Early Childhood Nutrition, Education and Fertility Milestones in Guatemala

U. Ramakrishnan, H. Barnhart, D. G. Schroeder, A. D. Stein and R. Martorell

Department of International Health and *Department of Biostatistics, The Rollins School of Public Health at Emory University, Atlanta, GA 30322

ABSTRACT Data on fertility milestones were collected in 1994 and linked to information collected in a trial conducted in eastern Guatemala between 1969 and 1977, to examine whether early childhood nutrition was associated with the timing of fertility milestones. In the original trial, two pairs of villages were randomly allocated to receive either a high energy, high protein supplement (Atole) or a low energy, no-protein supplement (Fresco). Mean age at follow-up was 23.47 y (n = 240). About 62% of women had experienced first birth (median age at first birth = 19.83 y). The median intervals from menarche to first intercourse and from first intercourse to first birth were 5.67 and 0.95 y; they were 1.68 and 0.06 y shorter, respectively, for the Atole group than for the Fresco group. Women who had received Atole in utero and/or during early childhood experienced earlier milestones even after adjusting for socioeconomic status (SES), education and age at the prior event. Median age at first birth was 1.17 y earlier for the Atole group. Better growth during early childhood (not severely stunted) led to earlier milestones (median age at first birth was 1.04 y earlier), primarily among women with illiterate fathers. Completion of primary school significantly delayed fertility milestones; the median age at first birth was 4.27 y later for those who completed primary school compared with those who did not (P < 0.05). In sum, improved nutrition during early childhood results in earlier fertility milestones, but the effects of schooling in delaying fertility milestones are greater in magnitude. Intervention programs that improve early childhood nutrition should be accompanied by investments in education that ensure that girls complete primary school. J. Nutr. 129: 2196–2202, 1999.

KEY WORDS: • childhood stunting • improved growth • education • fertility • food supplements

The improvement of childhood nutrition is viewed by many developing countries and international agencies, such as the World Bank and UNICEF, as an important strategy for enhancing human capital and promoting economic growth (Martorell 1996). One argument made against investments in early childhood nutrition is that they may lead to increased fertility and population growth (Bongaarts 1980), a major problem in many developing countries with limited resources. Specifically, improved childhood nutrition could lead to an earlier occurrence of key fertility milestones, such as age at menarche, first intercourse, first pregnancy and first birth. The earlier occurrence of first pregnancy and first birth would then be expected to result in higher total fertility rates (Balakrishnan et al. 1988, Freedman et al. 1981). A counterargument is that improved maternal nutritional status results in improved birth outcomes, such as higher birth weight and reduced infant mortality (Martorell et al. 1981, Rivera et al., 1996), and women whose children survive are more likely to participate in family planning (Rahman 1998).

Studies about nutrition and fertility milestones are limited mainly to menarche. In North America and Europe, age at menarche has declined by ~3 y since the beginning of this century (Tanner 1968 and 1975, Zacharias and Wurtman 1969). This has been attributed to improvements in the standard of living, including nutrition (Ostersehlt and Danker-Hopfe 1991, Prado 1986, Veronesi and Gueresi, 1994, Wolanski, 1985). Conversely, Chowdhury et al. (1978) reported delays in the age at menarche in famine/war situations involving acute food shortages. In a study of a rural Indian population in Guatemala, Delgado et al. (1985) found that taller and heavier girls were more likely to experience earlier marriage and, more importantly, that an early age at menarche was associated with earlier marriage. A major limitation of most studies to date, however, is their cross-sectional study design, which does not permit inferences of causality (Chowdhury et al. 1978, Delgado et al. 1985 Frisch 1972, Frisch and McArthur 1974, Hillman et al. 1971, Tanner 1975, Zacharias et al. 1976). The only prospective study about menarche is our own from Guatemala. Girls who were severely stunted at 3 y of age, defined as height-for-age Z-score (HAZ) < −3 based on the international National Center for Health Statistics (NCHS)/WHO reference (WHO 1986), attained menarche ~7 mo later (P < 0.05) than girls who were not stunted (HAZ > −2) (Khan et al. 1995). On the other hand, nutritional supplementation was not associated with age at menarche (Khan et al. 1995).

