11
Child Mortality and the Fertility Transition: Aggregated and Multilevel Evidence from Costa Rica

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INTRODUCTION

Is decreasing child mortality a prerequisite—a necessary condition—for decreasing fertility? Can decreasing child mortality alone trigger the fertility transition? These questions have important policy implications. If improving child survival is a precondition for birth control, family planning programs in the least developed regions are unlikely to succeed, especially if these programs have a vertical organization independent of child health interventions. In turn, if reducing child mortality is a sufficient condition, family planning programs may be somewhat superfluous: "Development is the best contraceptive." In this chapter I address the issue of whether reduced child mortality is crucial for the fertility transition by examining the empirical evidence from Costa Rica, a developing country that managed to decrease both child mortality and birth rates. Here I examine Costa Rica's record at the aggregate and the individual level.

A strong association between child mortality and fertility is well documented in the literature. Countries with low infant mortality almost always have low birth rates (Heer, 1966; Mauldin et al., 1978). Couples that have lost a child are, in turn, less likely to use contraception, tend to have more children, and have shorter birth intervals (Taylor et al., 1976). However, this association is neither proof of causation nor indicates the direction of causation. The association may have three closely linked origins: First, child mortality and fertility share a common set of determinants, such as mother's education, access to health services, breastfeeding practices, and less observable traits such as a preference for "high-quality" children or a less fatalistic outlook on life (Hanson et al., 1994). Second, lower fertility may lessen child mortality by acting on such potential mechanisms as maternal depletion associated with pregnancies and lactation (Trussell and Pebley, 1984), sibling competition for scarce family resources and maternal care including breastfeeding (Pebley and Millman, 1986), and transmission of infections in child-crowded environments (Blacker, 1987; Haaga, 1989). The third possibility—the one addressed in this chapter—is that the direction of causation runs from child survival to fertility. Although disentangling these three types of causal links is an impossible task with the data available, by statistically controlling the effect of particular variables and by paying attention to the sequence of events over time, I try to reach some conclusions about the third causal link: the role of child mortality on contemporary fertility transitions.

There are several explanations for the postulated effect of child mortality on fertility. In the classic demographic transition theory, high fertility is in part a response to high levels of infant and child mortality (Notestein, 1953; Davis, 1955). Parents have many children to replace those who have died (replacement effect) or parents set excess fertility goals in anticipation of their children's deaths (insurance effect) (Lloyd and Ivanov, 1988). Increased probabilities of child survival may thus be a necessary condition for fertility decline: Parents will not control their fertility unless they have assurance their children will survive (Taylor et al., 1976). Moreover, improvements in child survival may be a sufficient condition for fertility decline as soon as parents realize that it is no longer necessary to have many children or to suffer the economic consequences of larger families (Preston, 1978). Under these circumstances, fertility transition would be merely an adjustment process to conditions brought about by reduced child mortality (Carlsson, 1966). Where long periods of breastfeeding are the norm, a physiological mechanism may also be important: The death of an infant may substantially reduce the breastfeeding period and, consequently, the period of temporary infecundity after childbirth, which would result in shorter birth intervals and more children born by the end of the reproductive life (Cochrane and Zachariah, 1983).

Two earlier studies of the Costa Rican record show significant effects on reproductive behavior of couples whose children have died (Rutstein and Medica, 1978; Mensch, 1985). The replacement strategy is the most likely effect of one's own children's deaths. This effect seems reasonable and is well documented in populations that already control fertility, as it was in the Costa Rican samples analyzed in these two studies. In pretransition societies, however, it is hard to believe that couples turn on and off their fertility in response to child deaths. Data for European populations in the past usually do not show significant replacement effects (Knodel, 1978).

A third Costa Rican study, based on the 1976 World Fertility Survey, does not find a significant effect of child mortality in the community upon the reproductive behavior of individual women (Heer and Rodríguez, 1986). The insurance strategy is the most likely causal mechanism for the postulated effect of community-level child mortality. This effect has been seldom studied in other countries because of the lack of reliable multilevel data. One of the problems for building multilevel data sets is the definition of community and then having reliable estimates of child mortality or other contextual variables. The study of Heer and Rodríguez used the *cantón* as the unit for computing contextual variables. This Costa Rican administrative unit is, however, in many cases too large and internally too heterogeneous to be considered a meaningful entity; its boundaries are often arbitrary and the relevant context for the *cantón*'s edges may be that of neighboring *cantones*. In this chapter I overcome these limitations by using geographic information system data to obtain a precise and compact definition of "context" (the area within a radius of 5 kilometers in rural areas and 1 kilometer in urban areas from the index household). In addition, in this chapter I focus on the crucial event, adoption of family planning for the first time, as the dependent variable. In the studied cohorts, which grew up in a natural fertility environment, this represents a breaking point with the past.

After a brief analysis of Costa Rican national trends during this century, I examine the role of child mortality on the fertility transition at the macro- and the micro-level. The analysis at each level looks first at bivariate associations and then moves into multivariate associations with the purpose of isolating net effects. The macro-level analysis is based on data from 89 Costa Rican counties, which are small geographic entities defined on the basis of the country's administrative division in *cantones* and *distritos*. The multivariate analysis of this data set includes traditional regression models of the effect of child mortality on fertility at three points in time and between these points. It also models the event "fertility transition," as operationalized by two dependent variables: onset and pace of decline. The multivariate analysis of the onset of the fertility transition is carried out using Cox regression. The individual-level analysis uses a survey conducted in 1984 that included a lifetime calendar of contraceptive use. The analysis tests the hypothesis that contextual child mortality patterns influence the adoption of fertility control. This analysis focuses on the individual-level equivalent of fertility transition—the timing in the adoption of birth control—rather than on reproductive behavior in general, and it is restricted to the cohorts that lived through the fertility transition (i.e., women aged 15-34 in 1960). Given that the analysis combines contextual or macro-level indicators of child mortality and other variables to explain individual-level reproductive behavior, this analysis is referred to as "multilevel."

SECULAR TRENDS IN COSTA RICA

Costa Rica experienced one of the earliest and fastest, although incomplete, fertility transitions in the developing world. The total fertility rate fell from 7.3 to 5.5 between 1960 and 1968, the year an energetic national family planning program started, and then to 3.7 by 1976, the year the decline abruptly stopped (United Nations, 1985). After fluctuating erratically around 3.7 births, the rate began to decline again by 1986, although at a slow pace. According to the most recent estimate, the total fertility rate is 2.7 births per woman in 1995 and the contraceptive prevalence rate is 75 percent in 1993 (Caja Costarricense de Seguro Social, 1994).

There is no unique and simple explanation for the fertility transition in Costa Rica. Some authors stress the role of education, especially among women (Stycos, 1982). Other authors note the pervasiveness of the decline across all regions and social sectors to stress the role of the government in erasing differentials and redistributing income (Behm and Guzmán, 1979). Others underscore the explosive increase in the supply of contraceptives by the private sector and later by the public sector that took place in the 1960s (Tin Myaing Thein and Reynolds, 1972). It is obvious that the official family planning program, launched in 1968, had nothing to do with the early fertility decline, which occurred mostly among the urban, middle class. It is, however, accepted that the rapid propagation of the process to rural and urban working classes was catapulted by the energetic family planning program launched in 1968 (Rosero-Bixby et al., 1982). Recent literature also stresses diffusion, or social interaction, processes as one of the key determinants of the transition (Rosero-Bixby and Casterline, 1994, 1995; Knight, 1995).

