Child Mortality in the Developing World

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SINCE WORLD WAR II, SUBSTANTIAL DECLINES in infant and child mortality rates have occurred in most developing countries, resulting both from improvements in standards of living and from national and international public health activity. These declines, once substantiated, generated widespread optimism in the 1960s and 1970s about prospects for bringing about a child survival revolution in the Third World. George Stolnitz, for example, wrote in 1965: "Above all, it now seems clear that economic misery as such is no longer an effective barrier to a vast upsurge in survival opportunities in the underdeveloped areas." In the 1980s, however, such optimism has been replaced by considerable pessimism about performance in reducing child mortality and about prospects for further reduction. We contend that this change in attitude does not reflect a shift in underlying mortality trends; the pace of mortality decline in the developing world has changed little over the last three decades.

The pessimists identify at least three major areas of concern. First, some observers have worried that the pace of mortality decline achieved in many developing countries following World War II has not been, and will not be, sustained because of the slow pace of economic development. Initial concern arose from the belief that exogenously developed, technologically sophisticated public health interventions could not bring about sustained mortality decline in the face of only limited improvements in Third World living standards (Gwatkin, 1980; Ruzicka and Hansluwka, 1982a). More recently, significant deterioration of living standards in many countries of sub-Saharan Africa and Latin America has led to worries about the possibility of increases in child mortality rates (Cornia et al., 1988). Furthermore, some observers have argued that the economic stabilization or structural-adjustment programs designed to cope with deteriorating economic conditions may themselves contribute to increases in child mortality, because the package of measures incorporated in the program often includes reductions in government spending for social services, increases in food prices, and changes in exchange rates, leading to sharp reductions in family income (UNICEF, 1989).

A second concern relates to the effectiveness of the particular health interventions that have been and remain the centerpiece of many nationally and internationally sponsored health programs. Because of practical (and often political) difficulties in organizing comprehensive, community-based primary health care (Mosley, 1985), much of the public health effort of national governments and international agencies (for example, UNICEF's GOBI program, WHO's EPI, and the US Centers for Disease Control's CCCD programs)[1] has focused on immunizable diseases and on oral rehydration therapy. This focus on narrow interventions as opposed to broadly based community health programs has led to concerns about possible substitution effects in morbidity and mortality—namely, that many children who are prevented from dying of immunizable diseases or malaria will die instead from other nonimmunizable diseases (Hendrickse, 1975; Kasongo Project Team, 1981; Foster, 1984). If these substitution effects are substantial, improvements in child mortality during the 1980s and 1990s as a consequence of these narrow interventions would be considerably less than expected.

A third area of concern is the potential effect on child mortality of recent developments in disease patterns. Two such developments are likely to have a particularly important impact on trends in infant and child mortality rates in the 1990s, namely the AIDS epidemic and the spread of chloroquine-resistant malaria, both of which may have an especially devastating effect on children in sub-Saharan Africa.

The purpose of this article is to examine the empirical support for these concerns. In the next section, we review levels, trends, and age patterns of child mortality in the developing world over the past several decades. We then use evidence from this review and from other sources to seek support for the contentions that the pace of child mortality decline has slowed in the late 1970s and early 1980s, and that programs aimed at particular diseases merely shift the cause or age pattern of deaths without reducing overall mortality. We do not attempt to address the third issue, because of the difficulties in assessing the future impact of HIV infection (Bongaarts, 1988) and the potential consequences for infant and child mortality of a resurgence of malaria (Molineaux, 1985). It is still too early to expect either effect to appear in the empirical record.

Child mortality levels and trends in developing countries

Data sources

Any study of child mortality in the developing world is hindered by shortcomings in availability, accuracy, and timeliness of appropriate data. Even so, the situation has been improving over the last two decades. Vital registration is gradually becoming more complete, particularly in Latin America, the Caribbean, and East Asia. Indirect estimation of child mortality levels and trends from information on proportions of children surviving by age of mother has proved surprisingly satisfactory, and the necessary information has been widely collected in censuses and surveys over the last two decades. A large and expanding number of national surveys such as those coordinated by the World Fertility Survey and more recently the Demographic and Health Surveys have also included complete birth histories, thereby contributing further to our knowledge of levels, differentials, and particularly age patterns of child mortality. Despite these improvements, numerous gaps remain, both in terms of countries for which no reliable data exist and in terms of countries with insufficient data from which to draw inferences about trends. It can always be argued that these gaps are a fatal flaw in any cross-national study of child mortality trends limited to countries with available data, on the grounds that the countries with data may be systematically different from those without data in respect to key organizational or developmental characteristics. However, it seems to us considerably more misleading to draw conclusions on the basis of data sets including "estimates" for countries with no reliable data. The issue of recent trends in child mortality is important enough to merit careful empirical investigation, and such an investigation can only be based on the reliable data that are available.

The task of examining levels and trends of child mortality for the developing world has been made easier by two recent publications: one a review of mortality under the age of five for the entire world, containing estimates and projections covering the period from 1950 to 2025 (United Nations, 1988a); and the other a review of all child mortality data available through the mid-1980s for sub-Saharan Africa (Hill, 1987). The figures included in the United Nations publication are the result of a major review of evidence regarding child mortality for all countries with populations of 300,000 or more. The problem with using the UN numbers is that, in United Nations review publications, figures are given for each country and time period, in this case even up to 1980–85. Of necessity, many of the numbers are based on interpolation, extrapolation, or analogy with neighboring countries. There is no simple way of determining from the publication which numbers have an adequate empirical basis and which do not.

As to the second publication, Althea Hill's numbers are also the product of careful evaluation of the underlying data. But since data for sub-Saharan Africa are scarce, these estimates are of very uneven quality, particularly for the more distant past, and are often hard to interpret.

