and that lactation suppresses ovarian activity, and thus menstruation.

Second, among the demographic covariates two important variables were associated with resumption of menses: parity and use of contraception. Increased parity substantially reduces the risk of resuming menses after controlling for all the other factors. The use of contraception also increases the risk of resuming menstruation earlier. That is, women who used contraceptive methods were more likely to resume menses than women who did not use contraception.

Despite the importance of infant mortality in the determination of the amenorrheic period, we found that this variable is not significant at all. It seems that its effect is absorbed totally by breastfeeding variables.

The direction of the relation between age of the mother at birth and duration of amenorrhea is inconsistent with the results obtained in other studies. Younger urban Bolivian women tend to resume menses later than older women.

Third, the socioeconomic covariates are highly significant in all models. Mother's education is negatively associated with the duration of amenorrhea. That is, women with at least secondary schooling have greater probabilities of earlier resumption of menstruation than those with lower formal education, after controlling for all the remaining variables. Also, the city of residence also has an important effect on the waiting time of postpartum amenorrhea. Unmeasured factors such as work status and economic situation of the women, nutritional status, and cultural values and attitudes are probably reflected in these two socioeconomic factors.

Despite the results obtained in this study, breastfeeding cannot be expected to automatically reduce fertility in all circumstances for individual women, particularly among the most modern segments of the population. Lactation is not highly reliable as a contraceptive method at the individual level, but it has a significant effect at the societal level, especially in countries where the practice of contraception is not widespread.

Knodel (1977) estimated that the substitution of bottle-feeding for breast-feeding in the absence of any contraceptive practice would reduce the average birth interval by 14 percent in a population where breastfeeding is associated with an amenorrheic period that lasts on average 5 months. At the other extreme, in any population where amenorrhea among lactating woman is close to 18 months, the average birth interval may be reduced by 40 percent. Reductions by these amounts are equivalent to an increase in fertility by 16 and 64 percent, respectively.

In consequence, breastfeeding patterns (duration and frequency of lactation) are important factors in controlling fertility in developing countries. On the other hand, postpartum infertility associated with the practice of breastfeeding is a major determinant of spacing between births, which reduces the overall fertility levels. Thus, a major factor affecting fertility is postpartum infecundity,

which depends on the length of amenorrhea following childbirth to the onset of ovulation, or on the period of postpartum abstinence following a birth, when the abstinence is prolonged beyond the onset of ovulation.

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Table 1. Life tables estimates of the duration of post-partum amenorrhea and breastfeeding among urban Bolivian women by different covariates.

Variables	Duration (In months)		Sub Populations (%)
	Amenorrhea	Breastfeeding	
BREASTFEEDING VARIABLES			
Non-lactating woman	6.03	11.13	77.6
Still breastfeeding	11.91	36.00	22.4
Frequency			
1 - 5	3.58	8.02	10
6 - 12	6.25	12.24	32.8
13 +	8.17	12.69	57.2
DEMOGRAPHIC COVARIATES			
Parity			
1	5.31	12.28	29.8
2 - 4	6.68	12.29	50.4
5 +	9.24	12.84	19.8
Mother's age			
Less than 30	6.71	12.37	45.7
30 +	7.76	12.49	54.3
Infant mortality			
Alive	6.75	12.51	91
Died	6.35	6.37	9
Use of contraception			
Yes	3.92	8.60	11.8
No	6.99	12.85	88.2
SOCIOECONOMIC COVARIATES			
Mother's education			
Lower	9.66	13.45	40.8
Higher	5.03	10.90	59.2
City of residence			
La Paz	9.26	15.85	40
Cochabamba	6.73	12.05	26.5
Santa Cruz	4.04	11.13	33.5
TOTAL	6.73	12.41	N= 1,001

Table 2. Effects of breastfeeding variables on the duration of post-partum amenorrhea: Proportional hazard estimates. Model 1.

Variables	Coefficient	Standard error	Statistic	Relative risk
BREASTFEEDING VARIABLES				
Duration	0.7359	0.1122	6.5588	2.0874
Frequency				
1 - 5	0.4760	0.1242	3.8325	1.6096
6 - 12	0.2230	0.0792	2.8157	1.2498
13 +	-	-	-	1.0000
Log-likelihood	-4482.97			
Global chi-square	70.80			
d.f.	3			

Table 3. Effects of breastfeeding and demographic variables on the duration of post-partum amenorrhea: Proportional hazard estimates. Model 2.

Variables	Coefficient	Standard error	Statistic	Relative risk
BREASTFEEDING VARIABLES				
Duration	0.7283	0.1157	6.2947	2.0716
Frequency				
1 - 5	0.4104	0.1253	3.2753	1.5074
6 - 12	0.2031	0.0795	2.5547	1.2252
13 +	-	-	-	1.0000
DEMOGRAPHIC COVARIATES				
Parity				
1	0.5080	0.1224	4.1503	1.6620
2 - 4	0.2829	0.1073	2.6365	1.3270
5 +	-	-	-	1.0000
Mother's age				
Less than 30	-0.1109	0.0728	-1.5234	0.8950
30 +	-	-	-	1.0000
Infant mortality	0.0907	0.2158	0.4203	1.0949
Use of contraception				
Yes	0.3307	0.1100	3.0064	1.3919
No	-	-	-	1.0000
Log-likelihood	-4468.93			
Global chi-square	100.26			
d.f.	8			

Table 4. Effects of breastfeeding and socioeconomic variables on the duration of post-partum amenorrhea: Proportional hazard estimates. Model 3.

