

Infant Mortality in Costa Rica: Explaining the Recent Decline

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Costa Rica has undergone a dramatic reduction in its infant mortality rate from 68 per 1,000 live births in 1970 to 20 per 1,000 in 1980. In the present study, changes during this century, mortality differentials, and causes of death are analyzed, and multiple regression techniques are used to identify the determinants of the decline in Costa Rica's 79 cantons (counties). Although socioeconomic development and greatly reduced fertility contributed to the infant mortality decline, as much as three-fourths of the decline is attributable to public health programs implemented during the 1970s. The extension of primary health care—especially rural and community programs—seems to be responsible for 40 percent of the reduction. In addition, health services produced a notable decrease in the socioeconomic differentials related to children's risk of death. The unique achievements of this developing country offer a new strategy for public health improvement.

The 1970s was a decade of great progress in public health for Costa Rica, specifically in the reduction of its mortality rate. Life expectancy increased from 65 to 73 years,¹ narrowing the country's mortality gap with the more developed countries to the point where life expectancy in Costa Rica is now approaching the West European average.

An even more significant change was the sharp decline in the country's infant mortality rate, from 68 deaths per 1,000 live births in 1970 to 20 per 1,000 in 1980. This reduction is important because declines in infant mortality prior to 1970 had lagged behind the mortality reduction in other age groups. Before 1970, the gap in average life expectancy between Costa Rica and the more advanced countries was narrowing, while the infant mortality gap was getting wider. Infant deaths were the country's biggest public health problem during the 1960s, representing 40 percent of total registered deaths.

Mohs described the causality of Costa Rica's infant mortality decline as a "new paradigm."² The old "paradigm," or strategy, emphasized that high infant mortality rates were basically caused by socioeconomic underdevelopment and that public health action could only be a palliative. Thus, ministries of health assigned top priority to supplementary food programs and enlarged capacity of hospital beds (90 percent of health budgets).

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However, Mata and others had confirmed earlier that the main cause of child malnutrition is successive infections (especially diarrhea) and not primary food shortage.³ According to Mohs, Costa Rica's new model of health policies for the 1970s focused on infections and parasitoses as causes of malnutrition, morbidity, and mortality. The primary health care strategy was proposed to control these public health problems on all socioeconomic levels.

This article examines the factors and circumstances that enabled Costa Rica to improve its population's health during the 1970s, despite its economic underdevelopment.

Background

Costa Rica is a small Central American country with 2.5 million inhabitants. Approximately half of the population is rural, and one-third of the labor force is engaged in agriculture. The economy is based mainly on the exportation of a few tropical products, predominantly coffee and bananas. Due to the recent economic crisis, annual per capita income (US\$1,500 in 1981) fell below the Latin American average (US\$2,000).⁴

Costa Rica is distinctive in several ways. It is more developed socially than economically, but the increased life expectancy seen over the past decade suggests that its economic underdevelopment is no longer a determinant of its population's survival opportunities. In terms of social development, the illiteracy rate is less than 10 percent, almost all children attend school, 78 percent of the population is covered by social security, and 84

percent enjoy plumbing services. Costa Rica's racial and cultural homogeneity, political stability, and its constitutional renunciation of the right to have an army are also distinctive features.

The Infant Mortality Decrease

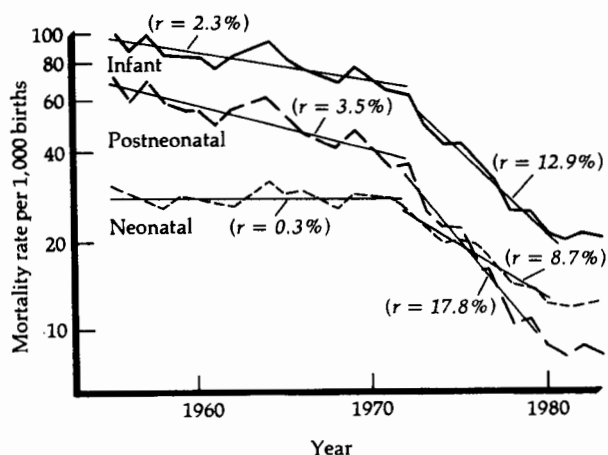
The acceleration of Costa Rica's relative decline in its infant mortality rate (IMR) seems to have started around 1972–1973, concluding in the 1980s (Figure 1).⁵ The annual reduction between 1955 and 1972 averaged 2.3 percent, while the decrease between 1972 and 1980 averaged 12.9 percent, nearly six times greater. This acceleration coincided with the first national health plan (1971), the law of universal social security (1971), the law of transfer of all public hospitals to the Social Security System, or CCSS (1973), the general health law (1973), and the implementation of the Rural (1973) and Community (1976) Health Programs.