Our objective in this review is to limit consideration to national estimates with rather strong empirical support. To this end, we have reviewed the estimates developed by the United Nations and by Hill and the procedures by which they were derived. For convenience we have adopted the UN practice of using average estimates for five-year periods, or quinquennia. The estimates we have used here were then selected from the two sources on the basis of certain criteria of reliability. The criteria used were as follows. First, a mortality estimate for a quinquennium had to be supported by empirical estimates for more than half the five-year period. Empirical support could take one of three forms: validated vital registration, a time series of child mortality derived from maternity histories, or a time series of estimates based on children ever born and children surviving. This criterion was applied in collaboration with the author of the UN study, although responsibility for the final selection is entirely our own. Second, in cases where multiple sets of estimates were available for overlapping time periods, consistency between the time series was required, unless a series based on one data source was clearly out of line with a number of mutually consistent series based on other sources, in which case we excluded the one divergent series.

A second objective of our study is to be as up-to-date as possible. Accordingly, we have used estimates available from very recent surveys, such as the Demographic and Health Surveys, where possible and where consistent with earlier estimates. In some cases, incorporation of the most recent available data has led to a reinterpretation of the prior series and to the use of series that differ throughout from the UN and Hill series.

We have imposed two other limitations on the data. First, we have focused exclusively on the period from 1960 to 1985. Second, we have excluded all countries with an estimated population in 1980 of less than one million, in order to reduce the weight given in the subsequent comparisons to small populations.

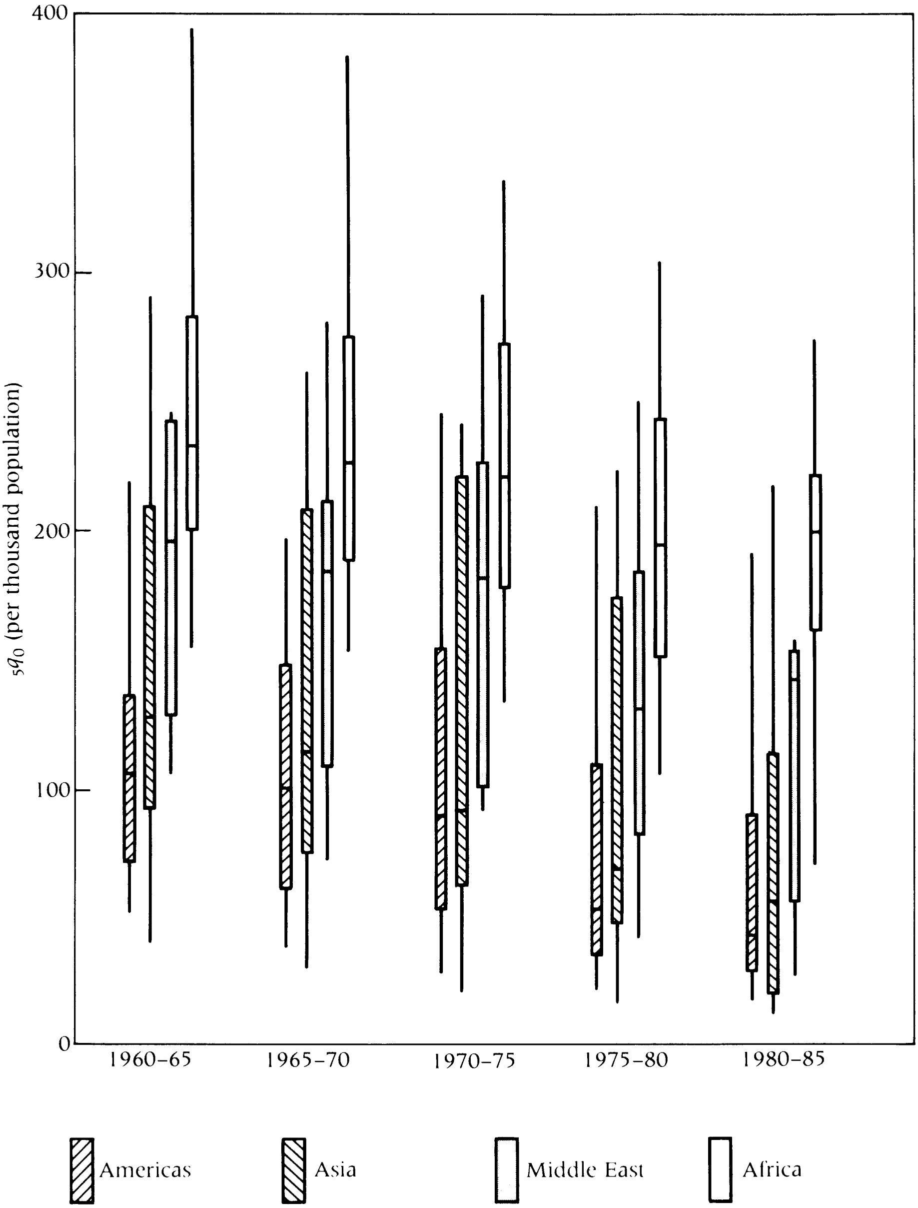
Despite the consistency checks and other criteria for inclusion that we have applied, the estimates that remain are imperfect. Indirect estimates may be affected by errors of sampling, reporting, or methodology; direct estimates based on maternity histories may be affected by sampling and reporting errors; and direct estimates based on vital registration may be affected by reporting errors. As more data become available, our estimates will need to be updated, and may need substantial revision. Given currently available data, however, we believe the estimates are the best that can be made, and are largely free from the effects of analogy, extrapolation, or smoothing.

The measure of child mortality that we use throughout the discussion of levels and trends is the probability of dying by age five, ${}_5q_0$. This indicator is used in preference to other measures of child mortality because it represents cumulative mortality throughout early childhood to an age at which mortality rates are relatively low, and because it is generally well estimated by indirect techniques based on the proportion of children who have died among children ever born. The estimates of ${}_5q_0$ used in this article are given in the Appendix (see Table A-1); Table A-2 summarizes the sources on which the estimates are based.