1 Supported by grants from UNICEF, Thrasher Research Fund and the National Institutes of Health (HD-22240, HD-22297, HD-33468, HD-34531).
2 To whom correspondence should be addressed.

0022-3166/99 $3.00 © 1999 American Society for Nutritional Sciences.
It is not known whether these variations in age at menarche by early childhood nutrition extend to the timing of first pregnancy and birth, which are outcomes influenced by biological and social factors. Several biological factors that may be determined in utero and early in life may affect future ability to conceive and deliver a healthy newborn and thereby influence age at first birth. Recently, Lumey and Stein (1997), using a retrospective cohort study design, found that poor nutrition during pregnancy, measured by exposure in utero to the Dutch Famine of 1944–1945, did not alter age at menarche or age at first birth, which led the authors to conclude that in utero exposure to nutritional deprivation in previously well-nourished women does not reduce fertility. However, those results must be verified in other settings, especially those in which malnutrition is common.

Social factors, such as socioeconomic status (SES) and education are well-known predictors of fertility behavior (Ann et al. 1983, Castro 1995, dos Santos Silva and Beral 1997). Surveys in 26 developing countries found that greater schooling in women was consistently associated with lower fertility (Castro 1995). Some studies show that education delays the age at first birth across varied settings (DeWit and Rajulton 1992, dos Santos Silva and Beral 1997, Engle and Smidt 1996, Nath et al. 1999, Nguyen et al. 1993). These effects may be due to the effect of female education on age at marriage, family size preferences and/or contraceptive use. Although the benefit of women’s education in reducing overall fertility is well known, the role it plays in the relation between nutrition and fertility milestones remains unclear.

In summary, although the link between nutrition and fertility has been long debated, no prospective studies have examined how improved nutrition during early childhood influences future reproductive performance. The objectives of this study were twofold: 1) to examine the relationship between early childhood nutrition and the timing of fertility milestones that occur after menarche; and 2) to examine the role of education and the extent to which it modifies the relation between nutrition and fertility milestones in a developing country setting with high rates of malnutrition.

SUBJECTS AND METHODS

Study sample. This study is a follow-up of participants in a longitudinal, community-based, food supplementation trial that was conducted in eastern Guatemala by the Instituto de Nutrición de Centro América y Panamá (INCAP) between 1969 and 1977. Four study villages were stratified by size (two large and two small) and were randomly allocated to receive either a high energy, high protein supplement (Atole) or a low energy, no-protein supplement (Fresco). Analyses were conducted on 682 kJ of energy and 11.5 g of protein per cup (180 mL), whereas Fresco provided 247 kJ per cup and no protein. Both supplements contained vitamins and minerals and were administered twice daily. Data on maternal nutrition and on growth and maturation, diet, illness and psychosocial development of children from birth to 7 y of age were collected. Additional details about the original intervention study are described elsewhere (Martorell et al. 1999a). Since 1988, a series of follow-up studies of the participants of the original study have been conducted in the same villages in collaboration with INCAP. This report utilizes data from the original intervention trial and the 1988 and 1994 follow-up examinations described below.

A total of 954 women who were born between January 1966 and August 1977 in the four study villages were exposed to supplementation either partially or totally, in utero and during the first 3 y of life in the original trial. Data on HAZ at or around 3 y, paternal illiteracy and SES during early childhood, and SES in 1988, were available for 395 women. Fertility data were available for 61% of this sample (n = 240). Comparison of the final analytical sample with women for whom follow-up data were not available (n = 714) indicated no differences in key variables such as type of supplement, level of stunting, SES during early childhood and maternal illiteracy.

Data collection. Reproductive histories were collected for all women of reproductive age who were residents of the four study villages between October and December 1994. Trained field workers interviewed women at home using pretested questionnaires. The study protocol received ethical clearance from Emory University and INCAP, and informed consent was obtained from all subjects. Events recalled included age at menarche (to the nearest month), date of first intercourse, all unions and marriages, all pregnancies and their outcomes (abortions, miscarriages, still births and live births) and details of past and current contraceptive use. In addition, data on the highest grade of schooling completed and current marital status were obtained.

