Center for Demography and Ecology

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# The Determinants of Postpartum Amenorrhea in Rural Guatemala: A Life Table Approach

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CDE Working Paper No. 94-22

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March 1995

The Center for Demography & Ecology receives core support for Population Research from the National Institute for Child Health and Human Development (P30 HD05876).

## INTRODUCTION

The objective of this paper is to investigate the association between breastfeeding, infant mortality, women's nutritional status and various socioeconomic factors, on the one hand, and the duration of postpartum amenorrhea, on the other. These relations are explored by using exclusively univariate life tables and product-limit techniques on the monthly prospective resumption-of-menses data from rural Guatemalan women.

In order to identify the existence of association between the covariates being considered in this study and the waiting time to menses, we describe empirical patterns among them without imposing any model on the observed data. That is, we examine individually the relationship of each covariate and the duration of amenorrhea postpartum through event history techniques (i.e., life-table and product-limit methods).

The first step in this analysis is to estimate the survivor function for the whole population. Second, this population is disaggregated into several sub-populations, to underscore the possibility of population heterogeneity. That is, the observed data are broken down into different groups according to various categories for each covariate under consideration. Optimal categorizations were obtained by repeated application of the product-limit life table. Third, separate empirical survivor functions are calculated along with different descriptive statistics, which are utilized to test the hypothesis that two or more random functions come from the same distribution. These descriptive statistics were estimated by the (actuarial) life-table method.

## THE DETERMINANTS OF POSTPARTUM AMENORRHEA

A positive correlation between duration of breastfeeding and duration of postpartum amenorrhea does not imply a strict causal relationship between them. In most developing countries, it has been observed that the end of amenorrhea occurred while mothers were still breastfeeding their children (Bongaarts, 1983). The relation is found because of a combination of the type of breastfeeding being practiced by these mothers and the direct effect of delayed weaning. The effect of women's nutritional status on the resumption of menses is more complicated, and it may be related to breastfeeding behavior.

In general, there are four mechanisms that may trigger the resumption of normal menstrual cycles in postpartum women (Jones, 1989). Two of them, weaning and infant mortality, have a **direct** causal effect. They terminate nursing episodes and, therefore, the hormonal stimulus that child suckling has on the delay of fecund menstrual cycles. The third mechanism is related to the breastfeeding behavior prevalent among those mothers who initiate menstruation while they are still breastfeeding. The fourth causal factor, maternal nutrition and health status, may also modify the hormonal stimulus by delaying the resumption of normal menstrual cycles. There are two possible paths through which nutrition could affect postpartum amenorrhea. In the first pathway, deficient nutrition may alter women's reproductive functions and cause a delay in the resumption of menses. The second path consists of an indirect effect and may work through breastfeeding patterns: a malnourished woman is likely to produce reduced amounts of milk so that her child has to suckle more intensively to obtain adequate nutrition.

The physiological mechanism underlying these observed relations originates in the hypothalamus, which is located in the basal region of the brain. The woman's hypothalamic nuclei releases **gonadotropin-releasing hormone** (GnRH) in a regular, episodic fashion, which in turn triggers the pulsatile and episodic release of **leutinizing hormone** (LH) and **follicle stimulating hormone** (FSL) from the pituitary. This biological process is also known as the **hypothalamic pulse generator** (HPG) (see McNeilly et al., 1985). The release of certain amounts of LH has been found to be crucial for normal ovarian activity and fecund menstrual cycles (Knobil, 1980; McNeilly et al., 1985; Glasier et al., 1984). Recent research has also shown that normal patterns of GnRH and LH release can be disrupted by external factors, such as heavy physical exercise or activity, or psychological stress, in addition to breastfeeding (Genazzani et al., 1991; Loucks, 1990). The exact neurotransmitter signal, which interrupts the release of GnRH and LH during these activities remains to be completely elucidated. In the case of breastfeeding women during the postpartum period, however, the suckling stimulus may be the primary signal which disrupts the normal pattern of hormonal activity (Tay et al., 1992). However, it seems that the disruption of the HPG neurons is a common characteristic of altered GnRH and LH release, and thus amenorrhea and fertility (Yen, 1987). This general mechanism represents a direct link between the external environment (i.e., stressors) and the internal regulation of the reproductive system.

**SOURCE OF DATA**

The data used in this paper come from the Longitudinal Study in Guatemala carried out in a chronically malnourished population, a prospective study of the physical and mental development of infants in four rural villages. A sample of 755 women was followed longitudinally by regular visits for nearly eight years. Women entered the study on the basis of their reproductive history, i.e., those who had at least one child aged less than seven years old. Mothers periodically provided data throughout their pregnancy and postpartum period. In this research I retrieved data for all women who had a delivery between January 1, 1969 and February 28, 1977 and who were followed-up until the latter date (when the survey officially ended). Under this constraint, 608 women and their 1430 birth intervals were selected (Pinto, 1994).

In prospective studies like the Guatemalan Longitudinal Study, censoring is present for cases where women did not have ending times, either because they were not available for the follow-up visit during the survey or because the survey ended before they experienced the event in question. As a consequence, methods that can deal with right censored information must be used in order to obtain unbiased estimates of the failure probabilities and survival functions.

There are two well-known methods, useful when analyzing univariate survival data, namely, the life tables and product-limit estimator.

In this paper we use the life table method to estimate the empirical survival function and the median survival time, and the Kaplan-Meier (product-limit) method to estimate the mean survival.

## METHODS OF ANALYSIS

### Basic ideas about univariate survival models

The data analyzed in this research are characterized by the presence of right-censored observations due to termination of the follow-up. For such women it is only known that their duration of postpartum amenorrhea exceeded some particular given value; that is, the exact durations are unknown. Because the longer-duration cases are in general more likely to be censored, these data cannot be analyzed by removing the censored observations. So, the methods to be utilized in our analysis must use adequately both censored and uncensored observations.

One of the most important concepts in event history analysis is that of **survival distribution** of the duration (or failure) times of a variable T. Also known as **survival function**, it describes the probability that a woman in our sample will remain amenorrheic longer than some time **t**, for any given birth. That is,

$$S(t) = Prob(T>t)$$

where S(t) denotes the survival function (SF) and T is the time elapsed from the birth of the child to the first appearance of menses of a randomly selected woman. Throughout the study we assume that T is a continuous non-negative random variable with cumulative distribution function F(t) and density function f(t). These functions are related to the SF. The function **F(t)**, the probability that the waiting time to postpartum menses does not exceed **t**, is defined as 1-S(t). The probability density function, **f(t)**, is defined as the derivative of F(t). Finally, the hazard function, **h(t)**, is defined as f(t)/S(t).

Two important techniques are reviewed in the next sections, the life-table (LT) and the product-limit (PL) methods, both of which provide non-parametric estimates of the relevant functions[1].

**Life-table method**

The life table is one of the most widely used methods to estimate the SF and all the mentioned functions (Kalbfleish and Prentice, 1980; Lawless, 1982; London, 1988). The life table estimates are computed by counting the number of uncensored and censored cases that fall in every time interval $[t_{i-1}, t_i)$, for i=1,2,...,k+1, where $t_0=0$ and $t_{k+1}=\infty$. Let $n_i$ be the number of events entering in the interval $[t_{i-1}, t_i)$ and $d_i$ be the number of women who resumed menses in the interval. On the other hand, let $b_i=t_i-t_{i-1}$, and let $n_i'=n_i-w_i/2$, where $w_i$ is the number of women censored in the interval. The quantity $n_i'$ is the effective sample size of the interval $[t_{i-1}, t_i)$.