The decrease in both neonatal (under one month of age) and postneonatal (one to eleven months) mortality accelerated substantially in 1972; however, the annual rate of decline in neonatal mortality was especially sharp, from 0.3 percent per year between 1955 and 1972 to 8.7 percent per year between 1972 and 1980. The decline in neonatal mortality is exceptional because the chiefly endogenous origin of neonatal deaths makes them difficult to prevent. The reduction of the risk of death in the first month of life was responsible for 34 percent of the infant mortality decrease between 1972 and 1980, contrasting with only 5 percent of the decline for the 1955–1972 period. Nonetheless, in the period 1972–1980, the major reason for the decline in the IMR continued to be the reduction in postneonatal mortality.

Figure 2 shows that the acceleration in the decline of infant mortality appeared in all categories of causes of death, with two exceptions: complications of pregnancy and delivery and congenital anomalies.⁶ The acceleration was stronger in three categories: immaturity, diseases preventable by vaccination (mainly tetanus and measles), and deaths avoidable by appropriate diagnosis and treatment (mainly septicemia and meningitis). However, part of the decline could be attributable to revisions of diagnostic criteria; that is, immaturity could have been reassigned to complications of pregnancy and delivery.

Diarrheal diseases and respiratory infections were the two main causes of infant death in Costa Rica prior to 1970. Therefore, the reduction of infant mortality was closely associated with control of these diseases. Reductions in these two causes account for three-fourths of the total decline between 1955 and 1972. After 1972 their reduction remains the major component of the decline, but their contribution to the decline dropped to 50 percent. On the other hand, immaturity and deaths avoidable by diagnosis and early treatment (especially septicemia) became, during the 1970s, important com-

Figure 1 Infant, neonatal, and postneonatal mortality rates, Costa Rica, 1955–1982



Note: r = percent of annual decrease.

ponents of the mortality decline, accounting for about 25 percent of the total decline.

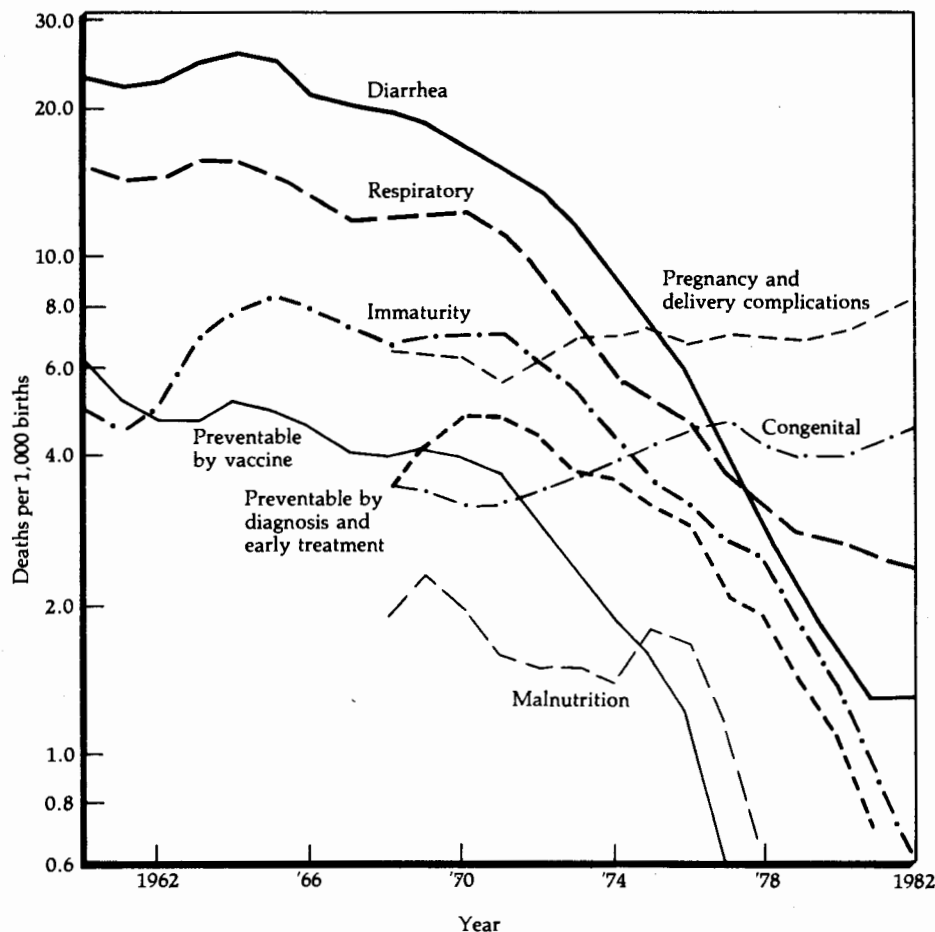
It can be concluded that the control of infection through sanitation, immunizations, and other improvements in child care was the principal component in the improvement of child health. Essentially, this component was the sole identifiable factor until 1972. Thereafter, the decline in neonatal mortality became steadily more important, relating to improvements in such services as neonatology, prenatal care, and family planning, some of which are expensive.