Although most studies mention child mortality decline among the socioeconomic transformations that may have brought some of the fertility transition, none considers it a crucial factor.

At the fertility transition onset, the country's infant mortality rate was 76 per 1,000 and the child mortality risk (the probability of dying before the age of 5 years) was 96 per 1,000, which are high levels at current standards but were not in the late 1950s. In absolute terms, most of the possible reduction in child mortality rate had already taken place by 1960. It had declined by two-thirds from levels of about 300 per 1,000 observed by the 1910s (Figure 11-1). In relative terms, however, the fastest infant and child mortality reductions occured in the 1970s. The child mortality rate of about 18 per 1,000 in 1990 is one-fifth that of 1960. This acceleration in the pace of child and infant mortality decline in the 1970s has been linked to three factors (Rosero-Bixby, 1991a): public health interventions, which probably were the most important; development, including social improvements and a vigorous and sustained growth in the economy (Figure 11-3), and the fertility decline.

Figure 11-1 compares the evolution during the twentieth century of the general fertility rate, the child mortality rate, and an indicator of the economy (imports per capita, one of the few indicators with a series covering the entire period). The data for this figure come from official statistics, which in Costa Rica are reasonably reliable. The only apparent association between the general fertility rate and the child mortality rate is the acceleration in the relative decline in the latter during the fertility transition.

Actually, this acceleration starts a few years after the fertility transition

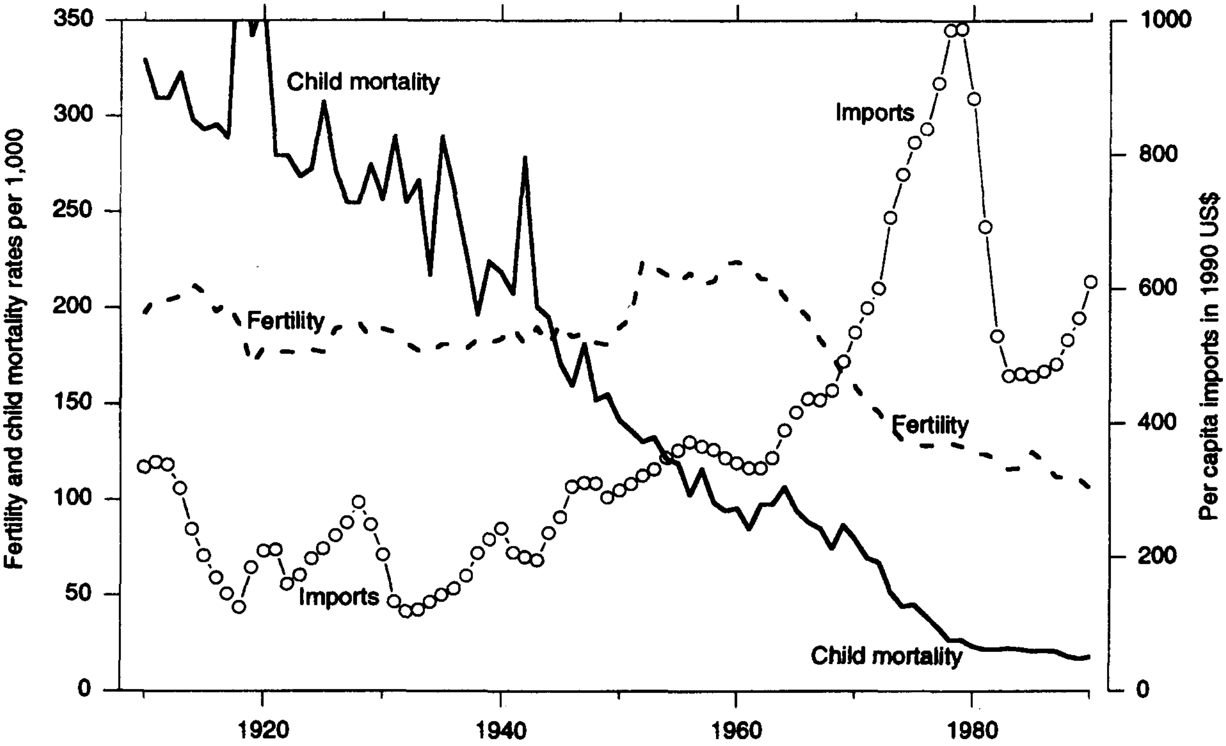


FIGURE 11-1 Child mortality rate, general fertility rate, and per capita imports, Costa Rica, twentieth century.

onset. This temporal sequence suggests that the direction of causation, if any, may run from fertility to child mortality. The rapid, concurrent economic growth suggests, in turn, that both child mortality and fertility declines were part of a broader transformation process in society and living standards.

Figure 11-1 hardly supports the thesis that child mortality decline was key for the fertility transition in Costa Rica. In particular, the record until 1964 is that neither the secular decline nor the short-term fluctuations (mostly due to measles epidemics) in child mortality was sufficient to alter fertility or start the transition. The small fluctuations in fertility during those early years are mostly linked to marital disruption, a marriage boom in the 1950s, and declines in widowhood. The only way that Figure 11-1 could be compatible with the "sufficient condition" thesis would be if the effect of child mortality requires long lags, or threshold doses, to act.

The data in Figure 11-1 are not conclusive as to whether a certain minimal level of child survival is required for fertility transition—the necessary condition thesis. If such a prerequisite exists, the Costa Rican experience indicates a child mortality rate threshold of 100 per 1,000 or higher.

The rate did not need to be as low as, say, 50 for people to adopt family planning; the fertility transition started at levels substantially higher than this. In turn, it would not be appropriate to conclude that the fertility transition is not possible at a rate of, say, 200 per 1,000. The transition did not start in Costa Rica in 1945 when the child mortality rate was approximately 200 per 1,000 either because of prevailing mortality conditions or because of the absence of other conditions, such as the availability of contraceptives or the rising costs of childbearing.

MACRO-LEVEL BIVARIATE ASSOCIATIONS

The covariations in fertility and child mortality across geographic units may cast some light on the nature of the association between these two variables. These covariations may be studied in a rich data set for 89 Costa Rican counties. The unit of analysis, the county, is a small geographic unit usually on the order of 20,000 inhabitants, defined on the basis of the Costa Rican administrative divisions, *cantones* and *distritos*. Indicators available in this data set are the marital fertility rate (births per married woman aged 15-44) in 1965, 1975, and 1985; and the child mortality rate (probability of dying before the fifth birthday) lagged 2 years. The numerator for computing the marital fertility rate is a 5-year average from the country's vital statistics; the denominator is an estimate based on the 1963, 1973, and 1984 censuses. The data on births were validated with estimates obtained by projecting the census populations backward. The child mortality rates in 1963 and 1973 were estimated using a variation of the Brass method (United Nations, 1983) on data from the 1973 and 1984 censuses on the proportions of surviving children by mother's age. The child mortality rate in 1983 is a

5-year average from vital statistics corrected by the ratio between the census-based estimate and a vital statistics estimate in 1973 (no correction was larger than 20 percent). Eleven counties with seemingly unreliable estimates were excluded from the original pool of 100 counties (details reported in Rosero-Bixby, 1991b).