Conceptual framework. We considered a series of successive time intervals among the following events: menarche, first intercourse, first pregnancy and first birth (Fig. 1). In addition, cumulative time intervals (menarche to first birth and age at first birth) were also considered. We hypothesized that either the type of supplement and/or severe stunting, both of which are measures of early childhood nutrition, were the key biological variables that could influence the timing of all the fertility outcomes, especially from menarche to first pregnancy (Stein and Kline 1991). The social variables that we considered were education (measured either as paternal literacy during early childhood or the completion of primary school by the study subject) and SES. Education could influence the timing of first intercourse and/or first pregnancy, but not menarche. We therefore examined the association between early childhood nutrition and fertility outcomes in models that included either the antecedents (paternal literacy and SES during early childhood) or concurrent (completion of primary school and current SES) social variables. Because there is no variability in the time interval from first pregnancy to first birth in our data, we used time to first birth in lieu of first pregnancy.

Variable definitions. Fertility outcomes. Age at menarche, first intercourse, first pregnancy and first birth were calculated to the nearest month by subtracting the reported date of these events (month, year) from the date of birth in the original longitudinal study. More than 90% of the first pregnancies were first births and time from first pregnancy to first birth was 9 mo for 95% of births. Therefore, time to first pregnancy was not considered due to lack of variability. The main outcome variables were the time intervals from menarche to first intercourse and from first intercourse to first birth. We also considered cumulative outcomes about menarche and first birth, i.e., time from menarche to first birth and age at first birth.

Atole. This was defined as a dichotomous variable to indicate the type of nutrition intervention received during early childhood (1 if Atole, 0 if Fresco).

Severe stunting. If present at 3 y of age, this was used as a cumulative measure of childhood nutritional status. Poor linear growth or stunting is the best summary measure of chronic exposure to poor diet, high rates of infection and inadequate care during early childhood (UNICEF 1990). Previous analyses have shown that nearly all growth retardation in our study population occurred by age 3 y (Martorell et al. 1999b). Length measurements, obtained prospectively during early childhood in the original longitudinal study, were expressed as HAZ using the international NCHS/WHO reference (WHO 1986). For women who did not have a length measurement at
Measured at follow-up

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Large Fresco (n = 56)</th>
<th>Large Atole (n = 70)</th>
<th>Small Fresco (n = 57)</th>
<th>Small Atole (n = 57)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>23.1 ± 2.9</td>
<td>23.7 ± 3.1</td>
<td>23.4 ± 2.6</td>
<td>23.6 ± 2.7</td>
</tr>
<tr>
<td>Socioeconomic status2</td>
<td>0.57 ± 0.88</td>
<td>0.04 ± 0.83</td>
<td>-0.34 ± 0.83</td>
<td>-0.10 ± 0.81</td>
</tr>
<tr>
<td>Not completed primary school, %</td>
<td></td>
<td></td>
<td>51.8</td>
<td></td>
</tr>
<tr>
<td>Measured in early childhood</td>
<td></td>
<td></td>
<td>78.6</td>
<td>45.6</td>
</tr>
<tr>
<td>Socioeconomic status2</td>
<td>0.43 ± 0.92</td>
<td>-0.23 ± 0.98</td>
<td>-0.55 ± 0.87</td>
<td>-0.08 ± 0.75</td>
</tr>
<tr>
<td>Paternal illiteracy, %</td>
<td>42.9</td>
<td>50.0</td>
<td>19.3</td>
<td>35.1</td>
</tr>
<tr>
<td>Severely stunted, %</td>
<td>44.6</td>
<td>18.6</td>
<td>59.6</td>
<td>21.1</td>
</tr>
</tbody>
</table>

1 Values for age and socioeconomic status are means ± SD.
2 P < 0.05 for differences between villages.
3 Height-for-age Z-score < −3.

RESULTS

Mean age at follow-up was 23.47 y (range, 19.22–28.76 y) and was similar across all villages (Table 1). However, there were significant differences among villages in SES, education, and nutritional status, both at the time of the original intervention trial and at follow-up. The large villages had higher SES scores than the small villages; the difference between the large and small Fresco villages was much greater than that between the pair of Atole villages. Although overall SES improved in all villages between 1975 and 1988, the between-village differences persisted. Village-level differences in the proportion of illiterate fathers and schooling were also present. The small Fresco village, which had the poorest SES, also had the lowest proportion of illiterate fathers and of study subjects who did not complete primary school. About one third (35%) of the study sample were severely stunted (HAZ < −3) at or around 3 y of age. As reported elsewhere, the Atole villages had significantly better nutritional status at 3 y of age than the Fresco villages (Schroeder et al. 1995).