Variables	Coefficient	Standard error	Statistic	Relative risk
BREASTFEEDING VARIABLES				
Duration	0.6620	0.1133	5.8429	1.9387
Frequency				
1 - 5	0.3121	0.1272	2.4536	1.3663
6 - 12	0.1236	0.0677	1.8257	1.1316
13 +	-	-	-	1.0000
SOCIOECONOMIC COVARIATES				
Mother's education				
Lower	-0.4179	0.0776	-5.3853	0.6584
Higher	-	-	-	1.0000
City of residence				
La Paz	-0.4152	0.0883	-4.7022	0.6602
Cochabamba	-0.2171	0.0935	-2.3219	0.8048
Santa Cruz	-	-	-	1.0000
Log-likelihood	-4456.60			
Global chi-square	121.97			
d.f.	6			

Table 5. Effects of breastfeeding, demographic, and socioeconomic variables on the duration of post-partum amenorrhea: Proportional hazard estimates. Model 4.

Variables	Coefficient	Standard error	Statistic	Relative risk
BREASTFEEDING VARIABLES				
Duration	0.6452	0.1162	5.5525	1.9064
Frequency				
1 - 5	0.2862	0.1276	2.2429	1.3314
6 - 12	0.1276	0.0722	1.7673	1.1361
13 +	-	-	-	1.0000
DEMOGRAPHIC COVARIATES				
Parity				
1	0.4054	0.1287	3.1500	1.4999
2 - 4	0.2258	0.1124	2.0089	1.2533
5 +	-	-	-	1.0000
Mother's age				
Less than 30	-0.1729	0.0913	-1.8938	0.8412
30 +	-	-	-	1.0000
Infant mortality	0.1570	0.2163	0.7258	1.1700
Use of contraception				
Yes	0.2617	0.1115	2.3471	1.2991
No	-	-	-	1.0000
SOCIOECONOMIC COVARIATES				
Mother's education				
Lower	-0.3381	0.0855	-3.9544	0.7131
Higher	-	-	-	1.0000
City of residence				
La Paz	-0.4326	0.0889	-4.8661	0.6488
Cochabamba	-0.2572	0.0948	-2.7131	0.7732
Santa Cruz	-	-	-	1.0000
Log-likelihood	-4448.40			
Global chi-square	138.81			
d.f.	11			

Table 6. Effects of demographic, and socioeconomic variables on the duration of post-partum amenorrhea: Proportional hazard estimates. Model 5.

Variables	Coefficient	Standard error	Statistic	Relative risk
DEMOGRAPHIC COVARIATES				
Parity				
1	0.3920	0.1286	3.0482	1.4799
2 - 4	0.1834	0.1114	1.6463	1.2013
5 +	-	-	-	1.0000
Mother's age				
Less than 30	-0.1885	0.0913	-2.0646	0.8282
30 +	-	-	-	1.0000
Infant mortality	0.4031	0.2101	1.9186	1.4965
Use of contraception				
Yes	0.2774	0.1113	2.4924	1.3197
No	-	-	-	1.0000
SOCIOECONOMIC COVARIATES				
Mother's education				
Lower	-0.3811	0.0849	-4.4888	0.6831
Higher	-	-	-	1.0000
City of residence				
La Paz	-0.5090	0.0875	-5.8171	0.6011
Cochabamba	-0.2510	0.0938	-2.6759	0.7780
Santa Cruz	-	-	-	1.0000
Log-likelihood	-4466.23			
Global chi-square	94.62			
d.f.	8			