Bivariate Macro-Level Associations

Figure 11-2 shows a hypothetical scatterplot for interpreting the data of bivariate covariations in fertility and child mortality levels. The figure's four quadrants result from combining high and low child mortality levels with high and low fertility rates. Most populations should fall in quadrants II and IV, the

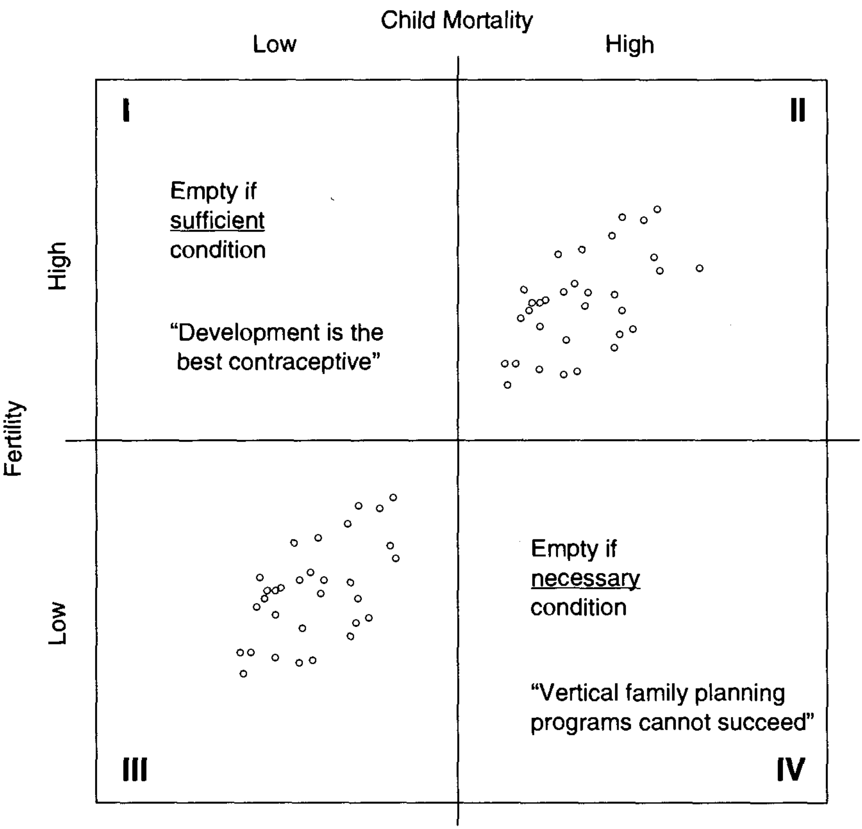


FIGURE 11-2 Expected scatterplot for the causal associations of child mortality on fertility.

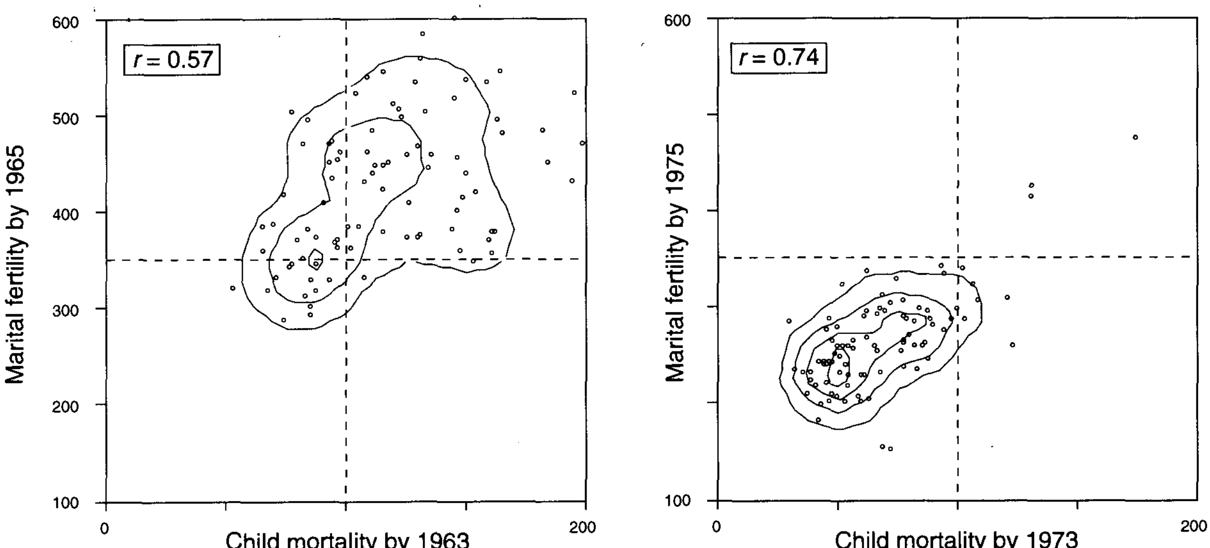
high-high and low-low quadrants. Quadrant I of low child mortality and high fertility is expected to be nearly empty if a decreasing child mortality is a sufficient condition to bring down fertility rates. Quadrant III of high child mortality and low fertility should not contain observations if lowering child deaths is a precondition for fertility decline. If real data show a substantial number of observations in quadrants I or III, the corresponding hypotheses should be rejected (although the contrary does not mean that the hypotheses are true). A few observations in quadrants I and III may occur in real data as a consequence of measurement errors or effect lags.

How do the Costa Rican counties behave in comparison with this hypothetical association? Figure 11-3 shows the scatterplots for 1965, 1975, and 1985. The 1985 marital fertility rate is also plotted against the child mortality rate 22 years earlier to give an impression of the effect of considering lengthened lags. A striking feature in the figure is the fast pace of change in both fertility and child mortality. In just 10-year intervals, there are remarkable shifts in the cloud of observations toward the origin. Although the expected positive correlation occurs in the four cross sections, the correlation becomes weak by 1985.

By 1965, although most counties lay in the high-high zone (quadrant II), some have moderate child mortality and high fertility rates as counter evidence for the "sufficient condition" thesis: Birth rates continued to be high in spite of moderate infant mortality. By 1975, counties with either high mortality or high fertility are extinct species for practical purposes. Very few counties ever fall in the region of low fertility and high mortality (quadrant IV). The "necessary condition" thesis is neither supported nor rejected by these data.

By the mid-1980s, all counties but one had a low child mortality rate of less than 50 per 1,000. The variation in fertility rates is somewhat broader and the correlation coefficient is a modest 0.31—a suggestion that at these low levels there may be little connection between the two variables.