Socioeconomic Determinants

Extensive evidence suggests that the economic and social conditions into which children are born strongly influence their survival. Consequently, infant mortality has been used frequently as an indicator of the standard of living. Poverty, ignorance, isolation, lack of basic services, and excessive fertility may make children more vulnerable to disease as well as hinder access to, or reduce the efficacy of, medical services.

Figure 3 summarizes information on the economic, social, and demographic evolution of Costa Rica during this century. The 1970s had the most marked reduction in infant mortality, just as the 1940s and 1950s had the sharpest decline in adult mortality. Figure 3 also shows that both periods (1945–1954 and 1965–1979) coincide with the years in which the economic indicator (foreign trade per capita at constant prices) exhibited important and sustained increases. The periods that roughly correspond to economic crises are shaded in Figure 3, according to the evolution of the foreign trade indicator and other economic indications. During these frequent periods of economic contraction and, generally, high

Figure 2 Infant mortality rates by cause of death, Costa Rica, 1960–1982



rates of unemployment and deterioration in living standards, the pace of reduction in mortality rates tends to slow down. The average reduction in infant and adult mortality during economic crises has been 1.4 and 2.0 percent a year respectively, which are lower than the rates in normal periods (3.8 and 3.6 percent). Since 1980 marked the beginning of a new recession it is not surprising that improvements in infant mortality halted in that year.

Nevertheless, changes in mortality cannot be attributed exclusively to the behavior of the economy. For instance, several countries with strong economic growth, like Brazil, still exhibit high mortality rates, while some poor countries, like Sri Lanka, have substantially reduced their mortality rates. Brazil has an IMR of 76 per 1,000 and an annual per capita income of US\$2,200, while Sri Lanka's current IMR is 37 per 1,000, despite a per capita income of just US\$300.

The decrease in mortality in Costa Rica during the first half of this century cannot be explained by economic

factors alone. In 1949 foreign trade reached the level observed in 1910: about US\$200 per capita. Despite economic stagnation from 1910–1949, mortality rates decreased substantially during this period. Improvements in social services, such as education and public health, and imports in technology apparently influenced mortality independently of economic conditions. In this regard Costa Rica resembled Sri Lanka.

Figure 3 also shows that the biggest changes in economic factors (i.e., foreign trade), women's education, fertility, and expenditures in public health took place after 1960. Thus, the decrease in infant mortality seems to result from the interaction of several positive circumstances rather than one factor alone.

Mother's education is one of the most clearly identifiable determinants of infant mortality. As a consequence of improvements in children's schooling in the 1940s and 1950s, the proportion of women with complete primary education increased from 17 percent in 1960 to 65 percent in 1980. This increase undoubtedly helped to

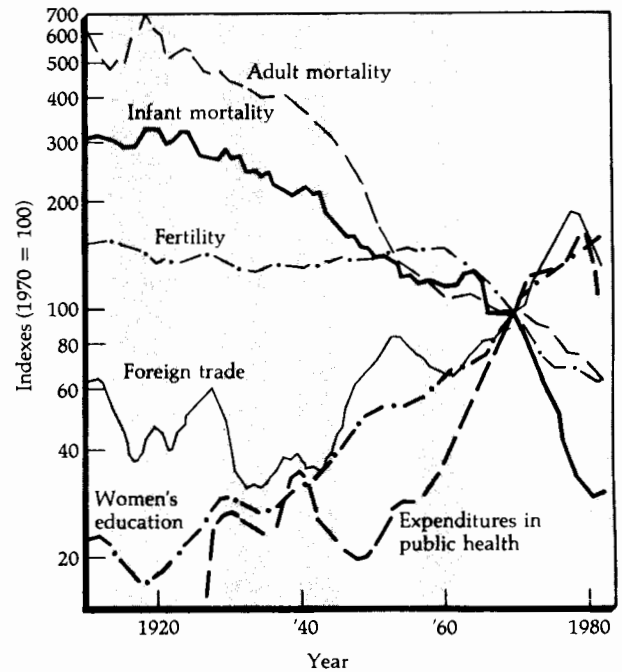
accelerate the decline in infant mortality. Behm documented the strong negative correlation between mother's education and child mortality in Latin America around 1970.⁷ He found that children of illiterate women have four times the probability of dying as children whose mothers have a secondary education. The relationship between early child mortality and maternal education in Costa Rica closely parallels that for Latin America, suggesting that important decreases in mortality rates could be attained by improving women's educational level. However, recent evidence shows that the differential in IMR by educational level has decreased.⁸ This means that the relationship between education and infant mortality has been partly neutralized and the effect of educational improvements must not be overestimated. The programs of primary health care (especially home visits of the health workers) probably improved the access of poor and low-educated mothers to medical services and to knowledge about the causes of disease.