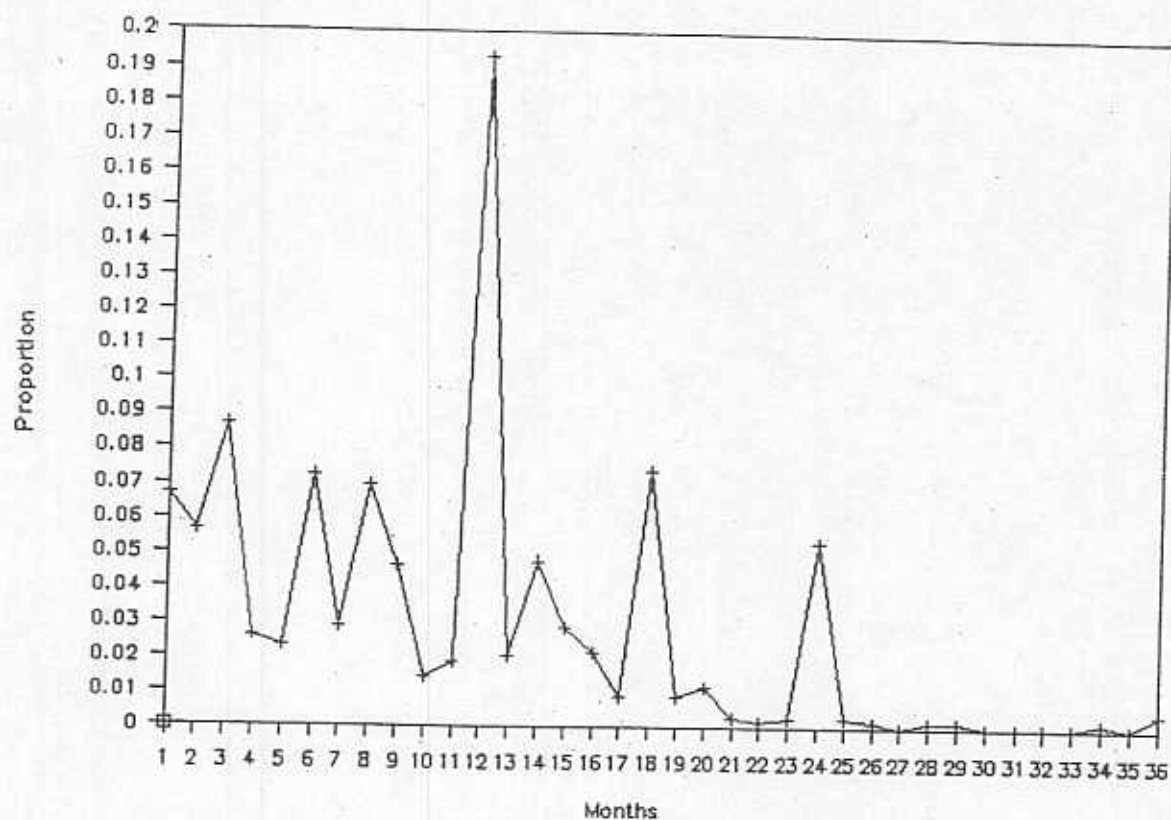


Figure 1. Retrospectively reported breastfeeding durations. Percentage distribution of women by reported duration of breastfeeding following their last live birth. Bolivia.

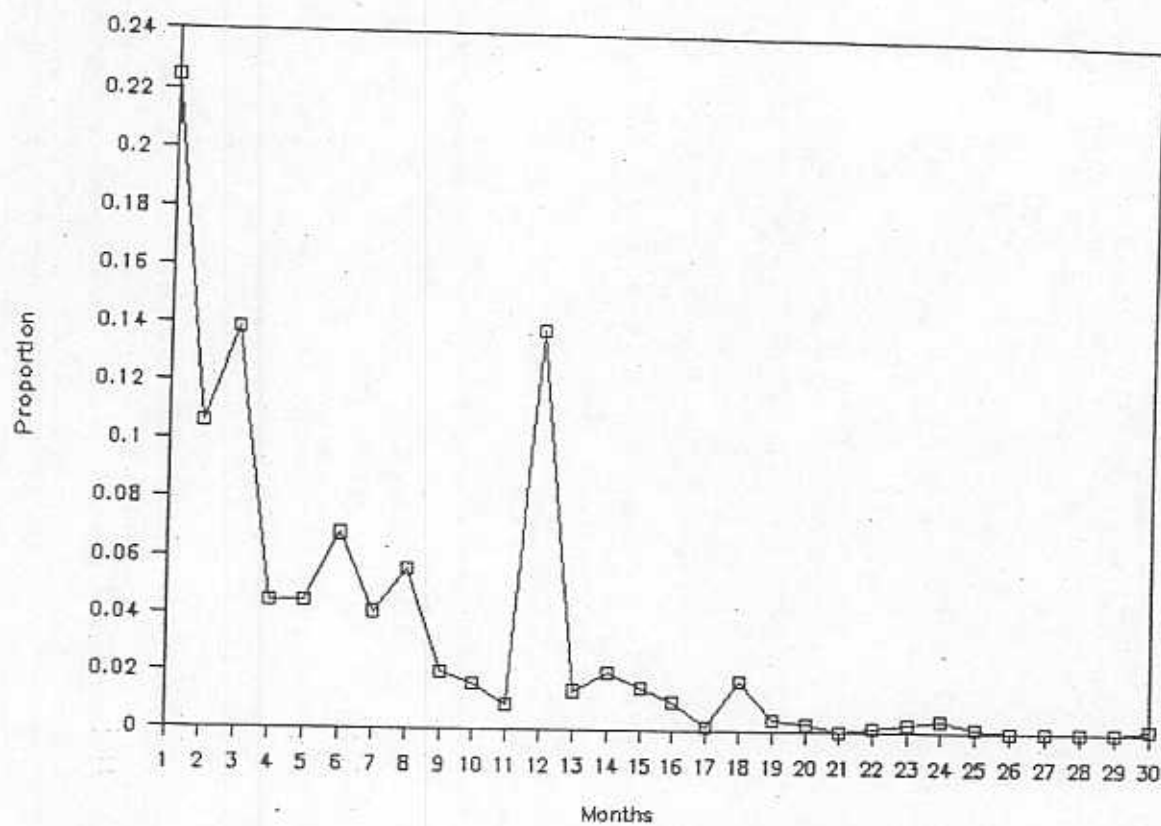


Figure 2. Retrospectively reported amenorrhea post-partum durations. Percentage distribution of women by reported duration of amenorrhea following their last live birth. Bolivia.