To what extent do child mortality levels in the past influence current fertility levels? An effect may come about if knowledge of the chances of child survival acquired in childhood and adolescence (news of child deaths heard at home from parents and other adults) is what make couples pursue an insurance reproductive strategy later on life (i.e., have as many children as possible to ensure that some will survive). Figure 11-3 examines this point by plotting the 1985 marital fertility rate against a 22-year lagged child mortality rate. The new correlation coefficient (0.65) is substantially higher than that for the 2-year lagged child mortality rate (0.31). This higher association may be, however, just an artifact of other variables such as the county's level of socioeconomic development. In particular, less developed counties, which tended to have a high fertility rate in 1985, had high child mortality in the 1960s; these counties, however, do not have high child mortality in the 1980s, thanks to health programs implemented in Costa Rica in the 1970s (especially primary health care interventions), which


r = 0.57
Marital fertility by 1965
Child mortality by 1963
600
500
400
300
200
100
0
200
r = 0.74
Marital fertility by 1975
Child mortality by 1973
600
100
0
200

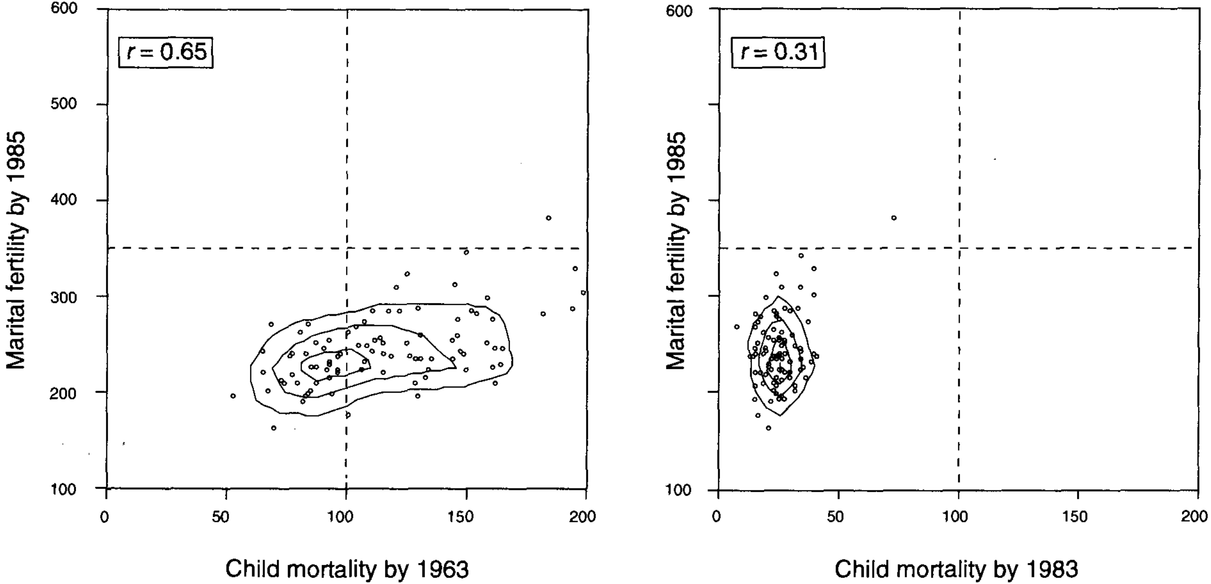


FIGURE 11-3 Relationship between marital fertility and child mortality, Costa Rican counties, 1965-1985. (N = 89 counties, R = correlation coefficient weighted by county's population.)

erased most of the socioeconomic differentials in infant mortality (Rosero-Bixby, 1986).

The scatterplot for the 22-year lagged effect shows a substantial number of counties in quadrant III, which can be taken as evidence against the thesis that low child mortality during childhood and adolescence is a precondition for controlling fertility later in life.

Multivariate Macro-Level Effects on Fertility Rates

To what extent are the bivariate association examined so far and its fluctuations over time a manifestation of third determinants shared by both child mortality and fertility? I addressed this question by statistically controlling the effect of potential confounders in multivariate regression models. In addition to child mortality, regression equations explaining the general marital fertility rate include seven indicators of socioeconomic, programmatic, diffusionist, and geographic conditions at the aforementioned three points in time (unless otherwise indicated, these indicators are lagged 2 years from the marital fertility rate and come mostly from the 1963, 1973, and 1984 censuses). Given that these indicators are considered only to control their potentially confounding effects on the relationship between child mortality and fertility, neither a theoretical construct nor details about their meaning and operationalization are given here (details in Rosero-Bixby, 1991b).

Multiple regression models estimated for the three cross sections of child mortality and marital fertility rates (1965, 1975, and 1985) show relatively modest net effects of child mortality lagged 2 and 12 years on marital fertility (Table 11-1). The net elasticities (i.e., the percentage of change in the marital fertility rate resulting from a 1 percent change in the child mortality rate) range between 0.02 and 0.18. All but the elasticity for the 2-year lagged child mortality rate in 1985 are statistically significant. As with the bivariate correlation coefficient, the association weakens in the cross sections before and after the fertility transition.

Although these estimates do control the potentially confounding effect of other variables in the model, there is no guarantee that the model is fully identified and thus that all spurious associations have been purged; there is always the possibility that the child mortality rate is picking up the effect of a confounding variable that was not included in the model. Regression models on change rates, rather than on levels, ameliorate this possibility by purging all of a county's characteristics and residuals that do not vary over time, such as systematic registration errors or cultural constants influencing both fertility and child mortality. (Random and other errors in the data are, however, magnified by the computation of changes, and the "regression to the mean" phenomenon may introduce considerable noise in the variance of changes (Bohrnstedt, 1969) and can bias toward zero the estimated effects (Freedman and Takeshita, 1969).)

TABLE 11-1 Multiple Regressions on the Marital Fertility Rate, Costa Rican Counties, 1965-1985

	Elasticity				
Explanatory Variable	1965[a]	1975[a]	1985[a]	1965-1975[b]	1975-1985[b]
Child mortality					
Lagged 2 years	0.05*	0.18*	0.02	0.10	−0.04
Lagged 12 years	—	0.08*	0.08*	—	−0.11
Development index	−0.02	0.16*	0.13*	−-0.96*	−0.46
Social security coverage	0.00	−0.04*	−0.04	−0.03	−0.07*
Legal union proportion	0.33*	−0.01	0.09*	−0.38	0.22
Family planning supply[c]	—	−0.01	−0.04	0.02	0.17*
Diffusion: out-county fertility	0.73*	0.70*	1.11*	2.92*	−0.01
Pretransition fertility	0.49*	0.19*	−0.05	—	—
Travel time to San Jose	0.10*	−0.01	0.08*	—	—
Constant	−11.23*	−8.06*	−8.87*	−1.13*	0.14*
Pseudo R^2	0.62	0.39	0.38	0.30	0.20

NOTES: All regressions weighted by the square root of the county's population. N = 89 counties. *indicates significant effect at $p < 0.05$.

[a]Poisson regression on the natural logarithm of the explanatory variables.

[b]Ordinary least-squares regression on proportional changes computed as $(X1 - X2)/(X1 + X2)$.

[c]For "family planning supply" in 1965-1975, the change is in absolute terms (from zero by 1965).