Then, the conditional probability of resuming menses in $[t_{i-1}, t_i)$ is estimated by the following expression:

$$\hat{q}_i = \frac{d_i}{n_i'}$$

As can be easily seen, these probabilities are the ratio of the number of women whose menses returned at that duration (i.e., interval in consideration) to the number of women still amenorrheic and at risk of resuming menses postpartum after that duration (i.e., in the following

[1] The LT and PL methods provide estimators that do not depend on any assumption about the shape of the hazard, which is the underlying generator of the process. More generally, these methods estimate S(t), f(t) and h(t) with no assumption about the form of the probability distribution of any of these functions. Such techniques are important when there is no theoretical knowledge about the nature of the hazard.

intervals).

The survival function at time $t_i$ is estimated by

$$\hat{S}(t_i) = \prod_{j=1}^{i} (1-\hat{q}_j)$$

The median duration at $t_i$ is estimated by the following expression:

$$\hat{M}_i = t_{j-1} - t_i + b_j \frac{S(t_{j-1}) - \frac{S(t_i)}{2}}{S(t_{j-1}) - S(t_j)}$$

The survival function, which is derived from the failure probabilities, is an estimate of the proportion of women who have not yet resumed menses at duration t. A detailed presentation of these formula can be found in Kalbfleish and Prentice (1980), Lawless (1982), and London (1988).

**Product-Limit estimator**

The Product-Limit estimate, also known as the Kaplan-Meier estimate, is a non-parametric method designed to estimate the survival function for ungrouped univariate survival data. The empirical survival function can be constructed as follows: suppose that there is a sequence of observations on the duration of postpartum amenorrhea such that $t_1 < t_2 < ... < t_k$. The size of risk set, $n_i$, is the number of women who did not resume menses prior to $t_i$; while $d_i$ is the number of women that fail (resumes menses) at $t_i$. On the other hand, let $s_i = n_i - d_i$. Then, the product-limit estimate of the SF at $t_i$ is the following cumulative product:

$$\hat{S}(t_i) = \prod_{j=1}^{i} (1-\frac{d_j}{n_j}) \quad .$$

Since the events at time $t_i$ are included in the estimate of $S(t_i)$, the estimator is defined to be right continuous.

The estimated mean survival time is

$$\hat{\mu} = \sum_{i=1}^{k} \hat{S}(t_{i-1})(t_i - t_{i-1})$$

where the value for $t_0$ is zero. Notice that if the last observation is censored, this formula underestimates the mean.

A detailed presentation of these formula can be found in Kalbfleish and Prentice (1980), Lawless (1982), and London (1988).

**Test for equality of survival functions**

The comparison of survival curves is an important step in the analysis of survival data, in order to determine whether or not two or more groups of women (i.e., samples) may have come from identical survival functions. In this research we have used three statistics to test equality of survival functions when comparing different groups of women: the log rank test, the Wilcoxon test and the likelihood ratio test (Kalbfleish and Prentice, 1980; Lawless, 1982). The first test is a censored-data generalization of the Savage test (log rank test), which uses exponential scores. The second rank test, the Wilcoxon test, is also a censored-data generalization. The likelihood ratio test (Lawless, 1982) assumes that the information in the various groups is exponentially distributed and it actually tests that the scale parameters are equal.

The rank statistics (log rank and Wilcoxon) are used to test homogeneity of survival functions among different groups of women. For purposes of computing an approximate probability value, these statistics are treated as having a chi-square distribution.

## ANALYSIS OF THE RESULTS

In this study we consider three types of estimates: the survival function of amenorrhea postpartum, the median survival time (or median duration) and the mean duration, along with their standard errors[2]. These estimates are calculated for the entire population (all women) as well as for the sub-populations considered throughout the research.

When using the life-table technique and the product-limit estimates, the monthly failures probabilities at every duration at which menstruation returned have been estimated as the ratio between the number of women who have resumed menses and 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 resumed menses at different durations after childbirth.

**Breastfeeding and mortality covariates**

Figure 1 shows the cumulative proportion of women amenorrheic, the proportion of women breastfeeding their children and the proportion of women who introduced supplements into their children's diets as estimated in the life table by duration since childbirth. As expected, these functions decrease steadily over time. While the survival function of amenorrhea and breastfeeding show a gradual monotonic decline, the survival function for supplementation describes a sharper decline, probably reflecting the early introduction of supplements into children's diets. The supplementation curve simply shows the proportion of children not yet on solid or liquid supplements[3].

The proportion of women who have weaned their children is greater than the corresponding proportion of women who have not yet resumed menses at every monthly duration

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[2] To determine the shape of the hazard function we used plots of the cumulative hazard, which are not reported in the study. The idea is very simple: the cumulative hazard function is defined as $H(t)=-\log S(t)$, where $S(t)$ is the survival function. On the other hand, the hazard function is defined as the derivative of the cumulative hazard. This result may be used to determine the shape of the hazard function (Lawless, 1982; London, 1988).

[3] Supplementation includes both clinical supplements (fresco and atole) given by INCAP staff and other types of supplements given by the mothers.

at least during the first two years. Similarly, the estimated survival curve of supplementation lags behind the other two curves by several months. This means that women begin to supplement their children's diets long before they wean them totally or experience resumption of menses.

In this particular population, breastfeeding was found to be nearly universal. Almost all interviewed women breastfed their children if they had the opportunity to do it. Women did not breastfeed if their breasts were dried or nipples infected or sore.

Table 1 provides the median and means durations for postpartum amenorrhea as well as for breastfeeding and introduction of supplementation. According to these figures, 50 percent of women reported a menstrual event by the 14th month; that is, the median duration of resumption of menses in the population under study is about 14 months. The median duration of breastfeeding is almost 17 months; and the median duration of supplementation is around four months. This means that by the age of four months about 50 percent of the children were already receiving some supplement and that by the end of 12 months virtually all children are given some form of supplementation[4].

The reported mean durations are similar to the median durations. For instance, the average menses-free duration since childbirth for all births is about 14.28 months. These results imply that for most rural women in Guatemala the end of the amenorrheic state occurs while they are still breastfeeding their children. This is a very common situation at the individual level, when longer durations of breastfeeding are accompanied by early introduction of fluid and solid supplements. Clearly, lactation cannot be a reliable contraceptive method beyond a certain length of time.

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[4] There is no statistically significant difference in age at weaning for male versus female children. The median duration of breastfeeding for males is 17.05 months and for females is 16.82. This confirms the ethnographic observation that both girls and boys are equally valued by their parents, although for different reasons (Mejia, 1972). Similarly, the median durations of postpartum amenorrhea by child's gender are not significantly different: 14.3 months for mothers who gave birth to males and 14.5 for mothers who gave birth to females.

In Figure 2 we introduce another dimension of the analysis of postpartum amenorrhea. The estimated survival functions of the duration of amenorrhea postpartum for five groups of women are displayed in that table. These groups were constructed in order to investigate the causes that affect menstrual cycles in women who nurse their children (Jones, 1989).

The first group contains those women who completely weaned their children before menses returned; that is, they weaned their children while they were still amenorrheic by the end of the survey (**weaning group**)[5]. The second group consists of women who resumed menses while they were still breastfeeding, or were still amenorrheic and breastfeeding at the end of the survey (**breastfeeding group**)[6]. The third group contains all woman followed-up in the survey (**all women group**). The fourth group includes women whose children died before menses returned, that is, the infants died while their mothers were still amenorrheic (**infant mortality group**). Finally, the fifth group consists of women who never breastfed their children because either they had a still-birth or they chose not to breastfeed their live-born children (**non-breastfeeding group**).

Figure 2 shows several features that are relevant to resumption of menses in rural Guatemalan women. First, the estimated survival functions for group 3 (all women) and group 2 (women in the breastfeeding group) are very similar. This phenomenon is due to the fact that all but 19 of the woman-child observations are in the latter category. Second, as expected, women

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[5] In this group the sequence of events is rather clear: the duration of breastfeeding is less than the duration of amenorrhea postpartum. For each birth interval, postpartum amenorrhea can be either a failure or a censored case over time.