Levels of child mortality

The child mortality estimates in Table A-1 are summarized by region and time period in Figure 1. The regions used are: Latin America and the Ca-

FIGURE 1 Distribution of developing countries by the probability of dying by age 5 ($_5q_0$), by region and time period



ribbean, henceforth referred to as the Americas; Asia (excluding Turkey and the Middle East) and Oceania, henceforth referred to as Asia; the Middle East, Turkey, and North Africa, henceforth referred to as the Middle East; and sub-Saharan Africa, henceforth referred to as Africa. Five-year time periods (1960–65 to 1980–85) are used. The estimates are summarized in the form of boxplots. For each period and region, the values of mortality below which 25 percent, 50 percent, and 75 percent of observations fall are obtained. A box is then constructed from the 25th to the 75th percentile, with a crossbar showing the median within the box; vertical lines extending from the top and bottom of the box show the maximum and minimum values respectively.

Three things stand out from Figure 1. First, over the whole period under consideration, child mortality is lowest in the Americas, next lowest in Asia, second highest in the Middle East, and highest in Africa. Second, even within regions and time periods there is a very wide range of child mortality conditions. Third, in all four regions, child mortality has generally been falling over the last two and a half decades. The only exceptions to the third observation in terms of median mortality levels by region are for Africa and the Middle East in the most recent period, 1980–85, which includes very few countries in both cases. For the Americas, the median level of probability of dying by age five falls from just over 100 per thousand live births in the period 1960–65 to just over 40 in the period 1980–85. The corresponding declines for the other regions are from 115 to 55 for Asia, from 195 to 140 for the Middle East, and from 230 to 200 for Africa. There is no pronounced narrowing of differentials between regions or between countries of a region over the period examined.

Recent trends in child mortality

In order to look more closely at recent trends in child mortality, we have calculated both the absolute and the percent changes in ${}_5q_0$ from one time period to the next for all countries having acceptable estimates for two or more consecutive periods. The absolute and percent declines are shown in Table 1. In each case, a negative sign indicates an increase in ${}_5q_0$. The results are summarized in the form of boxplots showing the 25th, 50th, and 75th percentile declines for each period and region in Figures 2 and 3 for absolute and percent declines respectively. The vertical lines extending from the boxes show the full range of observations.

Both absolute and percent declines are presented because they reflect different aspects of the process of mortality decline. An absolute decline indicates numbers of child deaths averted, and thus reflects the impact of intervention programs or other socioeconomic change. On the other hand, an absolute change does not indicate the pace of change toward some spec-

TABLE 1 Absolute and percent declines in the probability of dying by age 5 in the developing world, by country, region, and time period

Region and country	1960–65 to 1965–70		1965–70 to 1970–75		1970–75 to 1975–80		1975–80 to 1980–85	
	Number[a]	Percent[b]	Number[a]	Percent[b]	Number[a]	Percent[b]	Number[a]	Percent[b]
The Americas								
Argentina	4	6	10	15	10	17	6	13
Brazil	13	9	14	10	18	14	21	20
Chile	24	18	33	30	27	34	24	46
Colombia	16	12	30	25	25	28	22	34
Costa Rica	24	21	24	27	29	45	11	31
Cuba	16	21	16	26	17	38	7	25
Dominican Rep.	—	—	—	—	34	26	10	10
Ecuador	19	11	20	13	20	15	26	22
Guatemala	—	—	31	16	23	14	21	15
Haiti	—	—	—	—	25	11	18	9
Honduras	—	—	24	12	—	—	—	—
Jamaica	15	20	14	23	16	33	—	—
Mexico	14	11	13	12	13	13	10	12
Panama	15	16	14	17	21	31	10	21
Peru	24	11	35	18	12	8	35	24
Puerto Rico	15	28	10	26	7	24	3	14
Trin. and Tob.	3	6	13	26	5	14	4	13
Uruguay	− 1	− 2	2	4	3	6	15	31
Median	15	11	15	18	18	17	13	20
Asia								
Bangladesh	—	—	0	0	7	3	6	3
China	49	30	30	27	25	30	—	—
Hong Kong	15	32	11	34	5	24	4	25
India	—	—	—	—	19	9	—	—
Indonesia	24	11	26	13	29	17	24	16
Korea, Rep.	23	23	15	20	13	21	—	—

TABLE 1 (continued)

Region and country	1960–65 to 1965–70		1965–70 to 1970–75		1970–75 to 1975–80		1975–80 to 1980–85	
	Number[a]	Percent[b]	Number[a]	Percent[b]	Number[a]	Percent[b]	Number[a]	Percent[b]
Malaysia	19	21	10	14	16	26	5	11
Nepal	30	10	20	8	—	—	—	—
Philippines	14	11	13	11	12	12	6	7
Pakistan	—	—	13	5	26	12	—	—
Papua-New Guinea	39	17	—	—	—	—	—	—
Singapore	11	26	8	26	7	30	4	25
Sri Lanka	14	14	8	9	13	17	—	—
Thailand	18	13	27	23	21	23	15	21
Median	19	17	13	13	15	19	6	16
Middle East								
Egypt	—	—	40	14	50	21	35	18
Jordan	41	27	17	16	16	17	—	—
Kuwait	34	32	18	25	13	24	15	36
Syria	—	—	35	22	28	22	—	—
Tunisia	35	14	30	14	50	28	—	—
Turkey	33	14	22	11	25	14	18	11
Yemen	—	—	—	—	41	14	—	—
Median	35	21	26	15	28	21	18	18
Africa								
Benin	—	—	18	7	22	9	—	—
Botswana	10	6	22	14	28	21	35	33
Burkina Faso	10	4	4	2	—	—	—	—
Burundi	17	7	3	1	—	—	—	—
Cameroon	24	10	25	11	—	—	—	—
Central Afr. Rep.	36	12	37	14	—	—	—	—
Congo	19	11	—	—	—	—	—	—
Côte d'Ivoire	—	—	38	15	—	—	—	—

Gambia	4	1	—	—	—	—	—	—
Ghana	22	10	22	11	24	14	−10	− 7
Kenya	22	11	19	11	—	—	—	—
Lesotho	9	5	5	3	—	—	—	—
Liberia	15	5	4	1	32	12	23	10
Malawi	11	3	11	3	—	—	—	—
Mali	—	—	—	—	23	7	30	10
Mozambique	—	—	0	0	—	—	—	—
Nigeria	14	7	21	12	0	0	—	—
Rwanda	7	3	−12	− 5	4	2	—	—
Senegal	0	0	7	3	33	12	32	13
Sierra Leone	11	3	—	—	—	—	—	—
Sudan	0	0	—	—	—	—	—	—
Tanzania	8	3	10	4	—	—	—	—
Togo	40	15	—	—	—	—	—	—
Uganda	20	9	13	7	9	5	−15	− 9
Zambia	20	10	—	—	—	—	—	—
Zimbabwe	2	1	8	5	8	6	—	—
Median	13	6	11	5	23	8	27	10

— = Not available.