The estimate based on change rates in 1965-1975 shows a modest, positive elasticity of 0.10 of child mortality rate on marital fertility rate. This effect is not statistically significant ($t = 1.1$). The change rates in 1975-1985 show perverse negative effects of child mortality on fertility, but these effects are not statistically significant either. There is thus no support for the thesis that child mortality has been an important determinant of fertility in Costa Rican counties above and beyond socioeconomic and other conditions.

The results for other explanatory variables in the regressions on change rates merit brief comment. In 1965-1975, when most of the Costa Rican fertility transition took place, two strong and significant effects were socioeconomic development (elasticity of 7–1) and diffusionist influences from other relevant counties (elasticity of about 3). The family planning program (measured by the per capita density of services in a radius of 30 kilometers) does not appear as a significant factor during this period, which is not a surprise given that the program started somewhat late. These results conform to most explanations of the fertility transition. Between 1975 and 1985, although fertility rates for the country as a whole did not conform to a clear trend, fertility continued to decline in backward counties but increased in some of the more developed counties. According to the results from the 1975-1985 regression, these changes appear to be related to only two factors: a policy of "universalization" of social security coverage launched by the government in 1976 and the strength of government family planning services. The diffusionist process ceased to act, and the negative effect of development on fertility weakened.

Macro-Level Effects on the Onset and Pace of Fertility Transition

The pattern of variation over time in the aggregated associations suggests that the causal link between child mortality and fertility may be weak or nonexistent in pre- and post-transition equilibria. The causal connection, if any, emerges or strengthens only in cross sections taken halfway through the transition process. These patterns suggest that there is no general causal relationship, but a one-time, irreversible event that constitutes the fertility transition. The effect of child mortality on the fertility transition event could be that of a true causal agent that promotes the transition (the sufficient condition hypothesis), that of a precondition for the transition, or that of a mild facilitator of other determinants. Onset year and pace are two dependent variables that characterize the fertility transition. The onset year of the transition in the county is defined as the first year of a mean decline in the marital fertility rate of 3 percent per year over 6 years. The pace of the fertility transition is defined as the rate of reduction in the marital fertility rate over the 8 years following the onset of the transition.

In about 90 percent of Costa Rican counties, fertility started to fall between 1959 and 1968 (median is 1965)—before the government established the family planning program in 1968. What was the child mortality level by the onset of the fertility transition in these counties? It ranges between 50 and 190 per 1,000 for all counties, with an inter-quartile range from approximately 90 to 130 (see the box in the lower part of Figure 11-4). In one-fourth of the counties the fertility transition onset occurred when child mortality levels were 130 or more. A level of 130 means that couples with five children have a 50 percent probability of experiencing the death of a child. In spite of this close contact with children's deaths, fertility started to decline—suggesting that low child mortality often is not a prerequisite for the fertility transition.

Does the child mortality rate correlate with the timing of the fertility transition onset? Given the positive correlation between fertility and child mortality, I would expect an earlier transition onset in counties with lower child mortality. Interestingly enough, those counties with child mortality rates of 130 or higher were not the laggards for the transition onset. The late adopters (1969 or later) actually had somewhat lower child mortality rates when the transition started. This, however, is an artifact of the time trends in child mortality: The laggards benefited from the substantial fall in child mortality that occurred in the 1970s. Looking at the child mortality rate at a fixed point in time (1963) shows that counties with higher child mortality rates lag behind in the fertility transition.

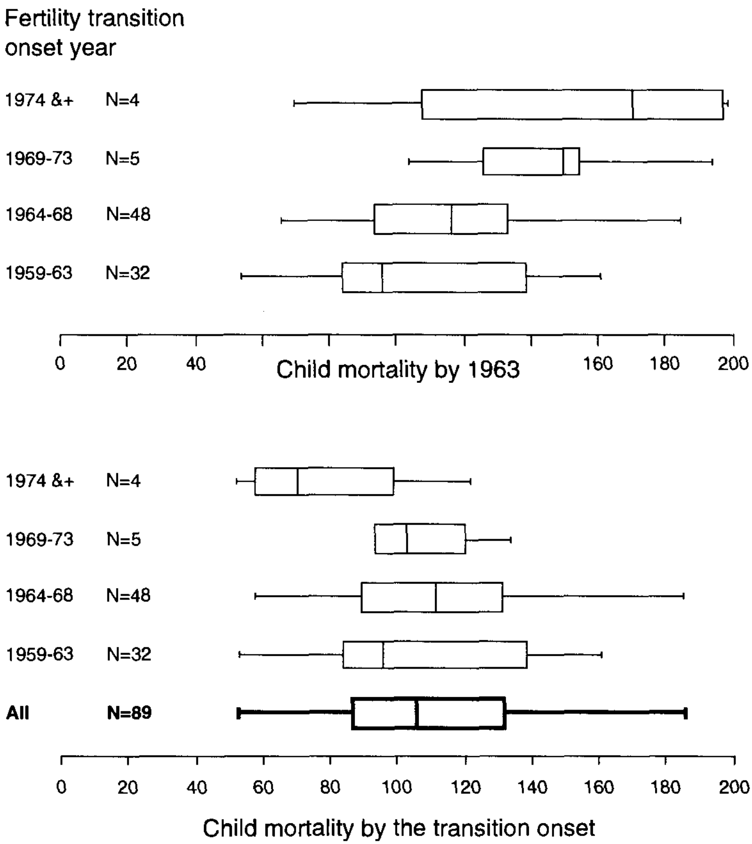


FIGURE 11-4 Child mortality by the fertility transition onset, Costa Rican counties.

The median 1963 mortality rate is about 150 among counties with transition onset in 1968 or later, whereas it is about 100 among the early adopters. The data are thus consistent with the expectation that high child mortality rates may delay the fertility transition.

With regard to the pace of the fertility transition, the expectation is that lower child mortality may facilitate or promote faster declines. Data for the 89 Costa Rican counties do not support this expectation. The marital fertility rate fell by 56 percent in the 8 years following the transition onset independently of the child mortality rate in the county (data not shown).

As with previous bivariate covariations, the association between the child mortality rate and the transition onset may be contaminated by interrelated county characteristics. To check this possibility, a Cox multiple regression model was estimated. Cox regression gives estimates of the proportional rate of occurrence

TABLE 11-2 Multiple Regressions on the Fertility Transition Onset Year and the Following Transition Pace, Costa Rican Counties, 1960-1988

	Elasticity	
Explanatory Variable	Onset Risk[a]	Pace[b]
Child mortality (interval)	–0.67	0.05
Socioeconomic development index	1.97*	0.23*
Social security coverage	–0.06	–0.02
Legal marital union proportion	–1.95*	0.03
Family planning service supply	—	0.03
Diffusion, out-county fertility	–7.65*	–0.48
Pretransition, in-county fertility	3.58*	0.78*
Travel time to San Jose	–0.23	–0.02
Onset year (1959 = 0)	—	–0.011
Constant	—	8.34
Pseudo R^2	0.06	0.26
Proportional effects for child mortality categories		
<75	2.64	1.02
75-99	1.24	0.95
100-124	0.60	0.94
125-149	0.95	1.00
150+	1.00	

NOTES: All regressions weighted by the square root of county's population. N = 89 counties. * indicates significant effect at $p < 0.05$.