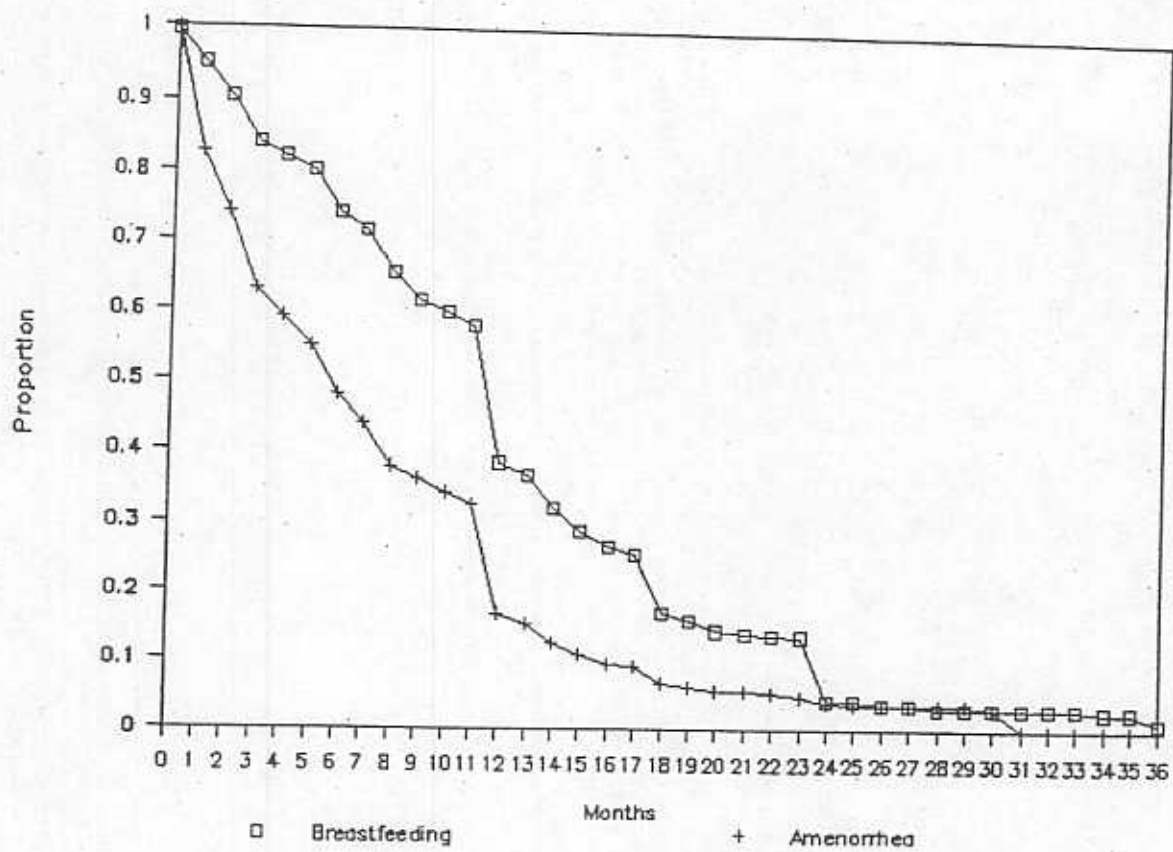


Figure 3. Survival functions for women who breastfed and were amenorrheic at different months of post-partum duration. Bolivia.