The reduction in fertility is another remarkable phenomenon in Costa Rica. Between 1960 and 1980, the total marital fertility rate (theoretical lifetime fertility of a married couple subjected to the duration-specific rates of a given year) declined from 7.6 to 3.4 births—a reduction rarely observed in such a short period. Decreasing fertility reduces infant mortality by decreasing the proportion of high risk pregnancies, which include closely spaced births, those from extremes of reproductive age, and those of grand multiparas. For example, a short birth interval leads to a probability of dying that is four times greater than an interval of at least 2.5 years, as depicted in Figure 4. These differentials are similar to those observed in other populations and persist across all socioeconomic levels.⁹ Even though the decline in fertility that occurred after 1960 did not reduce the proportion of adolescent pregnancies, it did result in an increase in birth intervals and a remarkable reduction in higher order births. Sosa estimated that this reduction alone is responsible for 24 percent of the decline in the Costa Rican infant mortality rate between 1960 and 1977.¹⁰

The reduction in fertility rates is partly a consequence of economic and social changes, but it is also an independent phenomenon. The implementation of a vigorous family planning program through public health services extended the fertility transition to the rural peasant and urban lower-social groups.¹¹ Two-thirds of those who used contraception in 1981 benefited from state services, including almost 90 percent of all agricultural laborers. The adoption of family planning, besides reducing the risk factors mentioned above, has indirect effects on child health that are difficult to quantify. Among these are "quality of life" factors, the adoption of a nonfatalistic attitude, and the fact that children in smaller families receive more parental attention.

In Figure 5, the impact of socioeconomic changes on infant mortality is evaluated by comparing the observed trend with expected rates based on the country's

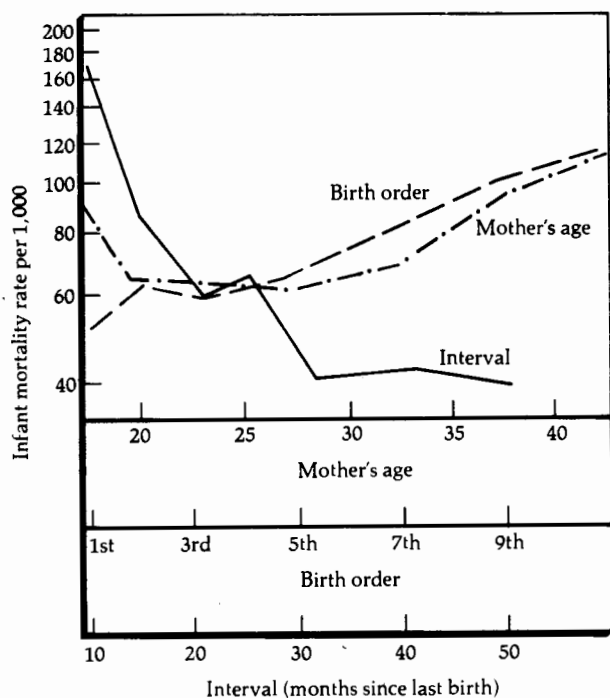
Figure 3 Indexes of health and socioeconomic development, Costa Rica, 1910–1982



Note: In the indexes used above, 100 is equal to the rate given as follows: for adult mortality, 100 = 2.3 deaths per 1,000 persons aged 20–49 years; for infant mortality, 100 = 62 deaths per 1,000 births; for fertility (i.e., total marital fertility rate), 100 = 5.0 children; for foreign trade (exports plus imports) per capita in constant prices, 100 = US\$295 (1970); for women's education (proportion of women 20–34 years of age with completed primary education — estimation based on enrollment data for 1908–1982 and census data), 100 = 42.4 percent; for expenditures per capita in public health in constant prices, 100 = US\$39.40 (1970). The shaded areas roughly correspond to the periods of economic crisis in Costa Rica.

developmental stages. Seven economic indicators and three social indicators (mainly of education) were translated into a theoretical index of the level of development using "correspondence relationships" of a transnational model.¹² Expected infant mortality rates were then determined based on the same model and (nonweighted) averages of those indexes. The results of this somewhat simplistic exercise confirm that Costa Rica has been more advanced socially than economically, with the expected infant mortality rate, according to the level of economic development, being higher than the rate that corresponds to the level of social development. The infant mortality rate observed until 1970 is intermediate between the two expected rates, and is analogous to the general advancement of the country. Between 1970 and 1980, however, the observed reduction in infant mortality (69 percent) is approximately three times the expected reduction (20 to 25 percent). Thus, socioeconomic change can explain only a third of this abrupt decline. Since no

Figure 4 Infant mortality rate by mother's age, birth order, and interval since last birth, Costa Rica, 1961-1975



Source: Maternity histories of the World Fertility Survey, 1976 (unpublished tabulations).