Overall, 65.0 and 62.1% of women had experienced first intercourse and first birth at follow-up, respectively. The median time intervals from menarche to first intercourse and from first intercourse to first birth were 5.67 y and 0.95 y, respectively. The median time from menarche to first birth was 6.32 y and the median age at first birth was 19.83 y.

Comparison of key outcomes by type of supplement (Table 2) indicates that the median time intervals from menarche to first intercourse and from first intercourse to first birth were 1.68 and 0.06 y shorter among those who received Atole than those who received Fresco; median age at first birth was 1.17 y earlier. However, there were strong between-village differences, especially for the time from menarche to first intercourse, and from menarche to first birth. Specifically, all fertility outcomes were significantly delayed in the small Fresco village. In this village, only 42 and 38% of women had experienced first intercourse and first birth, respectively. The median interval from menarche to first intercourse was 0.5 y earlier among those who were not severely stunted compared with those who were. A similar difference was seen for the time from menarche to first birth. Median age at first birth was 1.04 y earlier among those who were not severely stunted compared with those who were. These differences, however, were not significant (P = 0.25).

Time from menarche to first intercourse was ~2.11 y greater for women whose fathers were literate compared with those with illiterate fathers; the median age at first intercourse was 19.75 and 18.17 y, respectively (P = 0.005). The time from first intercourse to first birth was slightly smaller (0.1 y; P
The time from first intercourse to first birth was 1.12 (95% CI: 1.38, 2.84). Adjustment for antecedent covariates (parental literacy and SES during early childhood) yielded similar estimates (Table 2); the median age at first birth and age at first birth were delayed by \( \approx 2 \) y among those with literate fathers. The effects of schooling were greater. The median time from menarche to first intercourse was 6.17 y greater for women who had completed primary school compared with those who had not (Table 2); the median age at first intercourse was 20.75 and 18.13 y, respectively (\( P = 0.007 \)). Schooling had no effect on time from first intercourse to first birth. Overall, there was evidence of a strong effect of education, especially for completing primary school, in delaying the occurrence of first birth.

After adjusting for concurrent covariates (current SES and completion of primary schooling), the hazard ratio for Atole for time from menarche to first intercourse was 1.98 (95% confidence interval (CI): 1.38, 2.84), Adjustment for antecedent covariates (parental literacy and SES during early childhood) yielded similar estimates (Table 3). The hazard ratio for the time from first intercourse to first birth was 1.12 (95% CI: 1.10, 1.23), adjusting for the concurrent covariates. The adjusted hazard ratios (AHR) for the cumulative time intervals (time from menarche to first birth and age at first birth) were similar to those reported for the time from menarche to first intercourse. There were no significant interactions between type of supplement and education.

In the adjusted models, paternal illiteracy was significantly associated with shorter time from menarche to first intercourse, but longer time intervals from first intercourse to first birth. The AHR for schooling indicated that not completing primary school was significantly associated with earlier outcomes in all models except for the time interval from first intercourse to first birth. SES was not significantly associated with the attainment of milestones.

There was a significant interaction between education and severe stunting during early childhood for time from menarche to first intercourse but not for time from first intercourse to first birth. Better growth, i.e., not being severely stunted at around 3 y of age, led to earlier milestones only among women.