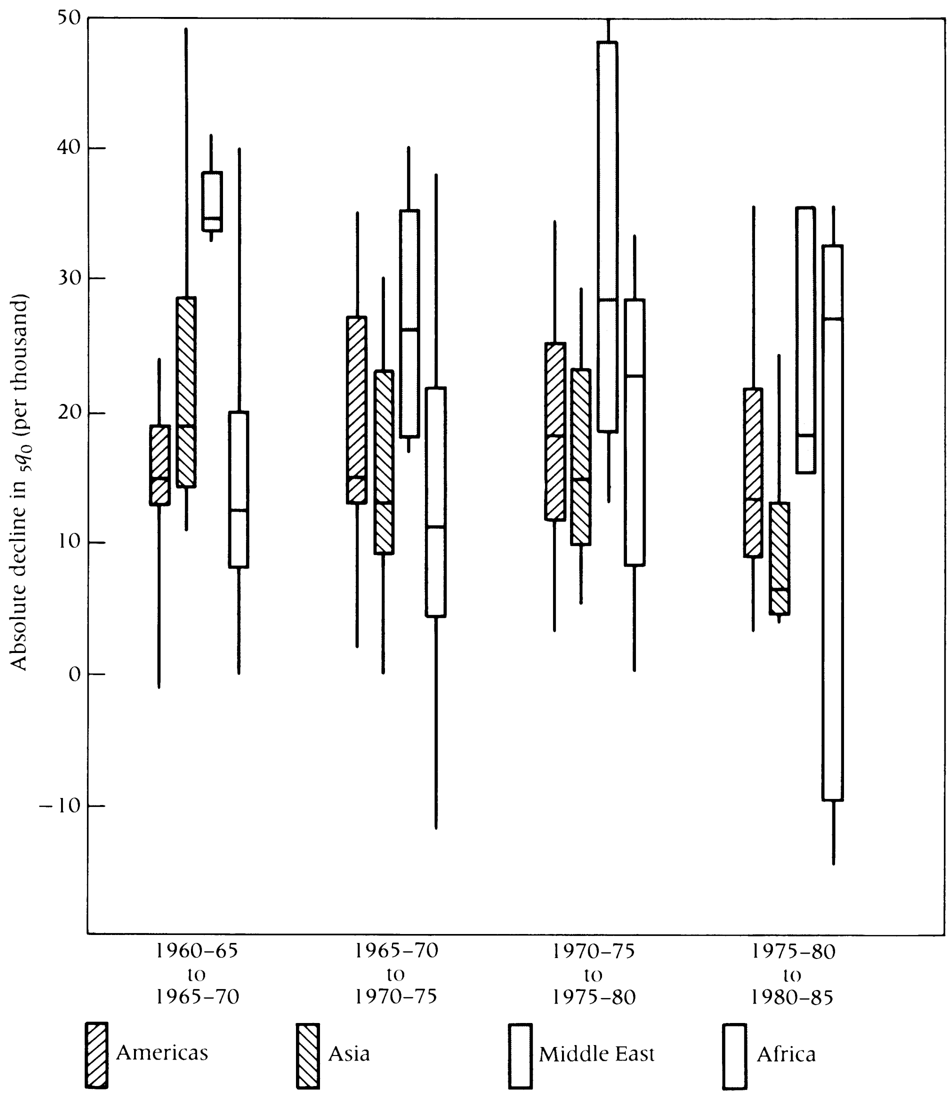
[a] Calculated as $_5q_0$ (per thousand live births) in the first period minus that in the second period.

[b] Calculated as $_5q_0$ in the first period minus that in the second period divided by the value in the first period, expressed in percent.

SOURCE: Table A-1.

ified target, and absolute changes cannot be compared across countries, regions, or time periods with very different levels of child mortality (it clearly makes no sense to compare a 40 per thousand drop in $_5q_0$ from an initial level of 300 per thousand with a 20 per thousand drop from an initial level of 35 per thousand). For these latter purposes, rates of change as indicated by percent declines are preferable.