[a]Cox regression on the onset risk and the natural logarithm of the explanatory variables measured by 1963.

[b]Ordinary least-squares regression on the percent fertility decline in the 8 years following the transition onset. Elasticity measured at the mean. Explanatory variables measured by the transition onset, lagged 2 years.

of a discrete event given some observed time-to-response variable (Cox, 1972). In the present analysis the time-to-response variable was the onset year of the fertility transition. Table 11-2 shows the elasticity in the risk of "transition onset," estimated by the Cox regression coefficients for explanatory variables entered in the model as natural logarithms. The table also shows the elasticities for the pace of fertility decline during the first 8 years of transition. These elasticities were evaluated at the variable's means using regression coefficients estimated by ordinary least squares. Note that the explanatory variables in the model for the onset are measured at the early 1960s, whereas in the pace model they are measured at the onset year.

Each percent increase in the child mortality rate would decrease the likelihood of starting the fertility transition by 0.7 percent. This effect, however, is not statistically significant. The child mortality effect on the transition pace is nil and not significant. Both the onset and pace are significantly accelerated by socioeconomic development (a summary index of seven indicators) and by reduced fertility in other relevant counties. These effects are much stronger for the onset of fertility transition than for the pace. For the latter, there is also a small, marginally significant effect of the family planning program.

To allow curvilinear effects, the child mortality rate was re-entered into the regression models as a categorical variable. The lower panel in Table 11-2 shows the risk ratio and the relative pace. There is now a marginally significant effect on the transition onset. Counties with a child mortality rate below 75 per 1,000 by 1963 are two or three times more likely to begin the fertility transition than counties with a rate of 150 or more. The pace of fertility decline, however, continues to be unrelated to child mortality.

MULTILEVEL ANALYSIS: INDIVIDUAL-LEVEL FERTILITY AND CONTEXTUAL CHILD MORTALITY

Nations, counties, or other aggregated units do not make reproductive decisions: couples do. Families (or women) are thus the right unit of analysis for studying the relationship between child mortality and fertility. The social dynamics implicit, however, is multilevel in nature: Specific individuals are the ones who make reproductive decisions but these decisions may be influenced by others' experience with child deaths, that is contextual child mortality rates. This effect of aggregated child survival experiences on individual reproductive decisions is at the core of the so-called hoarding or insurance strategy against likely child deaths. To test whether this reproductive strategy influenced the fertility transition in Costa Rica, I examine the record of adoption of family planning among the agents of fertility change, women born between 1927 and 1946. Older and younger cohorts added little to the fertility decline brought about by these cohorts (Rosero-Bixby and Casterline, 1995).

The event of interest, or dependent variable, for this analysis is the individual-level equivalent of the fertility transition onset, the timing for adopting contraception for the first time. The individual-level data come from a nationally representative sample of women gathered for a 1984 study of cancer and contraception (Lee et al., 1987; Rosero-Bixby et al., 1987; Irwin et al., 1988; Rosero-Bixby and Oberle, 1989). This sample is well suited for the present study because it includes the cohorts of interest as well as a lifetime calendar of reproductive events that provides reliable information on the first use of contraception and a migration history that identifies the place of residence during adolescence. The analysis is restricted to women aged 37-58 at the time of the survey who reported having ever been sexually active. The time until adoption of family planning was measured as the time between first sexual intercourse and first use of contraception. Observations were censored at 1981, 25 years since first intercourse or the 45th birthday, whichever came first. The sample size usable in the analysis was only 470 women, which means a limited statistical power for detecting small associations (this sample size has less than 80 percent statistical power for detecting relative rates in the range of 0.6-1.7).

The "exposure" variable—contextual child mortality—comes from the 1973 and 1984 censuses, coded into a geographic information system. Although mortality estimates were readily available at the county or even *distrito* level, conventional geographic units were not considered because of the large heterogeneities between and within them and the frequent changes in their boundary layout. Instead, a standard definition of "context," independent of administrative boundaries, was adopted, namely, the area within a radius of 1 kilometer in urban areas and of 5 kilometers in rural areas from the index women's reported place of residence during most of adolescence. The contextual child mortality was defined as the cumulative proportion of children who had died to women aged 40-49 who belong to the respondent's cohort and live in the previously defined context. Therefore, the proportion of children dead among women aged 40-49 in the 1973 census were assigned to respondents born in 1926-1936 and the proportion from the 1984 census, to respondents born in 1937-1947.

Other contextual indicators used in the multilevel analysis were:

- Completed fertility. Children ever born per woman aged 40-49 in the aforementioned census, cohorts, and radius.
- Proportion of households under the poverty line in the aforementioned radius. Poverty defined with unmet basic needs criteria (absence in a household of any two of seven minimum items, including running water, sanitation, electricity, dwelling's materials, a kitchen, bedrooms, and a radio or TV set).
- Family planning supply estimated as the per capita density of services (weighted by the inverse of distance) in a radius of 30 kilometers from the index household.

At the individual level, the following respondent's characteristics were considered:

- Completed years of formal education.
- Wealth index, number of commodities existing in the household by 1984.
- Calendar year at first sexual intercourse, which defines the starting point of the exposure and also time-trend effects.
- Age at first sexual intercourse.
- Whether the respondent has ever married (a time-varying covariate).

Bivariate and Multilevel Effects

Does the pattern of adoption of family planning differ with contextual child mortality levels? The presence of censored observations in the data calls for the use of life table techniques to estimate the adoption curves. Figure 11-5 shows the cumulative adoption curves for six contextual levels of child mortality. These are cumulative "survival" curves estimated by the Kaplan-Meier method (Kaplan and Meier, 1958). It is evident that women from low-mortality contexts adopt contraception quicker and in higher proportions than women in high-mortality contexts. The curves suggest three child mortality levels for differentiating the incidence of contraception: less than 75 per 1,000, 75 to 124, and 125 and higher. The Kaplan-Meier median waiting time for adopting family planning by these three groups is 4, 10, and 25 years since first intercourse, respectively (Table 11-3). The association could not be clearer.

There are large differences in the timing of the adoption of family planning related to other macro- and micro-level characteristics, but none appears to be as important or large as that observed between various child mortality groups (Table 11-3). However, the level of contextual child mortality itself seems strongly associated to these other characteristics. For example, the median family planning adoption time varies from 21 years since first sex among the poor to 3 years among the wealthy, but the child mortality proportion also varies greatly from

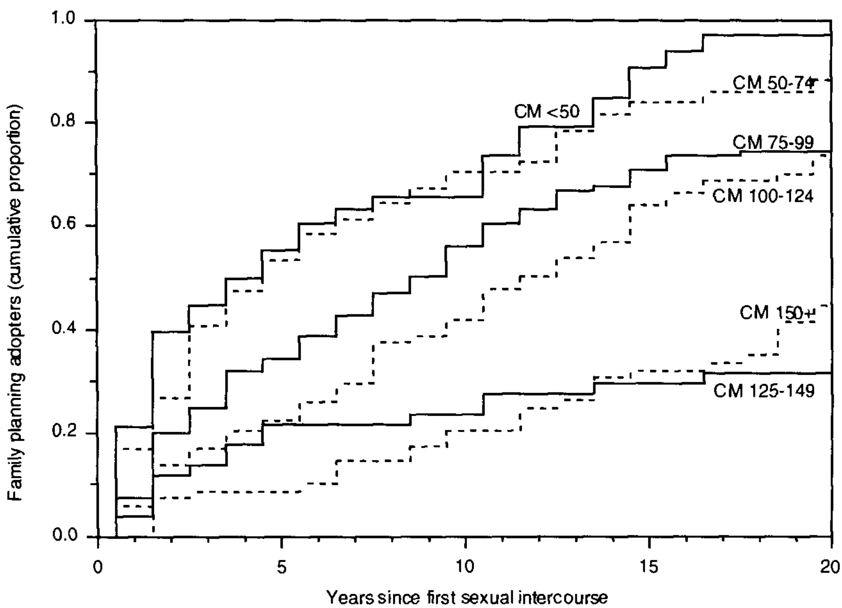


FIGURE 11-5 Family planning adoption curve by level of contextual child mortality (CM).