[6] The sequence of events in this second group is defined as follows: the first component is made up of those cases when the duration of postpartum menses is less than the duration of lactation for every birth interval over time. Lactation can be either a failure or a censored case. The second component is made up of those cases where the duration of postpartum menses is equal to the duration of breastfeeding, but both of them are censored cases. The latter group is mostly made up of open birth intervals. So, women in this group were still breastfeeding when menses occurred or was censored in a closed or open interval respectively.

who did not breastfeed their children at all have the shortest waiting times to resumption of menses. Similarly, the infant mortality group shows a very fast resumption of menses, second only to the non-breastfeeding group. Finally, the weaning group has the slowest return of menses in the sample.

Table 2 shows the median and mean values of the duration of postpartum amenorrhea for each group described above. Those women who weaned their children before normal menstrual cycles resumed have the longest waiting time to menses (a median of 16 months). Mothers who were still breastfeeding have a median waiting time of about 13 months[7]. It is important to understand that for the **weaning** group the causal direction can only be from breastfeeding to resumption of menses, because of the way this group was defined. In all these cases nursing terminated before menses had resumed and, in general, only when the prospective breastfeeding data is truncated at return of menses can the effect be considered causal. In contrast, for the **breastfeeding** group menses occurred while mothers were still nursing, so the termination of lactation cannot possibly cause resumption of menses. In this case factors such as patterns of breastfeeding may be involved in the process.

As expected, among mothers who never breastfed their children or whose children died before menses returned, the postpartum amenorrhea periods were very short when compared with the other women, and they exhibit medians of the order of 2.8 and 4.6 months respectively. The effects on menses are stronger in these two groups because the events that define the process imply either an abrupt termination of suckling or the lack of initiation of suckling. Therefore, the suckling hormonal stimulus that inhibits menstruation is present in neither case.

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[7] When open birth intervals are considered alone (that is, when events are censored by the end of the survey), the median waiting time to menses for mothers who were still breastfeeding is 18.41 months. This figure agrees with results obtained from retrospective studies for other countries.

In sum, both weaning and infant mortality (preceding menses), by terminating the suckling stimulus, appear to cause an acceleration of resumption of menses. However, their effects are fairly different and deserve a closer examination.

Figure 3 displays estimated survival functions for: (1) breastfeeding for women in the weaning group, (2) amenorrhea for women in the weaning group, and (3) breastfeeding for all women in the study. We can observe that weaning occurs throughout the postpartum period and not just at the beginning or at the end of the period of study. That is, the survival curve for group (1) is a reflection of the survival curve of group (3). On the other hand, the survival function for amenorrhea for the weaning group lags slightly behind the breastfeeding survival function; that is, women wean their children before menses resumes at every monthly duration. In fact, in Table 3 (Panel 1), the weaning group has a median survival time of about 14 months for breastfeeding duration and of about 16 months for the amenorrhea duration. Thus, the weaning group consists of mothers who have chosen to stop breastfeeding much earlier than mothers in the total population, which exhibits a median of around 17 months. These results confirm the fact that in this particular population the patterns of weaning seem to be directly responsible for the subsequent pattern of resumption of menstruation in this group.

A similar pattern of relations is observed in the estimated survival functions for the infant mortality groups. Figure 4 shows: (1) the survival curve for children who died before menstruation resumed, (2) the survival curve for amenorrhea (or menses) for women who experienced infant death before menstruation resumed, and (3) the survival curve for all dead children in the sample. As is conventional, a failure was defined as child death, between birth to 24 months, and exposure to risk was determined by the number of months from birth to child's death or last interview, whichever occurred first.

In Figure 4 we observe that women in the group who experienced child mortality before menses resumed represent mothers whose children died much earlier than all mothers whose infants died. We can also see that the mortality function for the infant mortality group (women whose children died before menstruation resumed) lags well behind the menses survival function of the same group. The median survival time for these two sub-populations is 1.9 and 4.6 months respectively (see Table 3, Panel 2). These results confirm the fact that in this particular population the patterns of infant mortality seem to be directly responsible for the subsequent pattern of resumption of menstruation in this group.

This exploratory analysis indicates that there is circumstantial evidence supporting the idea that patterns of weaning and infant mortality are highly influential as determining factors of the patterns of resumption of menses.

In the next figure we provide additional evidence highlighting these causal mechanisms. Figure 5 shows the distribution of times (estimated survival functions) from weaning (group 1), birth (group 2), and infant death (group 3) to first postpartum menses[8]. According to this figure, the estimated survival curves (postpartum duration in months of the proportion of women still amenorrheic) for the weaning and infant mortality subgroups are not different from one another, nor are they different from the survival function for women who never breastfed their children. In effect, in Table 3 (panel 3) the Log-Rank test shows that (with $p > 0.3987$) the estimated curves come essentially from the same population.

Additional information in Table 3 (panel 3) indicates that mothers who weaned their children before menses resumed have a median waiting time from weaning to menses of 1.89

[8] The idea is to compare waiting times from weaning and infant death until menses resumed or censoring occurred, whichever comes first. The new waiting times in the three groups were created as follows: (1) duration of menses minus duration of breastfeeding, (2) duration of menses for those mothers whose children did not breastfeed at all, (3) duration of menses minus age at death of the child. That is, the curves are shifted to the same origin.

months; mothers whose children died before menses resumed have a median waiting time from infant death to menses of 1.98 months; and finally, the median duration from pregnancy to menses for non-nursing mothers is 2.75 months[9]. These results show clearly that the time to resumption of menses (i.e., ovulation) in absence of suckling is about the same, no matter when during the postpartum period discontinuation of suckling occurs.

Finally, we investigate the association between patterns (types) of breastfeeding and postpartum amenorrhea. We find that, on the one hand, women who introduced supplementation in their child's diet earlier in life have faster resumption of menstruation at every month and, on the other, that women who breastfeed their children less frequently tend to also have faster resumption of menses. The tests for equality of the survival functions show that these estimated curves are actually different from one another. In Table 4 we display the median and mean duration of amenorrhea for the two categories of timing of introduction of supplements, as well as for the categories defined by nursing episodes per day. The former variable has two categories: when supplements are introduced at the sixth month or earlier, and when supplements are introduced at the seventh month or later. The latter variables have three categories: the mother nursed her child from one to seven times a day, from eight to eleven times a day, and from 12 to 22 times a day (on demand).

The later the time of introduction of supplements, the longer the duration of the amenorrheic period. In effect, those women who supplement breastfeeding during the first six months of a child's life resume menses earlier than women who supplement breastfeeding after the first six months. The estimated waiting times for these cases are about 14 and 16 months respectively. Figure 6 shows that women who breastfed their children less frequently (less than

[9] Actually, the survival curves and the medians calculated for these groups represent the lags observed in Figures 3 and 4. between groups (1) and (2).

eight times a day) had faster resumption of menses during the first 24 months than did women who breastfed more frequently. Women who breastfed on demand (more than eleven times a day) resume menses more slowly, and the rates of return to menses are lower than those in the other two groups. It is quite remarkable that the estimated survival function for low frequency of breastfeeding lags behind the survival function for high frequency by several months, and that their shapes are so different. According to the three tests (log-rank, Wilcoxon, and log likelihood ratio) shown in Table 4, each curve is significantly different from the others.

It can be seen in Table 4 that the higher the frequency of breastfeeding, the longer the waiting time to resumption of menses. The median duration of amenorrhea among mothers who breastfed on demand (12 or more times a day) is almost 6 months longer than the median duration among women who breastfed seven or fewer times a day. We found that in mothers with the lowest frequency of nursing episodes per day the anovulatory period lasts approximately 12 months, while in mothers with the highest frequency this period tends to last about 18 months. Thus, it seems that, as one would infer from theoretical considerations, the association between prolonged amenorrhea and breastfeeding is due not only to the direct effect of duration of lactation but to the combined effect of frequency of nursing and its overall duration.