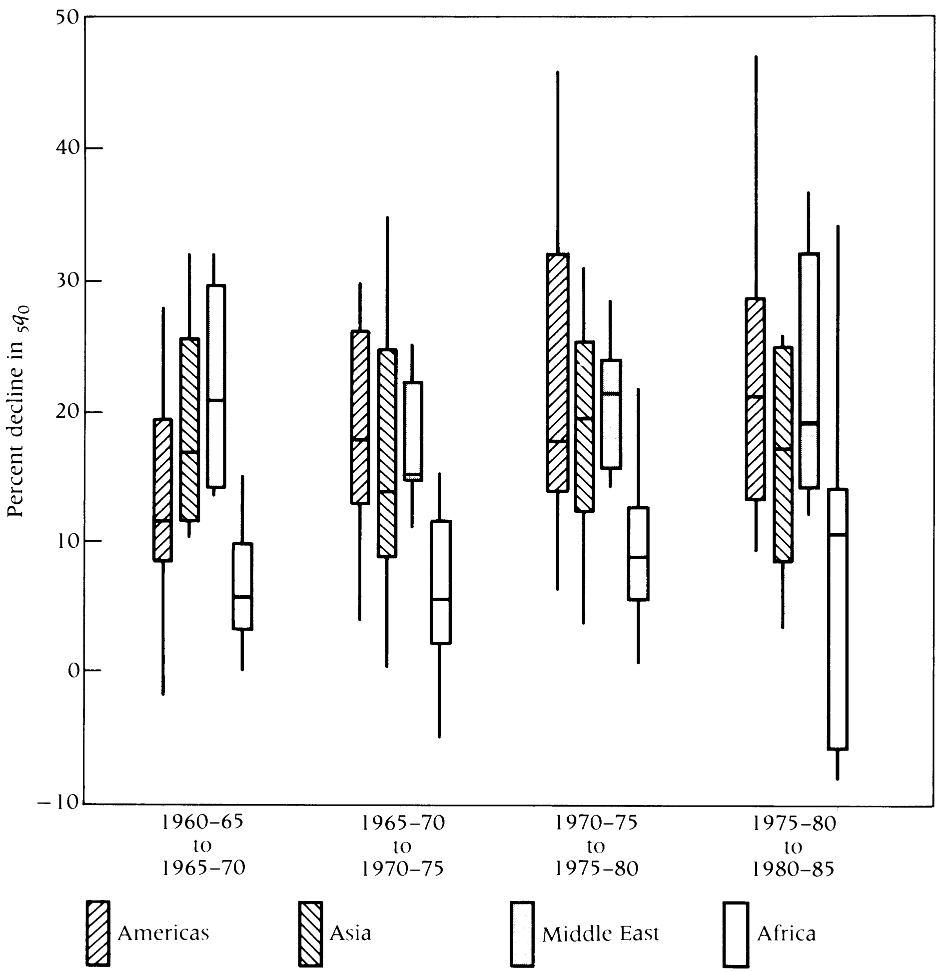
FIGURE 2 Distribution of developing countries by the absolute quinquennial decline in the probability of dying by age 5, by region and time period



SOURCE: Table 1.

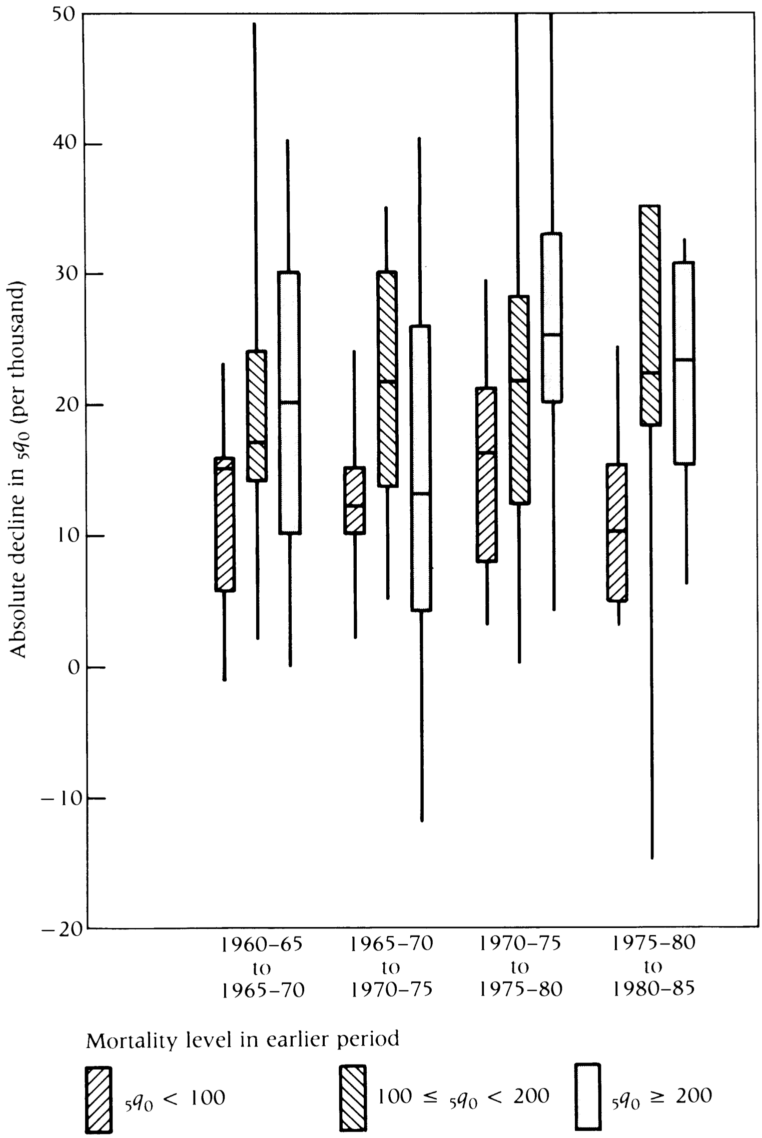
The absolute declines in Figure 2 show no clear or consistent patterns. The median absolute decline is greatest for the Middle East, except for the interval 1975–80 to 1980–85, when it is exceeded by Africa. Africa has the lowest median absolute declines for the first two intervals, whereas Asia has the lowest median absolute declines for the last two intervals. There is no pronounced change in the magnitude of the absolute declines over time. The percent declines in Figure 3 show rather more consistency, with smaller ranges, less difference between regions, and no obvious systematic change over time. The only pattern that stands out from Figure 3 is that the percent

FIGURE 3 Distribution of developing countries by the percent quinquennial decline in the probability of dying by age 5, by region and time period



SOURCE: Table 1.