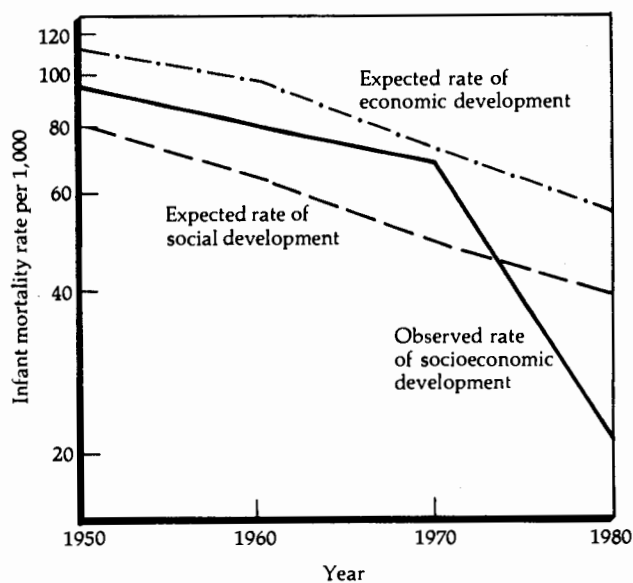
evidence exists to show that fundamental changes not included in the model have occurred (for instance, a modification in income distribution), the logical corollary is that the health policies of the 1970s may be primarily responsible for the impressive decline of Costa Rican infant mortality.

However, the achievements of Costa Rican public health programs should not be considered in isolation. Public health had the support of a government system with a high level of social sensitivity, substantial economic growth since 1964, and a relatively homogeneous, well-educated population.

Health Interventions

Costa Rica's first national health plan was implemented in the 1970s. Public resources for the health sector were increased and efforts were made to rationalize their use. The programs fell into two categories:¹³ (1) the adoption of the primary health care strategy, with the purpose of extending coverage of services—basically preventive care—to the population that was not previously served, and (2) extension, systematization, and qualitative improvement in medical services (some of them highly

Figure 5 Expected infant mortality rate based on economic and social development compared to observed rate, Costa Rica, 1950-1980



Note: The seven economic and three social indicators used were homes with electricity, telephones, automobiles, workers in agriculture, industrial gross national product, energy consumption, per capita gross national product, literacy, enrollment in grammar and high school, and newspaper circulation.

Source: See note 12 at the end of this article.

specialized), mainly under Social Security.

The basic primary care instruments were the rural health program (begun in 1973) and the community health program (1976). By 1980, 60 percent of the population was reached by domiciliary services in rural and urban areas. Immunization programs against measles, diphtheria, pertussis, and tetanus were effected. Sanitation activities (provision of potable water and sewage disposal) in rural areas were intensified, and community participation in health programs was encouraged.

In order to improve medical services, the hospitals of the Ministry of Health (often poor in resources and frequently offering deficient services) were transferred to CCSS. In addition, insurance coverage for illness was generalized, reaching 78 percent of the population in 1980. The CCSS doubled the number of centers offering outpatient services and tripled the amount of contracted physician-hours between 1970 and 1980.

Correlation and multiple regression analyses were carried out for data from 79 cantons (counties) of Costa Rica, in order to evaluate whether a significant statistical association exists between health interventions and infant mortality. Two analyses were undertaken. In the first, the dependent variable was the "level" of infant

mortality circa 1970, estimated by indirect techniques (the Brass method) applied to the census of 1973. In the second analysis the dependent variable was the relative decline in IMR from 1972 to 1980, estimated from the vital statistics assuming that inherent deficiencies (e.g., incidence of underregistration) did not change during the study period. Five "indexes of status" circa 1970 were the independent variables in both analyses, while in the second analysis five additional indexes measured changes of these variables over the decade.¹⁴ The independent variables were socioeconomic development, fertility regulation, hospital care, secondary health care, and primary health care (sanitation in 1970).

When the dependent variable was the "level" of infant mortality, the coefficients of correlation were, as expected, quite high with the five independent variables, particularly with fertility, sanitation (water and sewage disposal), and socioeconomic development. However, the association of the three indexes of health interventions lost statistical significance when multiple correlation analysis was done (see β coefficients and F ratios in Table 1). This does not mean that health services are unimportant as determinants of infant mortality, but rather that their effect up to 1970 was not independent of socioeconomic development. In contrast, fertility regulation shows an independent association with the IMR when environmental and sanitary conditions are controlled.

Of particular interest is the analysis in which the dependent variable is the "trend" in mortality. The relative decline in IMR correlates negatively with all five indexes of status in the 1970s (Table 2). The privileged *cantons* that had the best living conditions up to 1970 showed the least decrease in IMR during the 1970s. This confirms that many of the differentials in mortality had been neutralized. It also indicates that the former order of development (the accumulation of the greatest achievements in a few privileged regions) was altered by new factors that began to have an influence at the beginning of the 1970s. This point was evaluated by introducing into the model the five independent variables that measure change in the decade. The five simple correlation coefficients with the relative decline in IMR were, as expected, positive (second panel, Table 2). The correlation was stronger for the indexes of change in public health than for that of socioeconomic development. The highest values of r corresponded to improvements in primary health care (an index heavily weighted by the coverage of rural and community health programs, and also including indicators of vaccinations, level of community participation, and increase in potable water supply) and secondary health care (outpatient visits).