**Nutritional and clinical supplementation covariates**

To assess the effects of mother's nutritional status on the duration of menses postpartum, we introduce the body mass index (BMI) as a covariate. Malnourished women were defined as those with a BMI below 20, a figure that has been found in other studies to represent a threshold of chronic energy deficiency in developing countries (James et al., 1988; Naidu et al., 1991).

As we can see in Table 5, the differences in the duration of amenorrhea by nutritional status are in the expected direction. Women with better nutritional status resume menses faster than women with poor nutritional status. In fact, women with a BMI less than 20 units had a median duration of about 15 months; women with a BMI between 20 and 24 units had a median of 14 months; and women with a BMI greater or equal to 24 units had a median of 13 months. The statistical tests (log-rank, Wilcoxon, log likelihood ratio) show that these differences are in fact statistically significant. Therefore, in the absence of controls for breastfeeding patterns and for other relevant covariates, the association between nutrition and resumption of menses is fairly strong. But it could well be that maternal nutrition may not only have a direct effect but could be operating through breastfeeding and may even be spuriously associated (through its association with breastfeeding) with duration of menses.

Mothers' supplemental intake during pregnancy and lactation seems to be an important stimulant to resumption of ovulation and, therefore, menstruation. In two villages, a high protein-calorie drink called "atole" was served to all residents; whereas in the other two villages, a non-protein and low calorie drink called "fresco" was dispensed to all residents on a daily basis. According to the figures shown in Table 5, women who were living in the "atole" villages had much faster resumption of menses than those who were living in "fresco" villages. The former group had a median duration of postpartum amenorrhea of 13.8 months and the latter women had a duration of 14.9 months. These differences are statistically significant.

These results, like those presented before, imply that an **improvement** in women's nutritional status lead to shorter length of amenorrheic intervals.

**Demographic covariates**

In Table 6 we explore the association between the duration of postpartum amenorrhea and selected demographic characteristics of the women under study. As reported in other studies, increasing age of the mother at child's birth and parity are associated with longer durations of amenorrhea (Bracher and Santow, 1982; Huffman et al., 1987; Santow, 1987; Jones, 1989; Jones and Palloni, 1990). Other factors being constant, those women who give birth at older ages decrease significantly their risk of early postpartum return of menses. In fact, the median duration among younger mothers (between 12 and 19 years) is about 11 months, while the median duration for older women (30 years or more) is about 15 months.

The median duration for women with only one child is about 11 months while the median duration for women with four or more children is about 15 months. The differences by age and parity are statistically significant.

**Socio-economic covariates**

In Table 7 we examine the association between the duration of postpartum amenorrhea and selected socio-economic indicators. As found in other studies, the median waiting time to menses decreases as the level of education increases (Huffman et al., 1987; Santow, 1987; Srinivasan et al., 1988; Jones and Palloni, 1990). The median duration for women with lower education (none or one year in school) is about 15 months, compared to 14 months for women with more education (two or more years in school). The mean durations displayed in this table show similar trends.

These differences are rather small since they probably reflect the high degree of homogeneity of the population with respect to socio-economic characteristics such as education, quality of housing, modernity, labor patterns, etc.

Finally, the magnitude of the association between waiting time to menses and women's work related activities are fairly important and salient. Women involved in activities requiring non-strenuous patterns of work and less expenditure of energy (merchants, etc.) resumed menses faster than those women who performed strenuous physical labor (mainly agricultural occupations). In fact, women who reported to be merchants or skilled workers remained amenorrheic for about 13 months; whereas those who did not work outside the home (housewives) resumed menses 14 months after childbirth. Women engaged in heavy physical work remained amenorrheic for about 16 months. These differences are statistically significant according to the respective tests performed (see Table 7).

**CONCLUSIONS**

The exploratory results of bivariate associations presented in this chapter confirm findings obtained in previous investigations concerning the effects of patterns of breastfeeding, infant mortality, mother's nutritional status, and demographic and socioeconomic characteristics of the women on the length of postpartum amenorrhea. We were also able to show that the variations in the duration of postpartum amenorrhea attributable to these covariates are statistically significant.

Some of the most important findings in this paper are the following: both weaning and infant mortality (while women were still amenorrheic), by terminating the suckling stimulus, appear to cause an acceleration of resumption of ovulation (or menses). That is, in this particular population the patterns of weaning and infant mortality are highly influential as determining factors of the patterns of resumption of menses (Figure 3 and 4 respectively). Moreover, the distribution of times from weaning and infant death to first postpartum menses are similar (Figure 5).

We also found that maternal nutritional status and maternal work-energy expenditure patterns are strongly associated with the variations in the waiting time to menses in a univariate context. In fact, less nourished women have longer postpartum amenorrheic durations than better nourished women; younger women (and those with low parity) resume menses faster than older (and higher parity) women; and women who participate in work demanding high energy expenditure, such as agricultural activities, have longer durations of postpartum amenorrhea than those who do not.

Finally, women with a pattern of intense and prolonged nursing also tend to have longer postpartum amenorrhea periods. Despite early supplementation patterns in these villages, women who nursed more frequently maintained longer durations of postpartum amenorrhea than those who nursed less frequently.

Although these results lend support to the conjectures about the factors determining the patterns of resumption of menses (weaning, infant death, breastfeeding patterns, maternal nutrition, and work patterns), we still need to clarify the main mechanisms producing the relation and to verify these results with multivariate analysis.

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Figure 1.
Estimated survival functions of the duration of postpartum amenorrhea, breastfeeding and supplementation.
Guatemala, 1969-1977.