TABLE 11-3 Contextual Child Mortality and Median Duration until Adoption of Family Planning by Selected Variables

Variable and Categories	N	Median Adoption Year[a]	Contextual Child Mortality
Total	469	10.2	102
Contextual-level			
Child mortality			
29-74	140	4.0	57
75-124	209	9.9	98
125-290	120	24.9	164
Family planning supply 1968-1972			
Moderate	200	12.7	123
High	269	9.0	87
Completed fertility			
2.7-3.9	108	3.4	59
4.0-5.4	160	8.0	88
5.5-8.9	201	18.4	137
Households under poverty line			
<10%	309	6.5	82
10% or more	160	20.3	143
Individual-level			
Education (years)			
0-2	135	18.4	125
3-6	231	9.6	99
7 or more	103	2.6	81
Wealth group			
Poor	121	20.6	128
Low	216	11.2	102
Medium/high	132	3.2	80
Birth cohort			
1926-1936	231	18.1	130
1937-1947	238	5.9	76
Year first sex			
1937-1959	293	15.3	115
1960-1969	139	4.9	83
1970-1983	37	1.9	73
Age at first sex			
11-16	98	18.4	112
17-24	274	10.0	103
25-47	97	3.8	92

[a]Kaplan-Meier estimate. Time counted since first sexual intercourse (women aged 38-58 years in 1984, ever sexually active).

128 to 80 per 1,000, respectively. Child mortality variation overlaps substantially with all these other variables, and it is thus quite possible that most of the bivariate association is attributable to these confounding factors. Thus, statistical control of these confounding effects with multivariate models appears to be mandatory.

Multivariate and Multilevel Effects

Adjusted effects of contextual child mortality on the individual-level rate of adoption of family planning were estimated with Cox multivariate regression. The explanatory variables in the model were categorized to accommodate curvilinear effects. Two of the explanatory variables were allowed to vary over time: contextual family planning supply (zero until 1968 and the average for 1969-1979 thereafter) and individual marital status. Because preliminary models showed interaction between cohort and child mortality, the two variables were combined. Table 11-4 shows the estimated effects as rate ratios of adopting family planning.

Among the older cohorts of women born in 1926-1936, a contextual child mortality rate under 125 per 1,000 increases the rate of adoption of family planning by 51 percent. For the younger cohorts born in 1937-1947, crossing a child mortality threshold of 75 per 1,000 increases the likelihood of adopting family planning by 36 percent ($2.38 \div 1.75 = 1.36$). Net child mortality effects are statistically significant. The extreme shifts in mortality levels over time makes them, however, a moving target. For example, studying the effect of crossing the line of 125 deaths per 1,000 only makes sense for older cohorts because virtually no one among the younger cohorts has been exposed to a contextual mortality rate of 125 or higher.

Other variables with significant net effects on the adoption of birth control are marital status, the year when the observation started, and household wealth, as well as the contextual level of family planning supply. In contrast with previous results, there are no significant diffusion effects from contextual fertility in this data set, perhaps because the explanatory variable is cohort-based, rather than the period-based total fertility.

Is a moderate contextual child mortality rate a precondition for the adoption of family planning? The cumulative adoption curves in Figure 11-6 show that a contextual child mortality rate of 125 or higher may be a serious obstacle for adopting family planning but it is not an absolute impediment: About 20 percent of couples in this category have adopted birth control after 10 years of sexual activity. More interestingly, a Cox model estimated only for contexts where child mortality is 100 or higher shows that the adoption rate may increase sharply in these contexts with the supply of family planning services or with the household's wealth (Table 11-5). Thus, the obstacle of high child mortality can be circumvented.

TABLE 11-4 Rate Ratio of Adopting Family Planning Estimated with a Cox Regression Model

Variable	*N*	Rate Ratio	95% Confidence Interval
Contextual-level			
Child mortality, mothers' cohort			
≥125, old	109	1.00	Reference Group
<125, old	122	1.51	1.00-2.27
≥75, young	128	1.75	1.08-2.82
<75, young	110	2.38	1.39-4.06
Family planning supply[a]			
None	527	1.00	Reference Group
Moderate	158	1.76	1.20-2.60
High	176	1.59	1.09-2.34
Completed fertility			
2.7-3.9	108	1.00	Reference Group
4.0-5.4	160	0.88	0.64-1.21
5.5-8.9	201	0.99	0.64-1.53
Households under poverty line			
<10%	309	1.00	Reference Group
10% or more	160	0.80	0.56-1.13
Individual-level			
Education (years)			
0-2	135	1.00	Reference Group
3-6	231	1.19	0.90-1.57
7 or more	103	1.33	0.93-1.91
Wealth group			
Poor	121	1.00	Reference Group
Low	216	1.50	1.10-2.03
Medium/high	132	2.57	1.77-3.73
Age at first sex			
11-16	98	1.00	Reference Group
17-24	274	1.20	0.87-1.64
25-47	97	1.13	0.68-1.87
Marital status[a]			
Premarital	259	1.00	Reference Group
Ever married	602	2.47	1.79-3.40
Year first sex		1.04	1.00-1.07

NOTE: N indicates number of observed segments for these variables.

[a]Time-varying covariate.

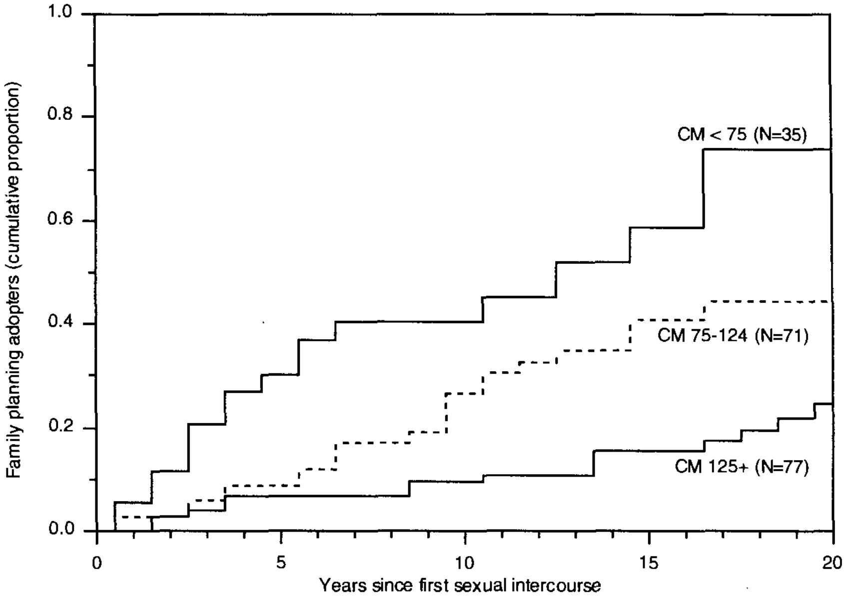


FIGURE 11-6 Family planning adoption curve among unlikely adopters by level of child mortality (CM).