When the variables of change were included in the multiple regression model, the indexes of status in 1970 (first panel of Table 2) no longer had a negative association with the relative drop in the IMR (see β coefficients). The negative simple r s were spurious, resulting from the

Table 1 Coefficients of correlation (simple r and β) with the infant mortality rate (IMR), circa 1970, Costa Rica

Independent variable	Coefficients of correlation with IMR		
	Bivariate correlation (simple r)	Multiple regression	
		β	F ratio
Socioeconomic development	-.74	-.33	6.1
Fertility regulation*	-.79	-.43	12.9
Hospital care	-.68	.14*	.9
Secondary health care	-.56	-.09*	.9
Sanitation	-.76	-.21*	2.2
All variables (multiple R)	NA	.84	33.9

Note: NA = not applicable.

*General fertility rate with minus sign.

*Not significant at the .05 confidence level.

Table 2 Coefficients of correlation (simple r and β) with the relative decline in infant mortality rate (IMR), 1972-1980, Costa Rica

Independent variable	Coefficients of correlation with decline in IMR		
	Bivariate correlation (simple r)	Multiple regression	
		β	F ratio
Circa 1970			
Infant mortality	.31	.49	8.3
Socioeconomic status	-.22	.67	8.0
Fertility regulation*	-.16*	.38	5.9
Hospital care	-.23	(-.17)*	(0.8)
Secondary care	-.18*	(-.02)*	(0.0)
Sanitation	-.14*	(.19)*	(1.0)
Change in the decade			
Socioeconomic progress	.17	.27	3.7
Fertility reduction	.27	.29	6.3
Hospital care increase	.30	(.12)*	(0.4)
Secondary care increase	.38	.33	11.1
Primary care increase	.42	.52	10.1
All variables (multiple R)	NA	.64	7.0

Note: Values included as the eighth independent variable are shown in parentheses. NA = not applicable.

*General fertility rate with minus sign.

*Not significant at the .05 confidence level. The β coefficients were estimated excluding these variables of multiple regression.

1970s health programs targets. These programs induced a major reduction in IMR in *cantons* that initially had less favorable conditions for progress. However, the high positive final correlation of the initial socioeconomic status ($\beta = .67$) suggests that previous development also made an important contribution to the decline in IMR.

Among the changes that took place during the decade, the index of primary care emerges as the most influential in the reduction of IMR ($\beta = .52$). The other changes that had a significant independent influence on the decline are, in order of importance: increase in secondary care, fertility regulation, and socioeconomic progress in the *canton*. By contrast, the improvement in hospital care, which had a significant bivariate effect, did not add any independent explanatory power to the model (this index was built with indicators of the change in distance to the nearest hospital, births in hospitals, and hospital discharges).

The effects of the selected independent variables and the expected decline in the national IMR according to the model are depicted schematically in Figure 6, which was built using the multiple regression coefficients of the model and the national averages of the change in each independent variable.¹⁵ The lower line of the figure indicates the expected changes in infant mortality according to the model. This expected IMR approximates quite closely the trends of the observed IMR (heavy line). The lines above the expected mortality indicate the expected trend of mortality in the absence of the independent variables shown there; or, put another way, they indicate the contribution of each of the independent variables to the expected decline.

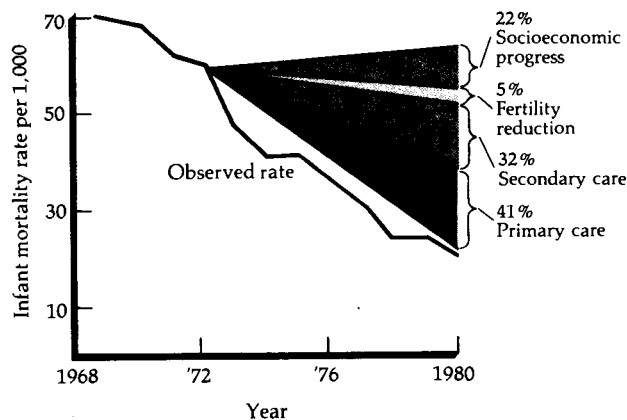
The programs summarized as primary care explain the major part of the decline in infant mortality (41 percent). The increase in secondary medical care also makes an important contribution (32 percent). On the other hand, the reduction in fertility resulted in a small contribution (5 percent), because in many *cantons* fertility was already low, while in 31 *cantons* the birth rate actually rose. The model attributes up to 75 percent of the explained decline in IMR to the three health interventions during the 1970s. The remaining quarter of the explained decline is attributable to economic and social progress during the period. This estimation does not take into account socioeconomic advances in Costa Rica or the decline in fertility prior to the 1970s. A determination of what would have happened if Costa Rica had followed an alternative development path would require too much speculation to be valuable. However, it can be advanced that the socioeconomic development achieved by the country appears as a necessary, but not sufficient, condition for the outstanding reduction in infant mortality during the 1970s.