### Table 2

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Age at menarche, y</th>
<th>Menarche to first intercourse, y</th>
<th>First intercourse to first birth, y</th>
<th>Menarche to first birth, y</th>
<th>Age at first birth, y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Supplement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atole</td>
<td>13.58 (127)</td>
<td>4.67 (127)*</td>
<td>0.91 (59)*</td>
<td>5.73 (127)*</td>
<td>19.46 (127)*</td>
</tr>
<tr>
<td>Fresco</td>
<td>13.50 (113)</td>
<td>6.35 (113)</td>
<td>0.97 (97)</td>
<td>7.13 (113)</td>
<td>20.63 (113)</td>
</tr>
<tr>
<td>Village</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Fresco</td>
<td>13.42 (56)</td>
<td>6.92 (56)*</td>
<td>0.88 (35)</td>
<td>7.79 (56)*</td>
<td>21.57 (56)*</td>
</tr>
<tr>
<td>Large Atole</td>
<td>13.92 (70)</td>
<td>4.67 (70)</td>
<td>0.98 (57)</td>
<td>5.54 (70)</td>
<td>19.11 (70)</td>
</tr>
<tr>
<td>Small Fresco</td>
<td>13.58 (57)</td>
<td>NA (57)*</td>
<td>0.93 (24)</td>
<td>NA (57)*</td>
<td>NA (57)*</td>
</tr>
<tr>
<td>Small Atole</td>
<td>13.58 (57)</td>
<td>4.67 (57)</td>
<td>0.97 (40)</td>
<td>6.11 (57)</td>
<td>19.72 (57)</td>
</tr>
<tr>
<td>Early childhood nutritional status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not severely stunted</td>
<td>13.50 (156)</td>
<td>5.50 (156)</td>
<td>0.97 (105)</td>
<td>6.98 (156)</td>
<td>20.30 (156)</td>
</tr>
<tr>
<td>Severely stunted</td>
<td>13.75 (84)</td>
<td>6.00 (84)</td>
<td>0.94 (51)</td>
<td>7.45 (84)</td>
<td>21.34 (84)</td>
</tr>
<tr>
<td>Paternal literacy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illiterate father</td>
<td>13.33 (90)</td>
<td>4.56 (90)*</td>
<td>1.02 (72)*</td>
<td>5.87 (90)</td>
<td>19.40 (90)</td>
</tr>
<tr>
<td>Literate father</td>
<td>13.67 (150)</td>
<td>6.67 (150)</td>
<td>0.89 (84)</td>
<td>7.91 (150)</td>
<td>21.67 (150)</td>
</tr>
<tr>
<td>Schooling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not completed primary school</td>
<td>13.75 (146)</td>
<td>4.25 (146)*</td>
<td>0.99 (113)</td>
<td>5.47 (146)*</td>
<td>19.35 (146)*</td>
</tr>
<tr>
<td>Completed primary school</td>
<td>13.42 (94)</td>
<td>10.42 (94)</td>
<td>0.87 (43)</td>
<td>11.18 (94)</td>
<td>23.62 (94)</td>
</tr>
</tbody>
</table>

1 Values are medians; sample sizes are shown in parentheses; *denotes \( P < 0.05 \) for comparison of Kaplan-Meier curves for each independent variable.

2 Median values are not available because fewer than 50% of subjects reached the milestone.

< 0.05) among women with literate fathers compared with those with illiterate fathers, but time from menarche to first birth and age at first birth were delayed by \( \approx 2 \) y among those with literate fathers. The effects of schooling were greater. The median time from menarche to first intercourse was 6.17 y greater for women who had completed primary school compared with those who had not (Table 2); the median age at first intercourse was 20.75 and 18.13 y, respectively (\( P = 0.007 \)). Schooling had no effect on time from first intercourse to first birth. Overall, there was evidence of a strong effect of education, especially for completing primary school, in delaying the occurrence of first birth.

After adjusting for concurrent covariates (current SES and completion of primary schooling), the hazard ratio for Atole for time from menarche to first intercourse was 1.98 (95% confidence interval (CI): 1.38, 2.84), Adjustment for antecedent covariates (parental literacy and SES during early childhood) yielded similar estimates (Table 3). The hazard ratio for the time from first intercourse to first birth was 1.12 (95% CI: 1.10, 1.23), adjusting for the concurrent covariates. The adjusted hazard ratios (AHR) for the cumulative time intervals (time from menarche to first birth and age at first birth) were similar to those reported for the time from menarche to first intercourse. There were no significant interactions between type of supplement and education.

In the adjusted models, paternal illiteracy was significantly associated with shorter time from menarche to first intercourse, but longer time intervals from first intercourse to first birth. The AHR for schooling indicated that not completing primary school was significantly associated with earlier outcomes in all models except for the time interval from first intercourse to first birth. SES was not significantly associated with the attainment of milestones.

There was a significant interaction between education and severe stunting during early childhood for time from menarche to first intercourse but not for time from first intercourse to first birth. Better growth, i.e., not being severely stunted at around 3 y of age, led to earlier milestones only among women.