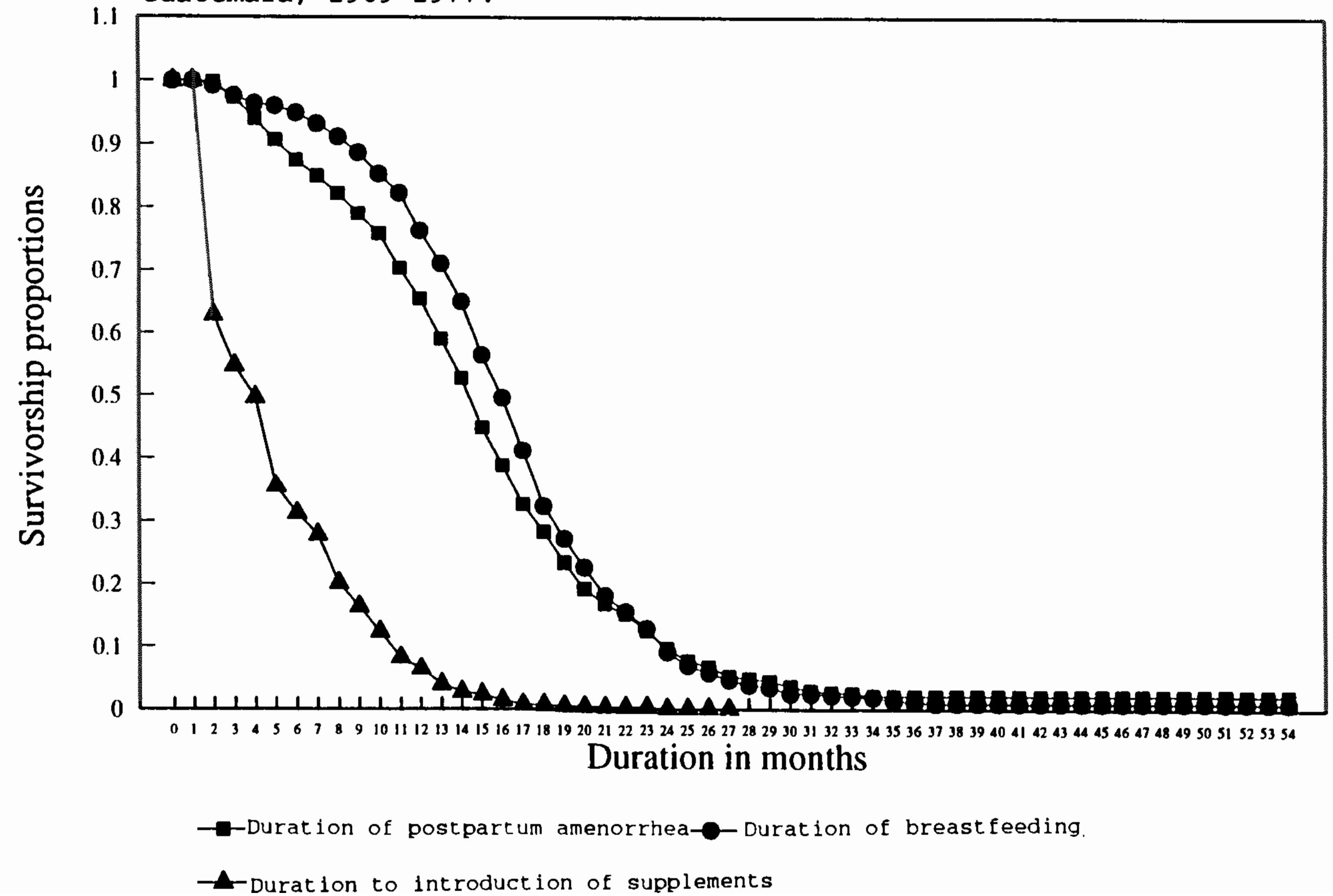

Figure 2.
Estimated survival functions of the duration of postpartum amenorrhea for all breastfeeding groups and all women. Guatemala, 1969-1977.

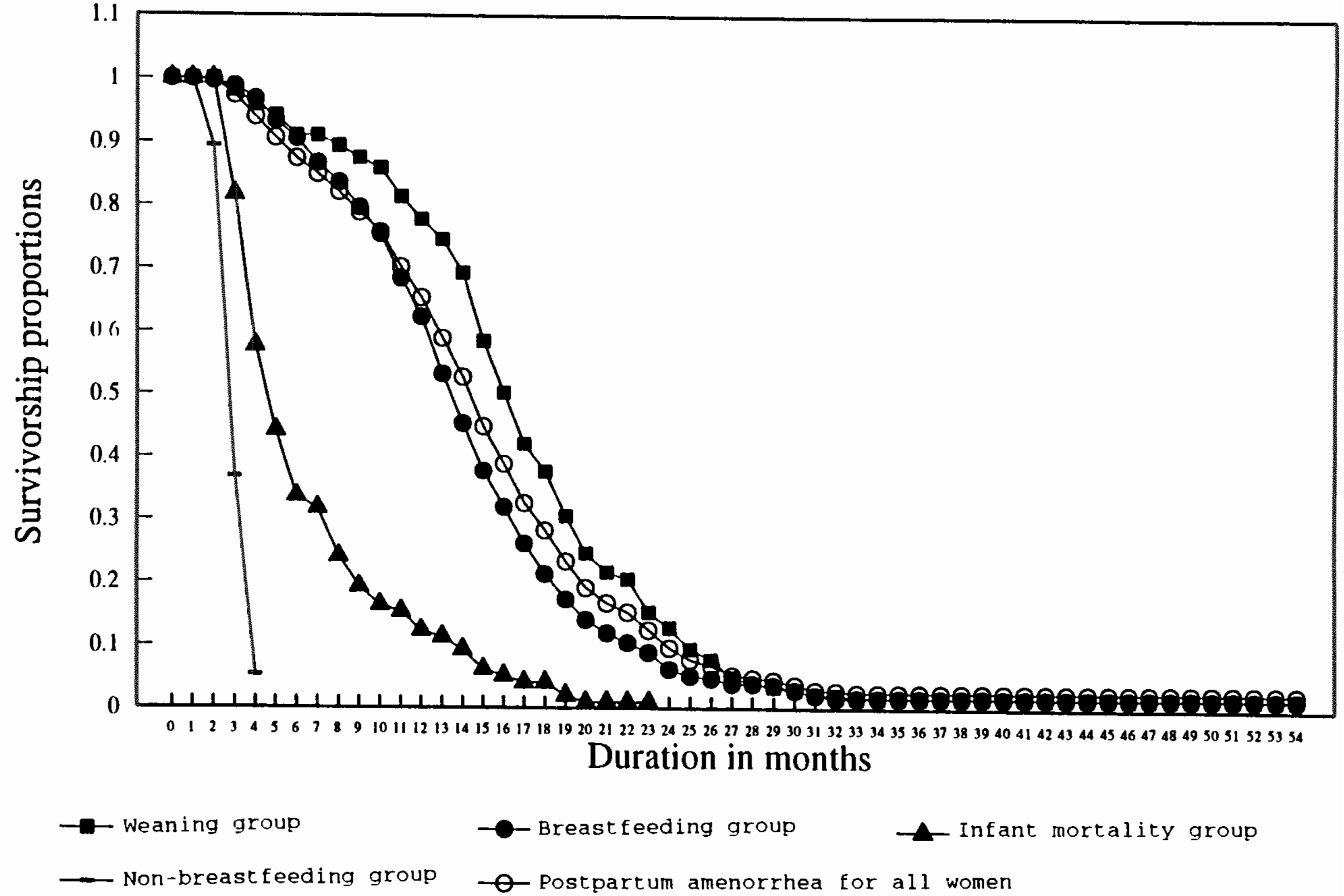

Figure 3.
Estimated survival functions of the duration of breastfeeding for the weaning group and all women and of the postpartum amenorrhea for the weaning group.
Guatemala, 1969-1977.