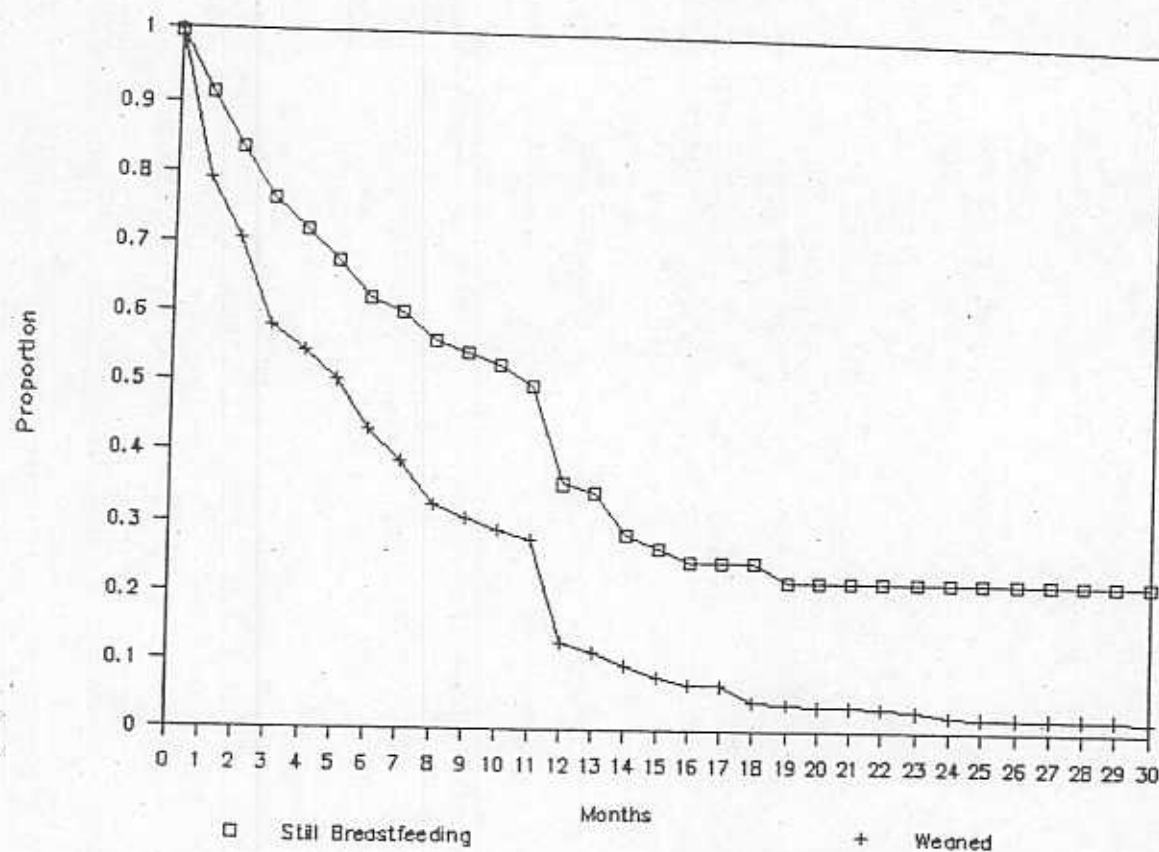


Figure 4. Survival functions for women by post-partum amenorrhea of those who were still breastfeeding and weaned their children at different months of post-partum durations. Bolivia.