Conversely, lowering child mortality seems by itself a factor for increasing the adoption rate of birth control. Figure 11-6 shows the adoption curves for women who, according to the regression estimates, were unlikely adopters of contraception, women with minimum wealth and education and no family planning services. Among these unlikely adopters, the cumulative adoption curve clearly shifts upward with lower contextual child mortality.

DISCUSSION

In a series of focus group discussions conducted with Costa Rican women in their 50s in 1993 (i.e., from the cohorts that lived through the fertility transition), high child mortality was not perceived as a reason for having large families in the past nor was its reduction seen as a reason for the shift to the small family of today (Rosero-Bixby and Casterline, 1995). Although these discussions focused on the diffusion of the family planning message, the child survival hypothesis was explicitly raised by the moderators in all groups. The suggestion that a decline in child mortality may have played an important role in the fertility transition did not resonate in the focus groups. However, two possible links with low child mortality emerged spontaneously in the discussions. Namely, (1) that

TABLE 11-5 Rate Ratio of Adopting Family Planning Estimated with a Cox Regression Model for Contexts with Child Mortality of 100 or Higher

Variable	*N*	Ratio	95% Confidence Interval
Family planning supply			
None	260	1.00	Reference Group
Moderate	97	1.92	1.04-3.51
High	57	1.91	0.99-3.72
Wealth group			
Poor	81	1.00	Reference Group
Low	92	1.63	1.09-2.44
Medium/high	36	2.20	1.33-3.66
Marital status[a]			
Premarital	120	1.00	Reference Group
Ever married	294	1.84	1.08-3.17
Year first sex		1.05	1.01-1.09

NOTES: *N* indicates number of observed segments for this variable.
[a]Time-varying covariate.

the family planning message often diffused in waiting rooms of health centers where increasing numbers of mothers were taking their children for preventive or curative care:

> I heard about family planning for the first time when I brought my sick daughter to the clinic. I started to listen to the other women. They would say, "Did you hear from Carmen that they are going to offer family planning here, that they are going to bring pills." Once I heard a woman telling that she used condoms and got pregnant. She didn't know what had happened inside, or if the condom was torn, the thing was that she got pregnant. Those women came from everywhere (Rosero-Bixby and Casterline, 1995:65).

(2) that the burden of helping their mothers to rear a large family was a motivation for wanting a small family. Increased child survival is an obvious reason for larger families:

> My mother had two pairs of twins and a lot of other kids. I would come home from school and had to go pick coffee and help my mother to sew because we needed the money to raise so many kids. It was changing diapers and washing all the time. And I got the idea that having lots of kids was a kind of slavery (Rosero-Bixby and Casterline, 1995:74).

Neither the focus group discussions nor the statistical record at the aggregate and individual levels support the claim that decreasing child mortality is critical for decreasing fertility. However, decreasing child mortality may facilitate the fertility transition, and high child mortality may delay the transition.

Just as there are developing countries that, in spite of moderate infant mortality, continue having high birth rates, the decline of child mortality in Costa Rica during several decades did not affect fertility trends. The data show that one cannot expect that crossing a child mortality threshold of 200 or 150 per 1,000 will automatically bring about fertility decline. Not even falling below 100 per 1,000 child deaths will generate an automatic response. In short, decreasing child mortality does not appear to be a sufficient condition for fertility decline, nor can the Costa Rican fertility transition be explained solely in terms of an adjustment process to moderate child mortality rates.

The data are inconclusive regarding the thesis that reduced child mortality is a condition for fertility decline. Supporting the thesis is the fact that practically no Costa Rican county, nor for that matter population in the world (Hanson et al., 1994), has experienced low fertility and high child mortality simultaneously. This statement is, of course, conditional on what one considers high child mortality. If one draws the line at a child mortality rate of 100 per 1,000 or higher, it is indeed almost impossible to find populations with controlled fertility. A closer look at the data show that in a substantial number of Costa Rican communities the onset of the fertility transition occurred at child mortality levels above 130 per 1,000. Moreover, individual-level data of the cohorts that changed fertility in Costa Rica show that the rates of adoption of family planning in contexts of high child mortality were far from zero. More interestingly, the data for those contexts show that adoption of family planning increases sharply with the presence of such conditions as family planning services and higher living standards. The obstacle of high child mortality does not seem impossible to beat.

Evidence suggesting that moderate child mortality may facilitate the fertility transition comes from the significantly earlier transition onset in counties with lower child mortality, as well as from the earlier adoption of family planning among women from low-mortality contexts. These effects persist after controlling for the potentially confounding effect of standards of living, education, supply of family planning services, and the like.

To discuss the causal mechanisms behind this association one should first understand how reproductive decisions are made before and during the fertility transition. Following Fishbein's theory of reasoned action, reproductive behavior may be shaped by "the person's beliefs that the behavior leads to certain outcomes and his evaluation of these outcomes," and "the person's beliefs that specific individuals or groups think he should or should not perform the behavior and his motivation to comply with the specific referents" (Fishbein and Middlestadt, 1987:363). The discussion about replacement and insurance strategies for having children (or before this, for having sex or using contraceptives) assumes the perfectly rational type of behavior implicit in the belief that behavior leads to predictable outcomes. It is probable, however, that reproduction, like many human actions, is not based mainly on day-to-day conscious decisions but guided by cultural norms and reference groups. High fertility as a response to high mortality may be implicit in these cultural norms. The distinction between replacement and insurance strategies does not seem meaningful at this collective level. Under a routine-dictated behavior, situations may occur in which an individual's self-interest clashes with the prevailing cultural precepts and leads the person to exercise conscious decision making. The onset of fertility transition could be one of these situations. Enlarged families resulting from improved child survival rates could be one of the reasons for questioning routine reproductive behavior. The second quote above from a Costa Rican woman suggests this possibility.

Although the Costa Rican experience cannot be extrapolated uncritically, the findings in this chapter suggest the following three policy considerations:

1. It would be a mistake for a government to expect an automatic fertility decline to follow a fall in child mortality. The latter does not seem to be a sufficient condition for the former.

2. High child mortality is not a good reason for not providing family planning services since a sizable proportion of couples may adopt family planning in contexts of high child mortality.

3. Fertility reductions are more likely to occur and family planning programs more likely to succeed in contexts where child mortality is low. A family planning intervention coupled with a child survival program will probably have more effect than a vertical program of only family planning services.

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