### Table 3

<table>
<thead>
<tr>
<th>#</th>
<th>Model (^{1,2})</th>
<th>Menarche to first intercourse (^{2})</th>
<th>First intercourse to first birth (^{3})</th>
<th>Menarche to first birth (^{2})</th>
<th>Age at first birth (^{2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type of supplement</td>
<td>1.98 (1.38, 2.84)*</td>
<td>1.16 (1.07, 1.24)*</td>
<td>2.03 (1.46, 2.82)*</td>
<td>1.95 (1.35, 2.82)*</td>
</tr>
<tr>
<td></td>
<td>Paternal illiteracy</td>
<td>1.65 (1.06, 2.55)</td>
<td>0.68 (0.54, 0.85)*</td>
<td>1.46 (0.88, 2.43)</td>
<td>1.48 (0.89, 2.46)</td>
</tr>
<tr>
<td>2.</td>
<td>Type of supplement</td>
<td>1.80 (1.37, 2.38)*</td>
<td>1.12 (1.01, 1.23)*</td>
<td>1.85 (1.39, 2.46)*</td>
<td>1.76 (1.30, 2.39)</td>
</tr>
<tr>
<td></td>
<td>No primary school</td>
<td>2.29 (1.30, 4.04)*</td>
<td>1.00 (0.90, 1.10)</td>
<td>2.43 (1.54, 3.84)*</td>
<td>2.50 (1.49, 4.19)</td>
</tr>
<tr>
<td>3.</td>
<td>Severe stunting</td>
<td>0.85 (0.67, 1.06)</td>
<td>0.77 (0.57, 1.05)</td>
<td>0.83 (0.70, 0.99)</td>
<td>0.86 (0.69, 1.07)</td>
</tr>
<tr>
<td></td>
<td>Paternal illiteracy</td>
<td>1.74 (1.11, 2.73)*</td>
<td>0.65 (0.53, 0.79)</td>
<td>1.56 (0.90, 2.70)</td>
<td>1.57 (0.90, 2.73)</td>
</tr>
<tr>
<td>4.</td>
<td>Severe stunting</td>
<td>0.79 (0.58, 1.08)</td>
<td>0.83 (0.55, 1.27)</td>
<td>0.77 (0.63, 0.95)</td>
<td>0.80 (0.62, 1.05)</td>
</tr>
<tr>
<td></td>
<td>No primary school</td>
<td>2.58 (1.33, 5.02)*</td>
<td>1.06 (0.92, 1.22)</td>
<td>2.75 (1.55, 4.89)*</td>
<td>2.82 (1.51, 5.28)*</td>
</tr>
</tbody>
</table>

1 Values are adjusted hazard ratios with 95% confidence intervals in parentheses for type of supplement (Atole = 1; Fresco = 0) or severe stunting (\( Y_{es} = 1; ~ No = 0 \); *denotes \( P < 0.05 \).

2 Models incorporate adjustments for socioeconomic status, village and age at menarche (\( n = 240 \)).

3 Models incorporate adjustments for socioeconomic status, village and age at first intercourse (\( n = 156 \)).
with illiterate fathers (Table 4). The effect of paternal literacy in delaying fertility milestones was greater among those who were not severely stunted during early childhood. The median time from menarche to first intercourse was 2.75 y greater for subjects with literate fathers compared with those with illiterate fathers among those not severely stunted during early childhood. The difference associated with paternal literacy was only 0.42 y among those who were severely stunted during early childhood. Similar results were seen for time from menarche to first birth and age at first birth. Completion of primary schooling by women in the study increased the time from menarche to first intercourse, with a larger effect among those who were severely stunted during early childhood. Similar effects were seen for the cumulative time intervals. Overall, completing primary schooling delayed the median age at first birth by at least 3 y.