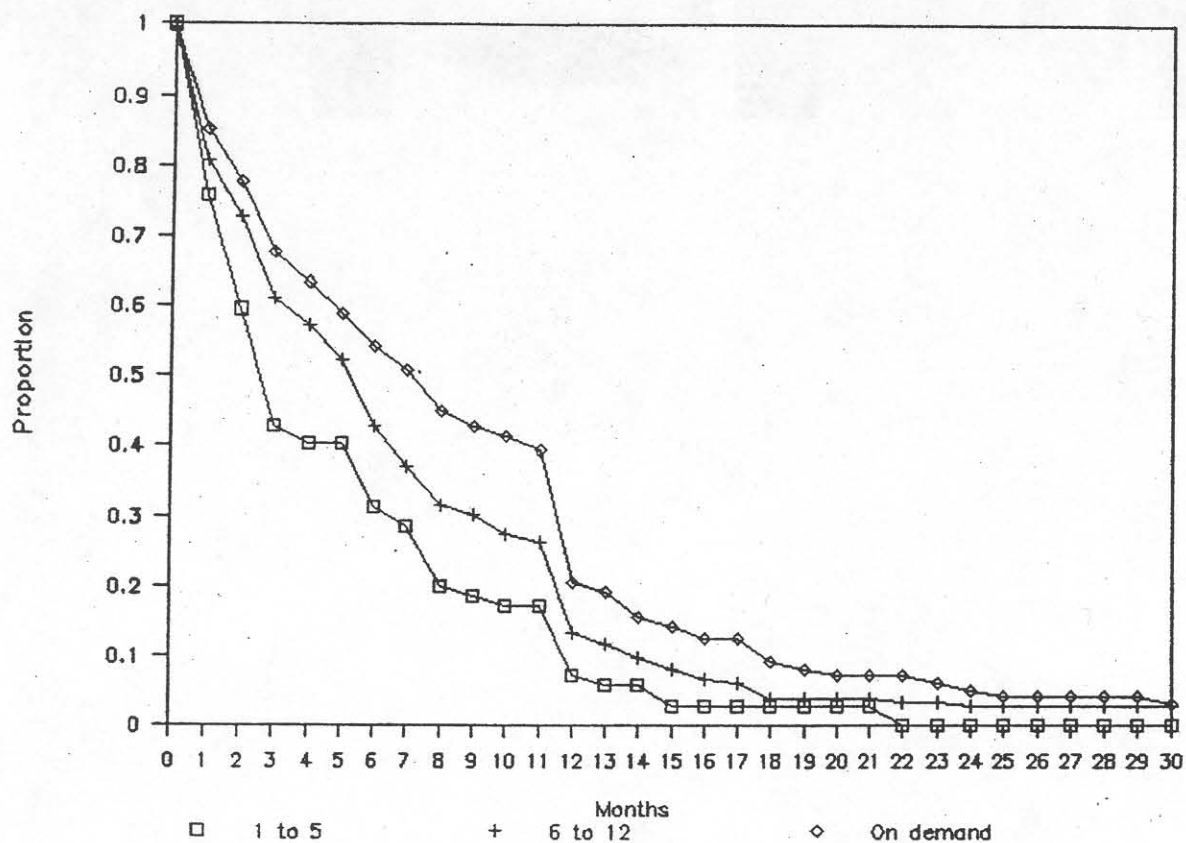


Figure 5. Survival functions for women by post-partum amenorrhea of those women who nursed their children between 1 to 5 times a day, 6 to 12 times a day, and on demand at different months of post-partum durations. Bolivia.

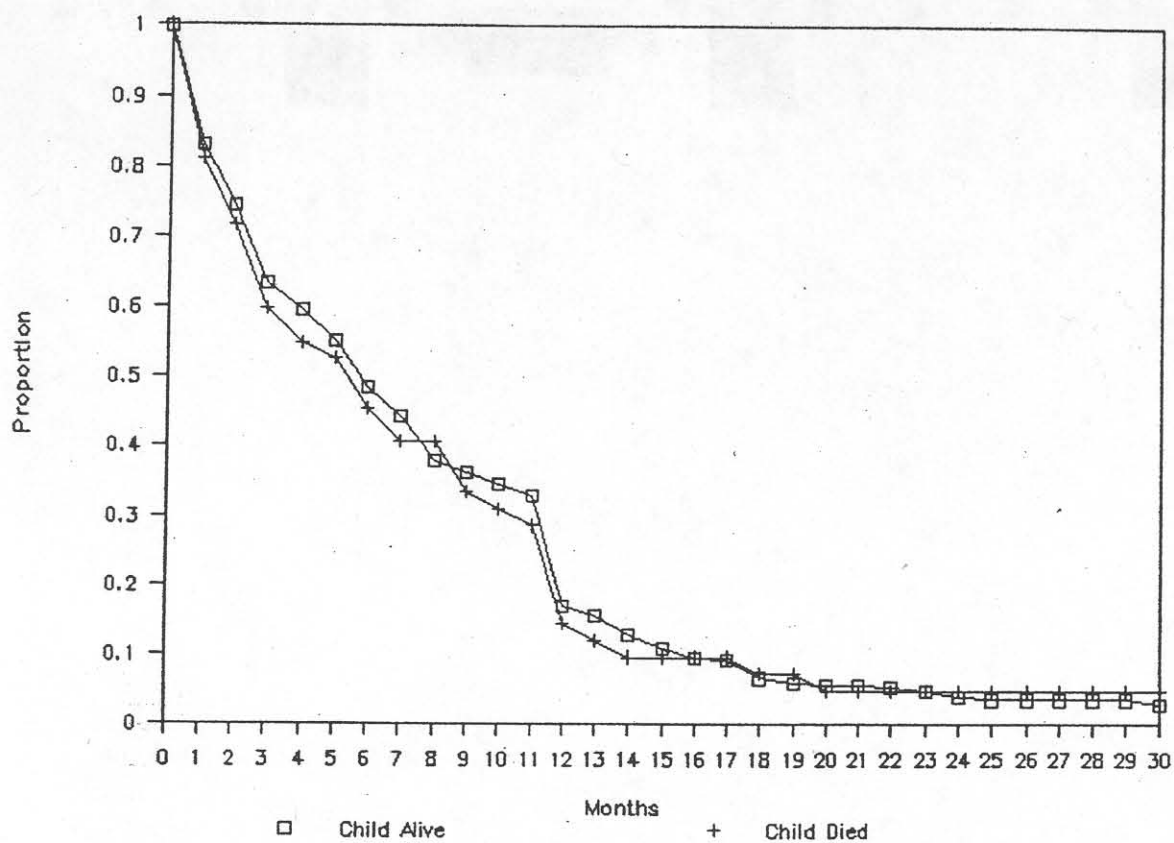


Figure 6. Survival functions for women by post-partum amenorrhea of those women whose last child is still alive and those whose last child died at different months of post-partum durations. Bolivia.