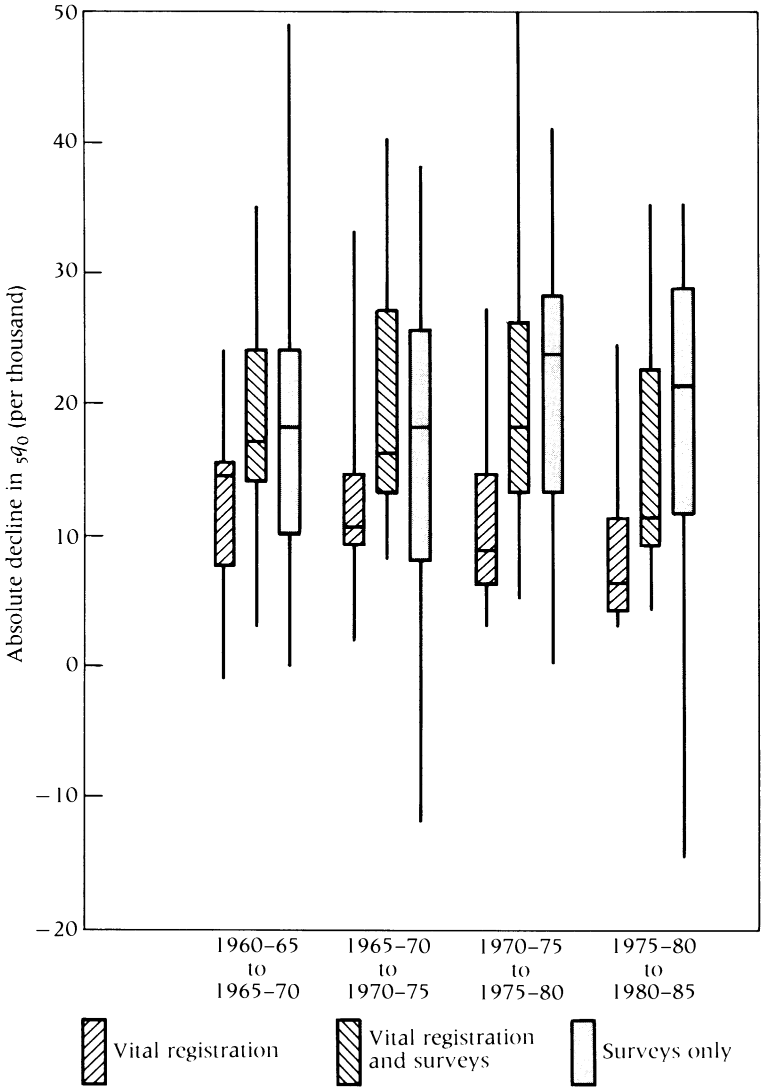
FIGURE 4 Distribution of developing countries by the absolute quinquennial decline in the probability of dying by age 5 ($_5q_0$), by initial mortality level and time period



SOURCE: Table 1.

declines in $_5q_0$ for Africa appear to be smaller than those in the other three regions. For the Americas, Asia, and the Middle East, the median percent declines in $_5q_0$ range from 10 to 20 percent per quinquennium; the median percent declines in Africa, on the other hand, range from 5 to 10 percent per quinquennium.

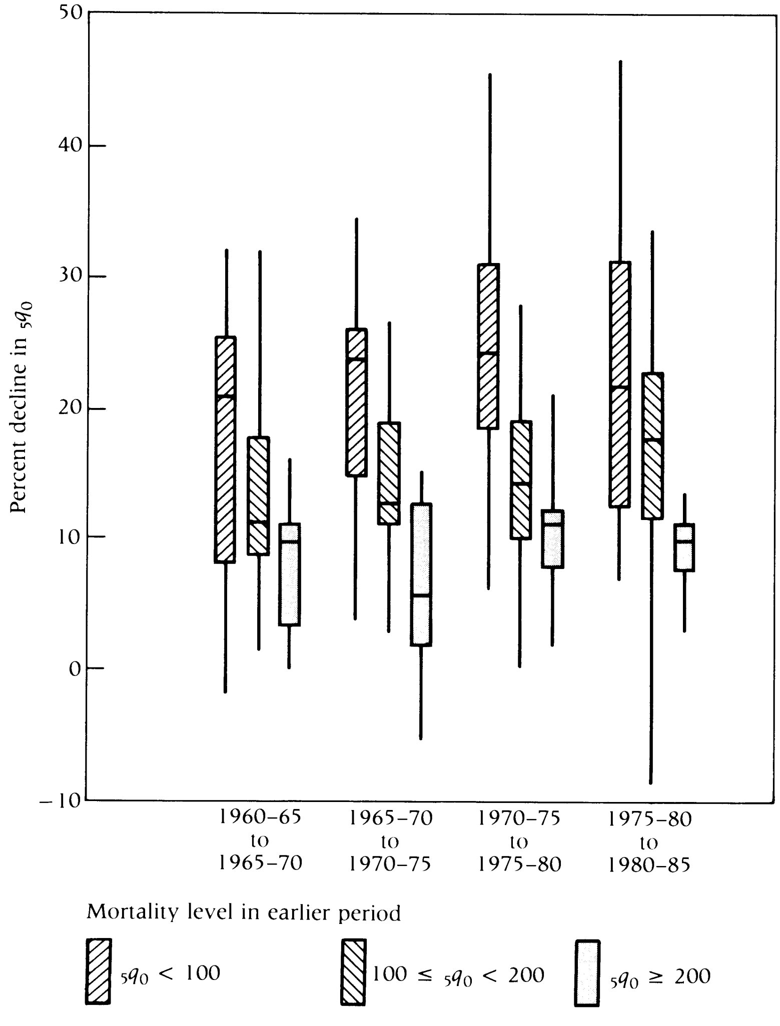
FIGURE 5 Distribution of developing countries by the absolute quinquennial decline in the probability of dying by age 5 ($_5q_0$), by type of data source and time period



SOURCE: Table 1.