The preceding analysis, based on national averages, could differ in certain subpopulations. To illustrate, four groups of *cantons* were separated according to their mortality levels at the beginning of the 1970s and according to the intensity of ensuing mortality reductions. Table 3 depicts how the model handles this classification.

The contribution of primary health care in the *cantons* where the mortality level was high (groups I and II) is clearly the most important (44 percent), but it is less important in those *cantons* where the initial mortality was

lower (a contribution of about 30 percent). In the latter, the reduction in mortality seems to have been caused mainly by secondary care improvements (about 50 percent). Economic and social progress had a similar effect in the four types of *cantons* (between 21 and 28 percent). On the other hand, fertility reduction acted only upon those *cantons* with a high initial infant mortality.

Figure 6 Components of the decline in infant mortality rate (IMR), Costa Rica, 1972–1980



Note: Estimation based on a multiple regression model.

Table 3 Contribution of factors to the decline in the infant mortality rate (IMR), 1972–1980, in four groups of *cantons* in Costa Rica

Factor	Contribution to decline in IMR				
	Total	Canton group			
		I	II	III	IV
Range of IMR circa 1970	—	≥68	≥68	<68	<68
Range of decline in IMR (%)	—	≥13	<13	≥13	<13
Number of cantons	79	30	9	18	22
Births (%)	100	35	13	19	35
Annual reduction in IMR (%)	13	17	11	17	8
Total contribution (%)	100	100	100	100	100
Socioeconomic progress	22	21	23	28	21
Fertility reduction	5	8	11	-4	-6
Improvement in secondary care	32	27	22	45	56
Improvement in primary care	41	44	44	31	29

These results confirm the singular importance of primary health care programs carried out in Costa Rica during the 1970s. In addition to its quantitative contribution, primary health care has several qualitative merits. Since the program was targeted to the population in greatest need, Costa Rica was able to reduce one of the conspicuous types of social injustice: the uneven distribution of mortality in childhood. Another study showed that *cantons* in which rural and community health coverage was 75 percent or greater experienced a fall in IMR from 80 to 17 per 1,000 in the 1970s, while *cantons* in which coverage was practically null showed a smaller decline, from 49 to 21 per 1,000 in the same period.¹⁶

Conclusion

Before 1970 the control of infant mortality lagged behind control of mortality in other age groups in Costa Rica. Poverty and ignorance strongly limited further improvement in child survival. The infant mortality rate was about 80 per 1,000, and infant deaths represented about 40 percent of all deaths in the country, with marked differences between socioeconomic classes.

From 1972 to 1980 the infant mortality rate declined dramatically from 60 to 20 per 1,000, in connection with economic and social improvements, a decline in fertility, and public health interventions. Since Costa Rica experienced a confluence of positive developments in the 1970s, the decline in IMR was, as shown, caused by more than one factor.

Statistical analysis identifies health interventions as the main determinant of the fall in infant mortality. Primary care interventions are especially important: rural and community health programs, vaccination, community participation, and environmental sanitation. Multiple correlation analysis suggests that up to 75 percent of the fall in IMR is the result of health programs, and around 40 percent is attributable to primary health care. Furthermore, by targeting less privileged population groups, primary care reduced prevailing differentials in child mortality.

Costa Rica's experience has shown that, while socioeconomic factors are important determinants of infant death, health interventions aimed at control of infections can effectively overcome socioeconomic obstacles, even in a less developed country with a free market system. This experience is correctly described as a new strategy for public health.

References and Notes

The author would like to thank Mark Oberle from the Centers for Disease Control and Judith Fortney from Family Health International for their helpful comments in the preparation of this paper.

- 1 The figures of life expectancy and infant mortality were taken from Luis Rosero and Hernán Caamaño, "Tablas de vida de Costa Rica, 1900-1980" ("Life tables of Costa Rica, 1900-1980") in *Mortalidad y Fecundidad en Costa Rica (Mortality and Fecundity in Costa Rica)*, (San Jose: Asociacion Demografica Costarricense, 1984).
- 2 Edgar Mohs, "Infectious diseases and health in Costa Rica: The development of a new paradigm," *Pediatric Infectious Diseases* 1, no. 3 (May 1982): 212-216.
- 3 Leonardo Mata, *The Children of Santa Maria Cauque: A Prospective Field Study of Health and Growth* (Cambridge: MIT Press, 1978).
- 4 The international figures are based on data from 1983 *World Population Data Sheet* (Washington, DC: Population Reference Bureau, 1983).
- 5 The series of infant mortality rates since 1955 was taken from Luis Rosero, "Determinantes del descenso de la mortalidad infantil en Costa Rica" ("Determinants of infant mortality decline in Costa Rica"), unpublished report of the contract APO-9072 (WU1), Pan-American Health Organization, 1984. These figures include corrections of the official data on births and deaths.
- 6 The grouping by cause of death is an adaptation of that proposed by Erica Taucher, "La mortalidad infantil en Chile" ("Infant mortality in Chile"), *Notas de Poblacion*, No. 20 (San Jose: Latino-American Demographic Center [CELADE], 1979), pp. 35-72. The International Classification codes (1965) included in each group are: diarrheal disease 001-009; infections of the respiratory system 460-519; unqualified immaturity 777; complications of pregnancy and delivery 760-776, 778-779; preventable by vaccination 32, 33, 37, 55; malnutrition 260-269; preventable by diagnosis and early treatment 38, 320, 345, 380-84, 520-77, 680, 709; and congenital defects 52, 140-239, 343, 740-759.
- 7 Hugo Behm, "Socioeconomic determinants of mortality in Latin America," in *Population Bulletin of the United Nations, 1980* (UN Publication No. ST/ESA/Series N/13), pp. 1-16.
- 8 For example, IMR by mother's education changed in the following way:

Mother's education (years)	IMR	
	1965-69	1975-79
<4	89	33
4-6	73	20
7+	24	16

See Luis Rosero, "The case of Costa Rica," in J. Vallin and A. Lopez (eds.), *Health Policy, Social Policy and Mortality Prospects* (Liège: Ordina Editions, 1985).

- 9 Luis Rosero, "Factores asociados con la mortalidad infantil en Costa Rica, 1961-1975" ("Factors associated with infant mortality in Costa Rica, 1961-1975"), in *Mortalidad y Fecundidad en Costa Rica*, cited in note 1.
- 10 Doris Sosa, *La Mortalidad Infantil y la Fecundidad en Costa Rica, 1960-1977 (Infant Mortality and Fecundity in Costa Rica, 1960-1977)*, (San José: Costa Rican Demographic Association, 1979).

- 11 Luis Rosero, "Determinantes de la fecundidad en Costa Rica" ("Fertility determinants in Costa Rica"), *Notas de Población (Population Notes)*, No. 32 (San José: Centro Latinoamericano de Demografía, 1983), pp. 79–122.
- 12 The "correspondence relationships" with a theoretical index of the development level (a range from 0 to 100) were proposed in a study by the United Nations for a wide range of economic, social, and demographic indicators. These relationships are presented in P. Mauldin and B. Berelson, "Conditions of fertility decline in developing countries," *Studies in Family Planning* 9, no. 5 (May 1978): 89–147, Table 11. The application of these relationships to Costa Rican data is presented in Rosero, cited in note 8, Table 9. The seven economic and three social indicators used in the estimation were (in parentheses are values of the index in 1950, 1960, 1970, and 1980): homes with electricity (42, 54, 63, 71), telephones (40, 41, 52, 71), automobiles (41, 59, 69, 74), workers in agriculture (32, 43, 53, 66), industrial GNP (30, 33, 42, 49), energy consumption (29, 32, 46, 51), per capita GNP (53, 60, 67, 74), literacy (65, 69, 73, 77), enrollment in grammar and high school (34, 51, 67, 80), and newspaper circulation (60, 61, 64, 68).
- 13 Lenín Saenz, "Health changes during a decade, the Costa Rican case," presented at the Rockefeller Foundation Conference on Good Health at Low Cost, Bellagio, Italy, 1985 (unpublished).
- 14 The procedure used to calculate the indexes is specified in Rosero, cited in note 5. The index "socioeconomic status" is based on a factor analysis of 11 indicators of the situation circa 1970: labor force in agriculture, labor force without wages, families below the poverty level, per capita electricity consumption, mean salaries, expenditure per capita in construction, population density, distance from the capital city, population with a high school education, women's school enrollment ten years previous, and the population covered by the Social Security system. "Socioeconomic progress" summarizes the relative change in consumption of electricity, construction expenditures, school enrollment, and social security enrollment. The index of status and change in hospital care summarizes three indicators: the distance to the nearest hospital, hospital discharges, and births in hospitals. The index of status and change in secondary care summarizes two indicators: per capita physician-hours and the rate of outpatient consultations. The index of sanitation is the average of the population with water supply and sewage disposal. The index of change in primary health care summarizes four indicators: coverage of rural and community health programs, rate of vaccination (DPT, measles, tetanus) in 1976–1978, whether a community health committee was created, and the increment in piped-in water supplies.
- 15 The regression coefficients and the averages of the independent variables used to estimate the percentage of annual mean reduction in IMR were: for IMR circa 1970, $b = 0$ and $\bar{x} = 70$; for socioeconomic status circa 1970, 0.18 and 49; for fertility regulation circa 1970, 0.05 and –144; for socioeconomic progress (1970s), 0.07 and 45; for fertility reduction (1970s), 0.07 and 9; for secondary care increase (1970s), 0.12 and 36; and for primary care increase (1970s), 0.11 and 51.
- 16 Rosero, cited in note 8.