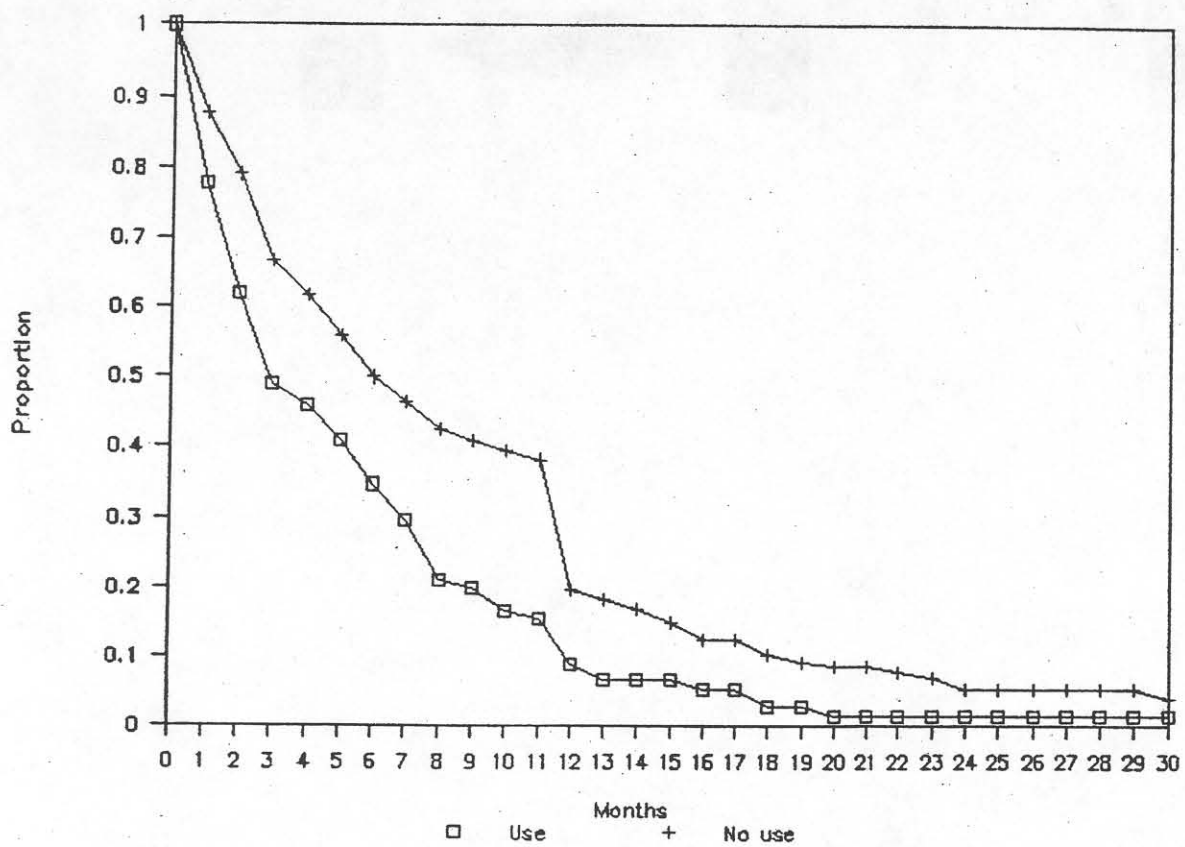


Figure 7. Survival functions for women by post-partum amenorrhea of those women who used contraceptive methods and those who did not use any one at different months of post-partum durations. Bolivia.