Taken together, the data do not support the contention that the pace of child mortality decline has slowed substantially in the 1970s or 1980s. Absolute declines may have slowed slightly in Asia, where a number of countries have already achieved low child mortality, but declines in the Americas have maintained a steady pace. The numbers of observations for

FIGURE 6 Distribution of developing countries by the percent quinquennial decline in the probability of dying by age 5 ($_5q_0$), by initial mortality level and time period

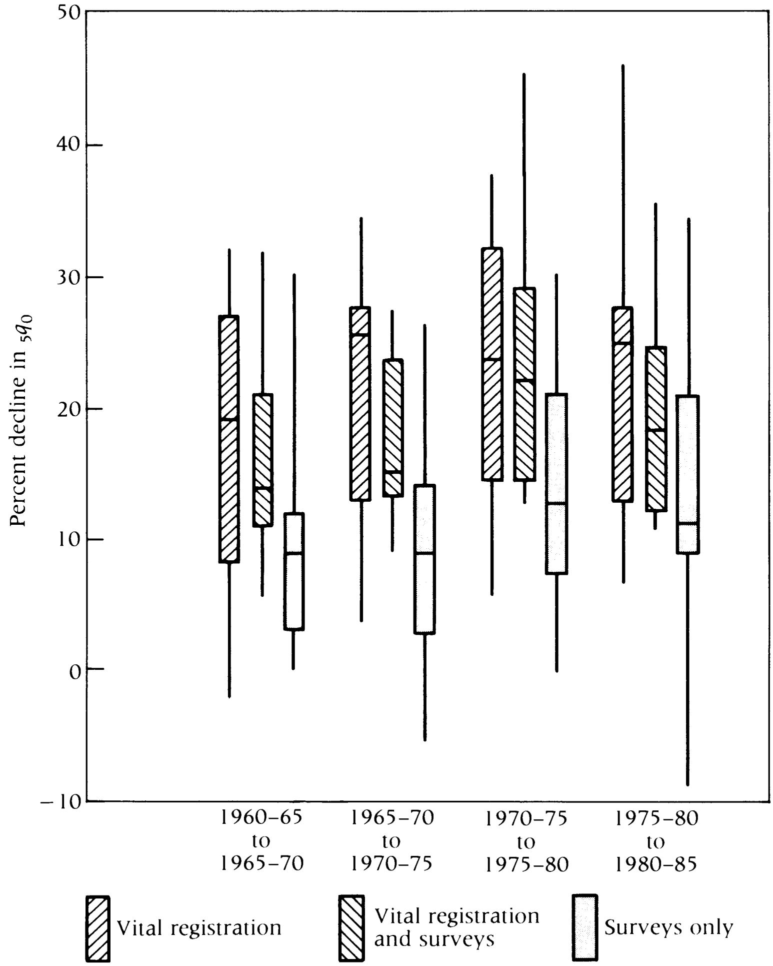


SOURCE: Tables 1 and A-1.

Africa and the Middle East are too small to support even impressionistic conclusions. Percent declines have remained remarkably similar over the whole period.

Caution is necessary, however, in interpreting these results since the countries for which data are available are not necessarily representative of the experience of the region, and since different sets of countries are included for each time period. While there is no entirely satisfactory way of allowing for the selections involved, some idea of their potential importance can be obtained by classifying countries according to characteristics that might be

FIGURE 7 Distribution of developing countries by the percent quinquennial decline in the probability of dying by age 5 ($_5q_0$), by type of data source and time period



SOURCE: Table 1.

associated with the pace of mortality decline. Two such characteristics have been used: the initial level of child mortality (on the grounds that success stories with rapid mortality reductions might be over-represented in the recent observations) and type of data source (on the grounds that the availability of recent data may imply above-average social infrastructure that may also be associated with rapid mortality decline). If selection effects are important, the declines in child mortality should be concentrated in the "favorable" categories—those with already low child mortality or those with child mortality measures based on vital registration; declines in the other, less favorable categories would be smaller. Results are summarized in the form of boxplots in Figures 4 and 5 for absolute declines, and in Figures 6 and 7 for percent declines.

Although clear patterns do appear in Figures 4 to 7, these patterns do not suggest that selection effects are of major importance. Absolute declines in ${}_5q_0$ are always smallest for countries in the low initial mortality category and for countries in the vital registration data source category. The pace of decline appears to have remained approximately constant over time in the low initial mortality category, but to have declined steadily in the vital registration data source category. The medium and high initial mortality categories, and the vital registration and surveys and surveys-only categories show no clear patterns of trend or differential. Percent declines in ${}_5q_0$ show very different patterns. The low initial level category and the vital registration data source category show the largest percent declines, though with no clear trend over time. The high initial level category and the surveys and vital registration data source categories show the smallest percent declines, again without clear trends over time. The intermediate category, both in terms of initial mortality level and in terms of data sources, shows intermediate percent mortality declines, though for the initial mortality level category the pace of decline increases steadily over the period. The lack of clear patterns within categories suggests that selection effects are not very large.

A slowdown in the pace of mortality decline?

In the early 1980s, considerable concern was expressed that the pace of mortality decline had slowed in the mid-1960s and the 1970s after an initial period of rapid decline following World War II (Gwatkin, 1980; Ruzicka and Hansluwka, 1982a; Sivamurthy, 1981; Arriaga, 1981; Preston, 1985; Palloni, 1985; Ruzicka and Hansluwka, 1982b; Caldwell, 1986). Davidson Gwatkin's dramatic conclusion in 1980, for example, was that "[T]he mortality data available, supplemented by what is known about related medical, social, and economic trends, suggest that the era of unusually rapid developing country mortality declines has at least temporarily come to an end. Overall, progress continues, but at a slowing rate. While some countries have continued to record impressive gains, stagnating and even upward mortality trends are reported in others" (1980, p. 637). Gwatkin and Lado Ruzicka and Harald Hansluwka (1982a) note that the situation is particularly troubling because the slowdowns appear to have occurred while life expectancy in many developing countries remains low. Most writers discussing this trend have focused on changes in mortality rates at all ages combined, as summarized by the expectation of life at birth. For our purposes here, it is important to note that changes in life expectancy are likely to be closely tied to changes in infant and child mortality, particularly at high levels of overall mortality. The relationship is not linear, however. For example, in a standard model life table system (Coale–Demeny, 1983, West family), a 10 percent decline in $_5q_0$ from an initial level of 200 per thousand live births (holding other mortality rates constant) is associated with an increase in life expectancy at birth, $e(0)$, from 47.7 years to 48.9 years, or 2.5 percent. The same percent decline from an initial level of 100 increases $e(0)$ from 60.1 to 60.8, or 1.2 percent; from a starting point of 50, the corresponding $e(0)$s are 67.7 and 68.0, for an increase of only 0.4 percent. Thus, constant percent declines in child mortality measures may be consistent with declining rates of improvement in life expectancy. Be that as it may, the arguments by Gwatkin (1980), Ruzicka and Hansluwka (1982a), and others about the limitations of current preventive and therapeutic health care strategies pertain most strongly to the health of young children, who are more likely than other segments of the population to contract and die from complications of diarrhea and dysentery, respiratory disease, parasitic infection, and undernutrition.[2]