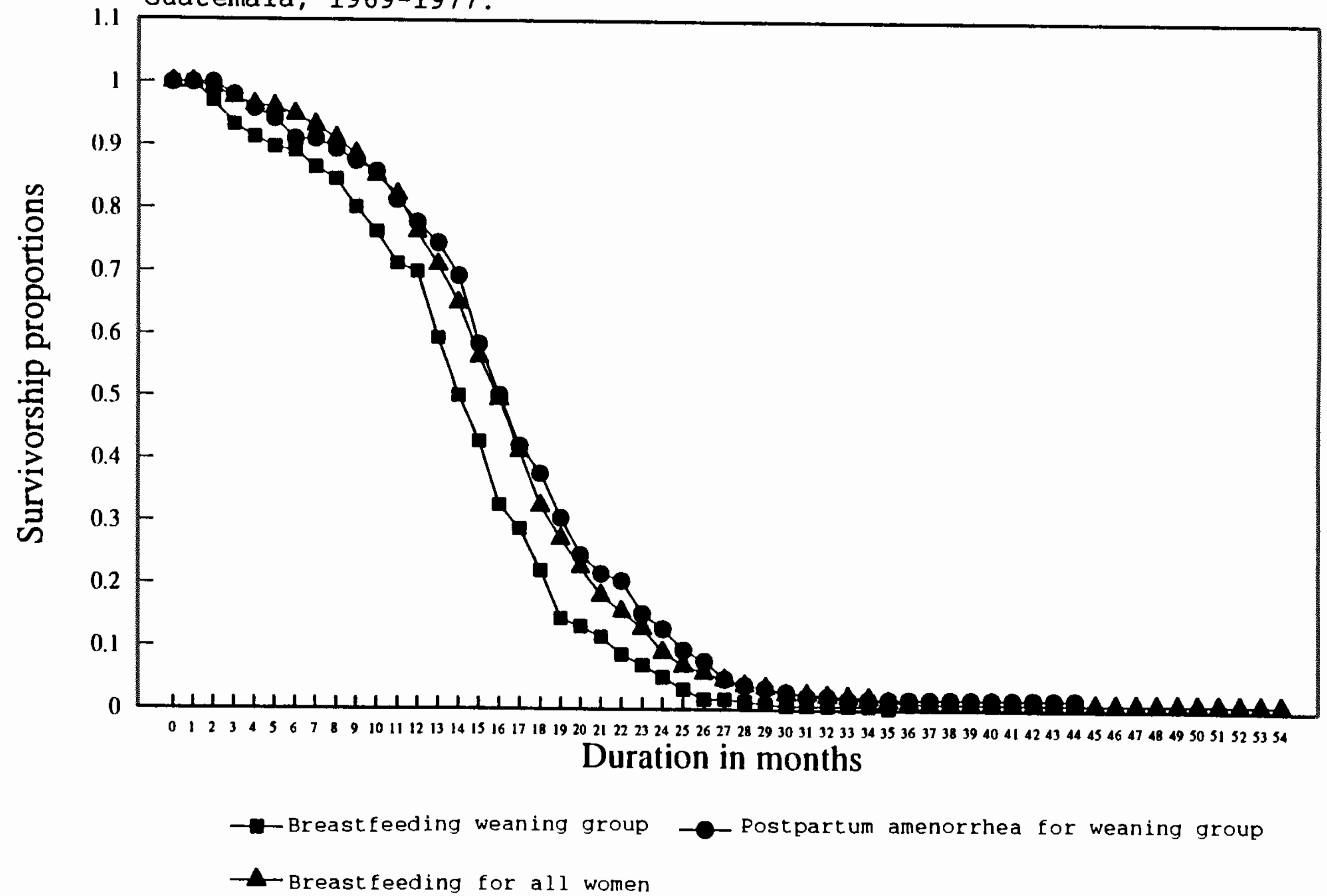

Figure 4.
Estimated survival functions of the mortality for the infant mortality group and all children and of the duration of postpartum amenorrhea for the infant mortality group.
Guatemala, 1969-1977.

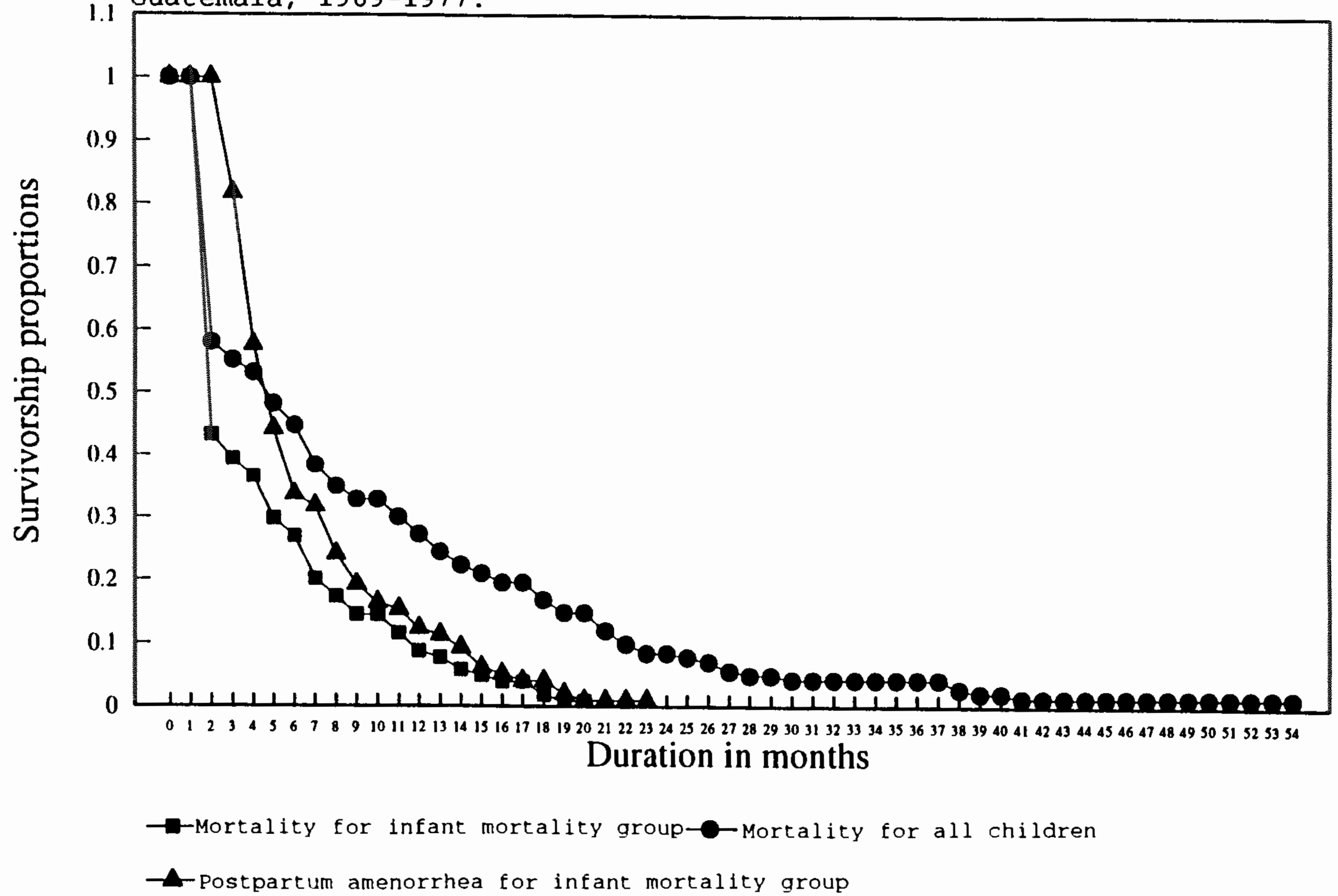

Figure 5.
Estimated survival functions of the duration of postpartum amenorrhea for the weaning group, infant mortality group and non breastfeeding group.
Guatemala, 1969-1977.