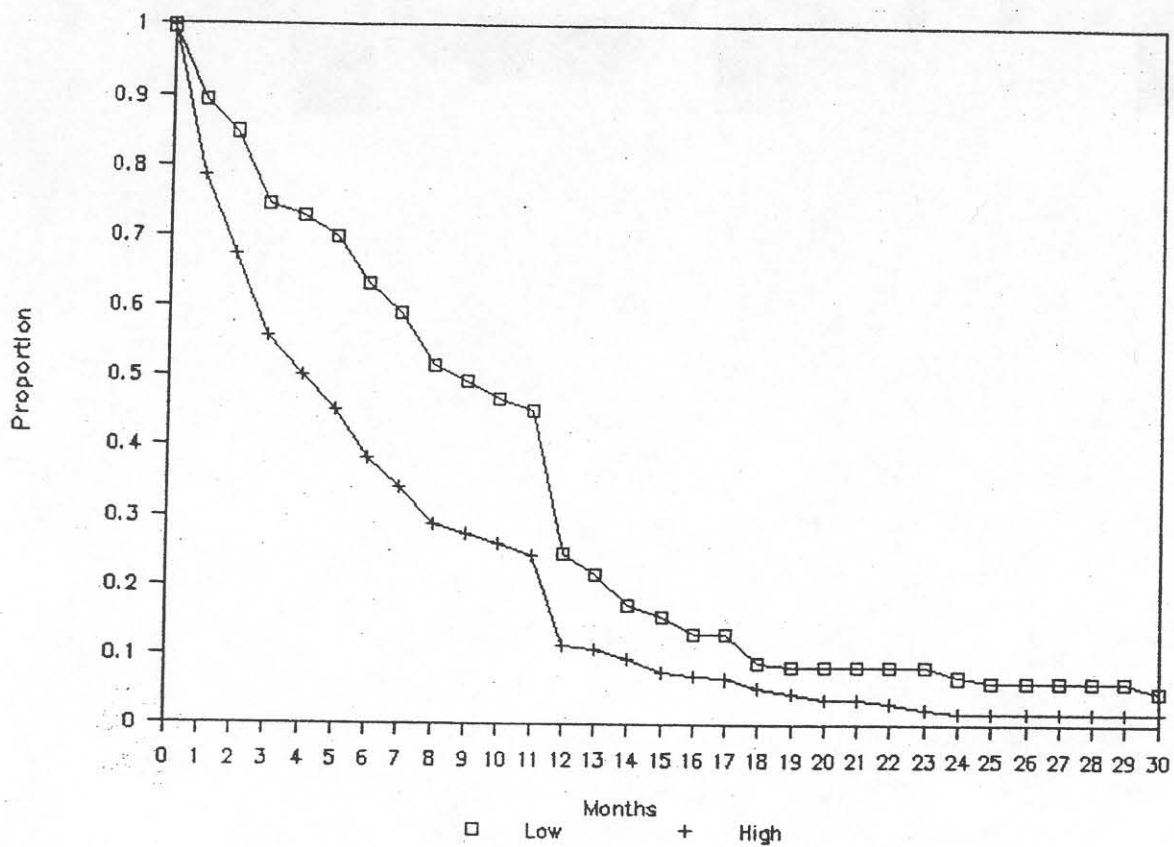


Figure 8. Survival functions for women by post-partum amenorrhea of those women with high formal education and with low education at different months of post-partum durations. Bolivia.

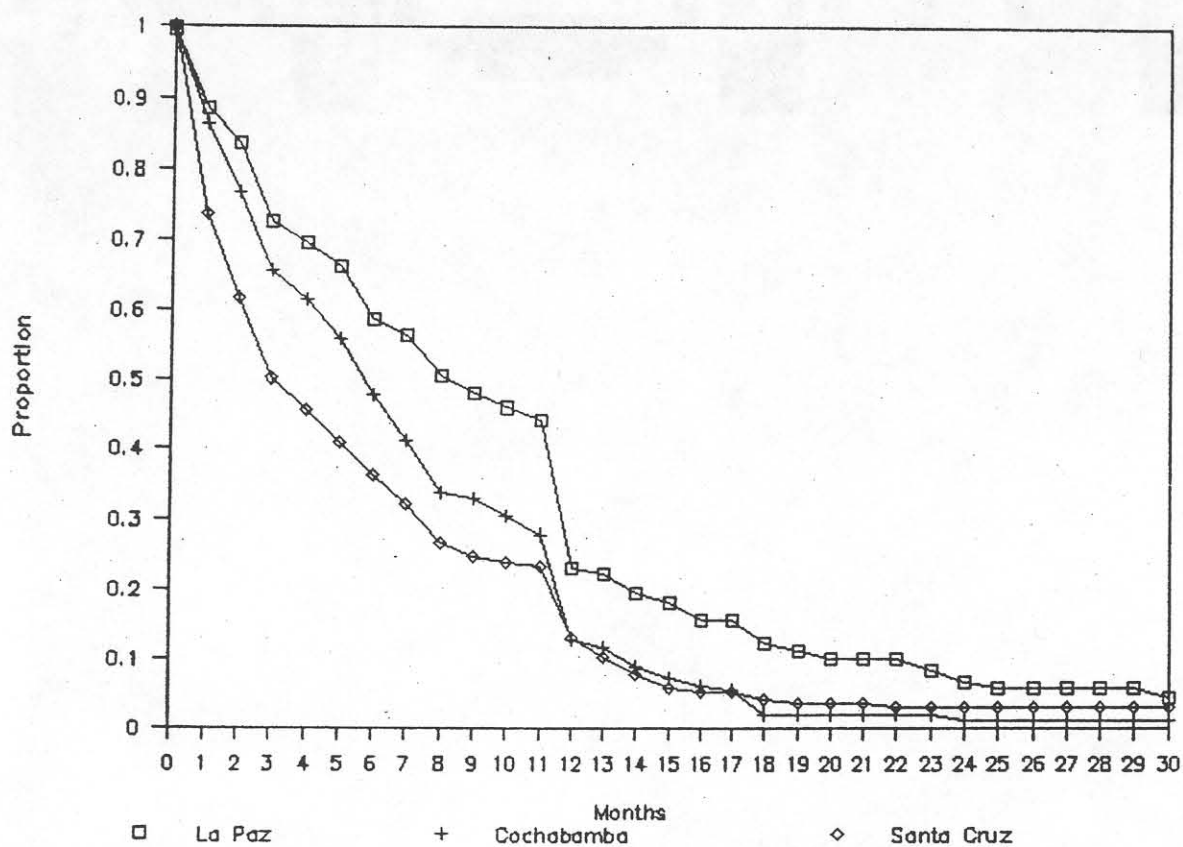


Figure 9. Survival functions for women by post-partum amenorrhea of those women who lived in La Paz, Cochabamba, and Santa Cruz city at different months of post-partum durations. Bolivia.

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