**DISCUSSION**

This study is the first to examine the relationship between early childhood nutrition and fertility outcomes using prospectively collected data in a developing country. The mean age at first birth and time from menarche to first birth are similar across villages, the more culturally defined fertility milestones, such as the time interval from menarche to first intercourse, were significantly later in the small Fresco village. Earlier work has also shown that this village is quite distinct both socially and ecologically from the other villages (Bergeron 1993). This village had a strong tradition of higher schooling that dates back to even before the intervention study. Both paternal literacy and completion of primary schooling were the highest in this village. Unfortunately, we lack the data to examine conclusively whether these village-level differences in fertility milestones existed before the original intervention study. Although the village-level allocation of treatment was appropriately accounted for in our analysis, the small sample size (two pairs of villages) limits our ability to control for these inherent village-level differences.

In the case of severe stunting, previous work by Khan et al. (1996) using data from the same INCAP cohort, found a difference of about 7 mo in the mean age at menarche between subjects who were severely stunted (HAZ <-3) at 3 y of age compared with those who were not stunted (HAZ > -2). However, we found a smaller nonsignificant difference (3 mo; P = 0.1), which may be due to the small sample size and the
fact that we compared two groups, i.e., severely stunted or not, instead of three groups as in Khan et al. (1996).

Our results demonstrate the importance of social determinants, especially education, in delaying fertility milestones. Paternal literacy was associated with a longer time from menarche to first intercourse, but was not associated with earlier first birth after adjusting for other covariates. Completion of primary school had a larger effect and significantly delayed the timing of first intercourse and first birth, even after adjusting for socioeconomic status and age at menarche. It should be noted, however, that schooling delayed only the time to first intercourse from menarche, but not the time to first birth from first intercourse. Contraceptive use was extremely low in this population, which may explain the lack of effect of schooling on the second interval. The other reason may be related to the accuracy of recall of age at first intercourse. The interval from first intercourse to first birth is short, suggesting that women may have reported age at first intercourse based on the timing of first pregnancy and/or birth. Age at menarche was not associated with completion of primary school, which suggests that it is unlikely that early matures dropped out of school earlier; rather, we hypothesize that either better school performance or staying in school longer were associated with a reduced risk of having sex. This finding is consistent with previous studies that have examined the role of social factors in predicting fertility milestones (Ann et al. 1983, Castro 1995, dos Santos Silva and Beral 1997, Engle and Smidt 1996).

A major contribution of our study is evidence of a strong interaction between early childhood stunting and education. Our findings suggest that the observed effect of stunting on time from menarche to first intercourse may also be due to behavioral rather than biological mechanisms. Better growth led to earlier outcomes only among those whose fathers were illiterate, suggesting familial influences. On the other hand, shorter girls who remain in school may be perceived as being less attractive and less mature for childbearing, and therefore have later outcomes.

In summary, this paper suggests that improved nutrition, especially food supplementation during early childhood, results in earlier attainment of fertility milestones. However, these effects may be countered by social factors, especially education. The effect of completing primary school in delaying fertility milestones was larger in magnitude than that of improving nutrition. Because they come from only one setting and are based on relative small samples, these findings should be considered with caution, and more work is required to improve our understanding of the underlying biological and social mechanisms that explain the sequence of events that lead from early childhood to age at first birth. In the meantime, programs that aim to improve early childhood nutrition should be implemented in conjunction with efforts to make sure that every child attends and stays in school. It should also be noted that earlier work has shown that “educability,” i.e., performance on tests of knowledge, numeracy, and vocabulary that were administered during adolescence, improved among those who received Atole compared with Fresco, while controlling for the level of schooling (Pollitt et al. 1995). To benefit from improved educability, investments in education such as the provision of good schools as well as improving the availability of family planning services would be required to see long-term benefits. In conclusion, the combination of improved nutrition and better education will result not only in later fertility milestones, but also healthier and better-nurtured children.

ACKNOWLEDGMENTS

This study would not have been possible without the strong institutional support and role of INCAP in coordinating and organizing data collection and entry over the years. The participation of the women and families in the study villages is gratefully acknowledged. The contributions of Joan Herold, Associate Professor, Department of Behavioral Sciences and Health Education at the Rollins School of Public Health in designing and providing oversight for data collection and management for the 1994 fertility survey and the assistance of Clark Denny and Morgen Hughes in data management and analysis are gratefully acknowledged. Finally, the valuable contributions and recommendations made by the anonymous reviewers are recognized.

LITERATURE CITED


Macro International Inc. (1990) Guatemala 1987: results from the demographic and health survey. StataCorp, College Station, TX.