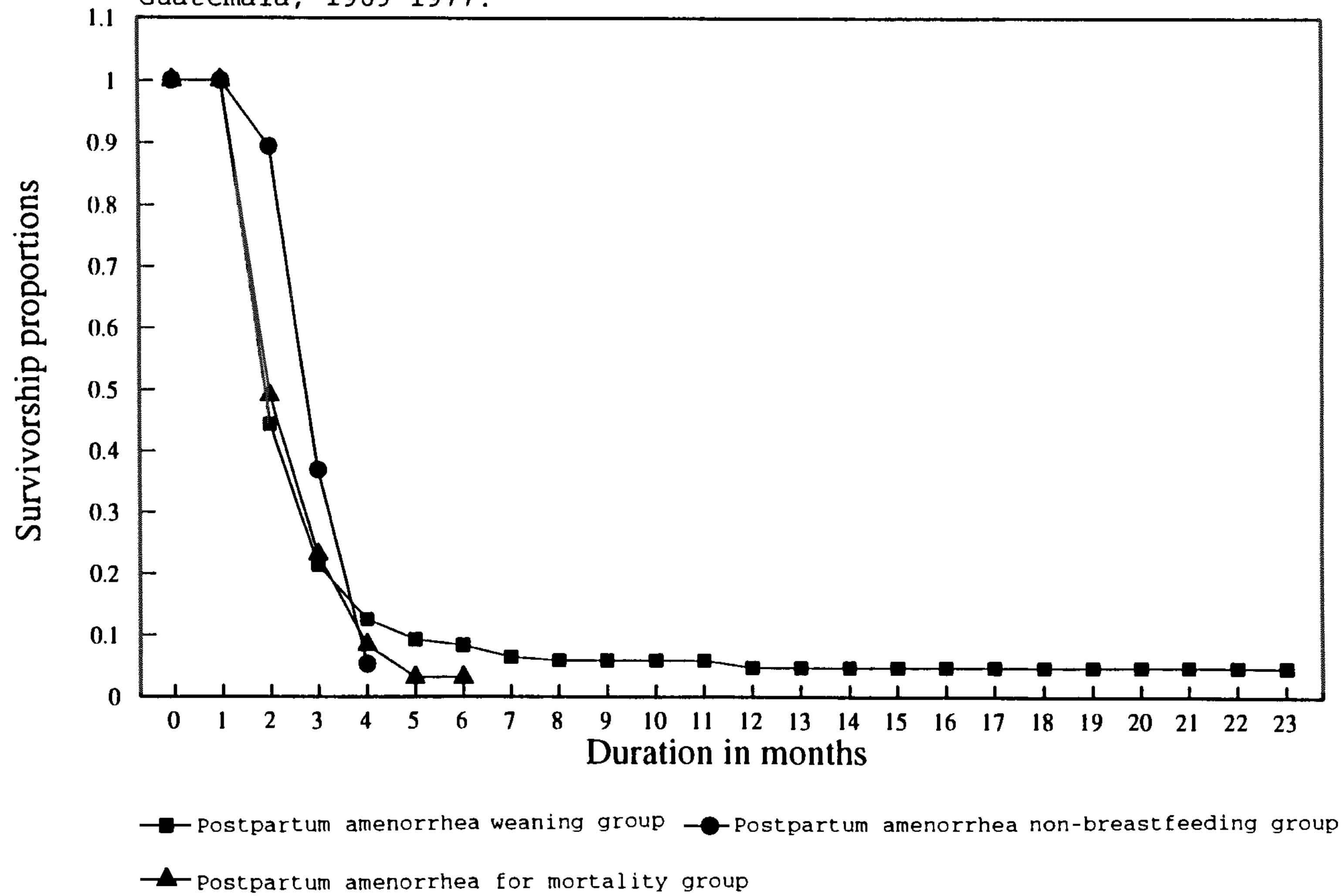

Figure 6.
Estimated survival functions of the duration of postpartum amenorrhea for the low, medium, and high nursing times a day. Guatemala, 1969-1977.

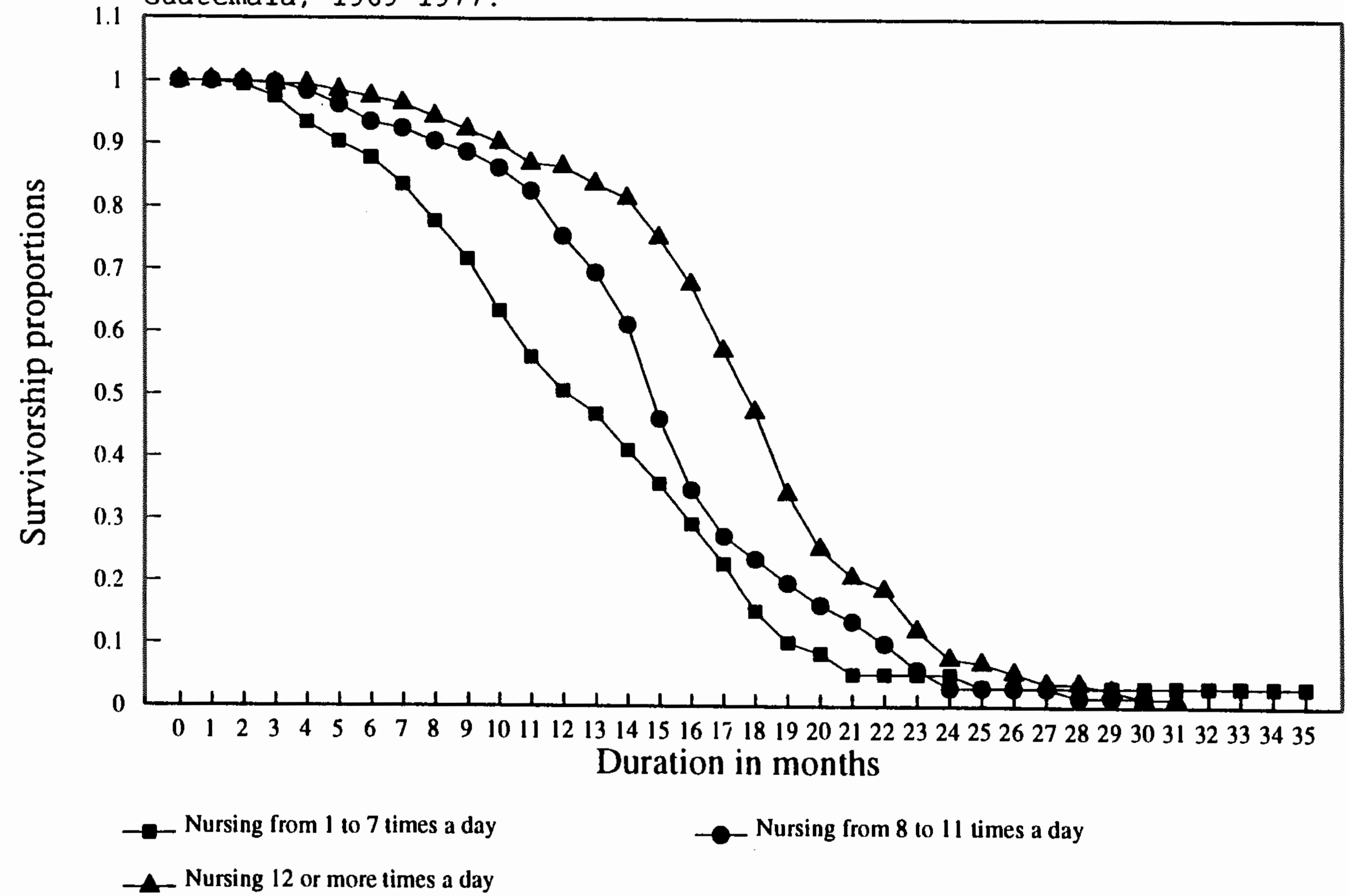

Table 1
Duration of Post partum Amenorrhea, Breastfeeding and Partial Breastfeeding. Guatemala, 1969-1977.

| Life Table Indicator | Postpartum Amenorrhea | Breast-feeding | Partial Breast-feeding |
|---|---|---|---|
| Median | 14.34 | 16.94 | 3.93 |
| (s.e) | (0.17) | (0.19) | (0.26) |
| Mean | 14.28 | 16.64 | 4.44 |
| (s.e) | (0.21) | (0.19) | (0.11) |
| N | 1430 | 1430 | 1430 |
| Failures | 1057 | 1076 | 1368 |

Source: INCAP Longitudinal Study.

Table 2
Duration of postpartum amenorrhea for women in the breastfeeding, weaning, and infant mortality groups.
Guatemala, 1969-1977.

| Life Table Indicator | Groups: Breast-feeding | Weaning | Infant Mortality | Non breast-feeding | Postpartum Amenorrhea |
|---|---|---|---|---|---|
| Median | 13.41 | 16.03 | 4.57 | 2.75 | 14.34 |
| (s.e) | (0.21) | (0.35) | (0.36) | (0.22) | (0.17) |
| Mean | 13.53 | 15.9 | 5.78 | 2.32 | 14.28 |
| (s.e) | (0.23) | (0.38) | (0.43) | (0.17) | (0.21) |
| N | 887 | 313 | 104 | 19 | 1430 |
| Failures | 686 | 280 | 102 | 19 | 1057 |

Source: INCAP Longitudinal Study.

Table 3
Duration of postpartum amenorrhea, breastfeeding and mortality for women in the breastfeeding, weaning, infant mortality, and non-breastfeeding groups.
Guatemala, 1969-1977.

| Groups | Median (s.e.) | Mean (s.e.) | N | Failures | Pr>Chi-Sq |
|---|---|---|---|---|---|
| PANEL 1 | | | | | |
| Breastfeeding weaning group | 14.02 (0.38) | 13.37 (0.34) | 313 | 313 | |
| Amenorrhea for weaning group | 16.03 (0.35) | 15.90 (0.38) | 313 | 280 | |
| Breastfeeding all groups | 16.94 (0.19) | 16.64 (0.19) | 1430 | 1076 | |
| PANEL 2 | | | | | |
| Mortality for Inf.mort.group | 1.88 (0.09) | 3.92 (0.45) | 104 | 104 | |
| Amenorrhea for Inf.mort.group | 4.57 (0.36) | 5.78 (0.43) | 104 | 102 | |
| Mortality for all group | 4.64 (0.82) | 8.53 (0.94) | 143 | 143 | |
| PANEL 3 | | | | | |
| Amenorrhea for weaning group | 1.89 (0.05) | 2.32 (0.15) | 313 | 280 | |
| Amenorrhea for Inf.mort.group | 1.98 (0.10) | 1.87 (0.12) | 104 | 102 | |
| Amenorrhea for non-breastf.group | 2.75 (0.22) | 2.32 (0.17) | 19 | 19 | |
| Log-Rank | | | | | 0.3987 |
| Wilcoxon | | | | | 0.0139 |
| -2 Log(LR) | | | | | 0.2395 |
| d.f. | | | | | 2 |

Source: INCAP Longitudinal Study.

Table 4
Summary of life table analysis of the duration of postpartum amenorrhea for breastfeeding variables.
Guatemala, 1969-1977.

| Breastfeeding Variables | Median (s.e.) | Mean (s.e.) | N | Failures | Pr>Chi-Sq |
|---|---|---|---|---|---|
| PARTIAL BREASTFEEDING | | | | | |
| Less than 7 mos. | 15.98 (0.36) | 15.61 (0.42) | 415 | 217 | |
| Greater than 7 mos. | 19.62 (0.47) | 20.89 (0.61) | 162 | 101 | |
| Log-Rank | | | | | 0.0001 |
| Wilcoxon | | | | | 0.0001 |
| -2 Log(LR) | | | | | 0.0026 |
| d.f. | | | | | 1 |
| NURSING EPISODES PER DAY | | | | | |
| 1 - 7 times | 12.14 (0.94) | 12.12 (0.43) | 200 | 147 | |
| 8 - 11 times | 14.74 (0.18) | 14.58 (0.33) | 346 | 226 | |
| 12 - 22 times | 17.71 (0.23) | 16.99 (0.39) | 217 | 160 | |
| Missing | 12.98 (0.23) | 13.72 (0.33) | 667 | 524 | |
| Log-Rank | | | | | 0.0001 |
| Wilcoxon | | | | | 0.0001 |
| -2 Log(LR) | | | | | 0.0063 |
| d.f. | | | | | 3 |

Source: INCAP Longitudinal Study.

Table 5
Summary of life table analysis of the duration of postpartum amenorrhea for nutritional and clinical cupplementation variables.
Guatemala, 1969-1977.

| Nutritional Variables | Median (s.e.) | Mean (s.e.) | N | Failures | Pr>Chi-Sq |
|---|---|---|---|---|---|
| BODY MASS INDEX | | | | | |
| bmi<20 | 15.35 (0.49) | 15.11 (0.38) | 245 | 205 | |
| 20<bmi<24 | 14.22 (0.31) | 13.99 (0.34) | 347 | 301 | |
| bmi>24 | 13.04 (0.93) | 12.64 (0.62) | 98 | 85 | |
| Log-Rank | | | | | 0.0017 |
| Wilcoxon | | | | | 0.0006 |
| -2 Log(LR) | | | | | 0.1708 |
| d.f. | | | | | 2 |
| CLINICAL SUPPLEMENTATION | | | | | |
| Atole | 13.83 (0.23) | 13.70 (0.27) | 770 | 571 | |
| Fresco | 14.88 (0.24) | 14.90 (0.31) | 660 | 486 | |
| Log-Rank | | | | | 0.0031 |
| Wilcoxon | | | | | 0.0060 |
| -2 Log(LR) | | | | | 0.1011 |
| d.f. | | | | | 1 |

Source: INCAP Longitudinal Study.

Table 6
Summary of life table analysis of the duration of postpartum amenorrhea for demographic variables.
Guatemala, 1969-1977.

| Demographic Variables | Median (s.e.) | Mean (s.e.) | N | Failures | Pr>Chi-Sq |
|---|---|---|---|---|---|
| MOTHER'S AGE | | | | | |
| 12 - 19 | 11.2 (0.56) | 11.33 (0.53) | 168 | 136 | |
| 20 - 29 | 14.43 (0.21) | 14.44 (0.29) | 722 | 520 | |
| 30 + | 15.11 (0.43) | 14.95 (0.33) | 527 | 391 | |
| Missing | 17.46 (1.26) | 14.45 (2.42) | 13 | 10 | |
| Log-Rank | | | | | 0.0001 |
| Wilcoxon | | | | | 0.0001 |
| -2 Log(LR) | | | | | 0.0071 |
| d.f. | | | | | 3 |
| PARITY | | | | | |
| 1 child | 11.17 (0.53) | 12.14 (0.51) | 252 | 201 | |
| 2 - 3 children | 13.79 (0.33) | 14.27 (0.38) | 425 | 298 | |
| 4 children + | 15.16 (0.25) | 14.97 (0.26) | 753 | 558 | |
| Log-Rank | | | | | 0.0001 |
| Wilcoxon | | | | | 0.0001 |
| -2 Log(LR) | | | | | 0.0030 |
| d.f. | | | | | 2 |

Source: INCAP Longitudinal Study.

Table 7
Summary of life table analysis of the duration of postpartum amenorrhea for socioeconomic variables.
Guatemala, 1969-1977.

| Socioeconomic Variables | Median (s.e.) | Mean (s.e.) | N | Failures | Pr>Chi-Sq |
|---|---|---|---|---|---|
| MOTHER'S EDUCATION | | | | | |
| 0 and 1 year | 15.15<br>(0.30) | 15.06<br>(0.36) | 398 | 299 | |
| 2 or more | 14.04<br>(0.21) | 13.57<br>(0.24) | 796 | 628 | |
| Missing | 14.22<br>(0.50) | 16.13<br>(0.78) | 236 | 130 | |
| Log-Rank | | | | | 0.0001 |
| Wilcoxon | | | | | 0.0039 |
| -2 Log(LR) | | | | | 0.0009 |
| d.f. | | | | | 3 |
| MOTHER'S WORK | | | | | |
| Housewives | 14.39<br>(0.23) | 14.03<br>(0.23) | 845 | 643 | |
| Agricultural/ manual workers | 16.67<br>(0.18) | 16.37<br>(0.86) | 74 | 56 | |
| Merchants, Skilled workers | 13.82<br>(0.49) | 13.52<br>(0.41) | 267 | 220 | |
| Missing | 14.02<br>(0.51) | 15.9<br>(0.76) | 244 | 138 | |
| Log-Rank | | | | | 0.0001 |
| Wilcoxon | | | | | 0.0199 |
| -2 Log(LR) | | | | | 0.0047 |
| d.f. | | | | | 3 |

Source: INCAP Longitudinal Study.

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