Was there a general slowdown in the decline of mortality rates, and particularly child mortality rates, in developing countries during the 1960s and 1970s compared with earlier periods, due to the fact that the easiest gains had already been achieved? And, if so, has this deceleration continued in the 1970s and 1980s?

Gwatkin's argument about such a deceleration was based on United Nations estimates of life expectancy, which showed the average annual increase in life expectancy (in years) for all developing countries combined to be .64, .60, .52, and .40 for the four quinquennia 1950/55–1955/60 through 1965/70–1970/75, respectively (Gwatkin, 1980, Table 2). The estimates also showed a decelerating rate of change in each region (Latin America, Africa, and Asia) during this period of time. As we discussed earlier, these estimates for many countries, particularly during the 1950s, are based on conjecture rather than data.[3] In particular, reliable national-level mortality data for Africa are not available for the 1950s, and even the 1960s, for many countries (Brass et al., 1968). Therefore, any conclusions for this region about deceleration of mortality decline during the 1960s and 1970s as compared with the 1950s are highly (perhaps entirely) speculative.

In Asia, it is clear that the two largest countries, China and India, do not conform to the pattern described by Gwatkin (1980) and Ruzicka and Hansluwka (1982a). In China, for which reliable data are now available, much of the remarkably rapid mortality decline occurred after the early 1960s (Coale, 1984; Preston, 1985), although part of the decline in the mid-1960s relative to the late 1950s and early 1960s was artificially created by the dramatic rise in mortality rates during the Great Leap Forward. The pace of mortality decline slowed during the 1970s, but by that time China had reached low levels of mortality.[4] As for India, evidence presented by Samuel Preston and P. N. Mari Bhat (1984) contradicts earlier reports of a slowdown in the pace of mortality decline during the 1970s. Such slowdowns have, however, been reported for other countries in this region—for example, in the Philippines (Concepción, 1982, Table 1) and Sri Lanka (Meegama, 1982), though mortality in the latter has now reached very low levels.

A careful analysis of the issue of deceleration in mortality decline was carried out by the United Nations and the World Health Organization in 1982 (United Nations, 1982) and updated by the United Nations (1988b). This analysis was restricted to countries with mortality estimates that were deemed reliable after thorough evaluation. The study concluded that evidence of a slowdown was persuasive only in Latin America, although drawing any conclusion about changing mortality in Africa was difficult because so few countries have reliable data. These results confirmed the findings of other studies (Arriaga, 1981; Palloni, 1981, 1985) indicating a slowdown in the pace of mortality decline in Latin America in the 1960s and 1970s, as compared with the 1950s. It is important, however, to note the considerable diversity in the experience of Latin American countries since World War II (Palloni, 1981; Arriaga, 1981).

The explanation for the change in the pace of mortality decline in Latin America from the 1950s to the 1960s and 1970s fits the pattern described by Gwatkin (1980). Much of the decline in overall mortality in the 1940s and 1950s appears to have been due to the introduction of successful malaria eradication programs[5] (Palloni, 1985; Molineaux, 1985; Arriaga, 1981), although in some countries these programs accompanied more general socioeconomic development. Alberto Palloni (1985) notes that among Latin American countries with a high prevalence of malaria, the major mortality decline did not begin until use of insecticides to kill mosquitos became widespread. In these same countries, after malaria was brought under control, subsequent progress in reducing mortality has been slow (Palloni, 1985).

These conclusions about deceleration in overall mortality decline in the 1960s and 1970s in developing countries are likely to apply to child mortality as well: the slowdown may have been limited to some countries in Latin America, although the data for Africa in the 1950s are not sufficient to make a judgment. For the 1960s, 1970s, and early 1980s, reliable data are available for a larger number of countries. Do we observe a deceleration in the pace of decline in child mortality during this period? We presented earlier, in Table 1, two methods of examining changes in child mortality by region: one based on absolute declines, the other based on percent declines. For Latin American countries, neither the absolute declines nor the percent declines show any sign of deceleration or acceleration from the early 1960s through the early 1980s. In Asia and in the Middle East, the absolute declines diminish over time, although the percent declines remain roughly constant. The difference between the two measures of change reflects a movement by a number of Asian and Middle Eastern countries to low mortality levels during this period. In Africa, both the absolute and the percent declines appear to have accelerated somewhat over the period in terms of their medians, although the range of estimates for the most recent period is extremely wide. Thus, on a regional basis and for countries with reliable data, we find no evidence of a slowdown in the pace of decline in child mortality, except in the case of Asia, where mortality rates reached low enough levels to make continued large absolute declines difficult or even impossible to achieve. In fact, the decline in child mortality appears to have accelerated in Africa during this period, despite the poor economic performance of many countries in that region.

Structural adjustment and child mortality

A more recent concern relates to the effects on the pace of infant and child mortality decline of (a) deteriorating economic conditions in many developing countries, and (b) policies of economic stabilization (or structural adjustment), undertaken by a number of countries in Africa and Latin America in the 1980s, often at the behest of the International Monetary Fund and the World Bank, to cope with economic downturn and massive national debt (UNICEF, 1989; Cornia et al., 1988; Behrman, 1988; Palloni, 1989). The components of such structural-adjustment programs that are potentially detrimental to health include falling real wages, rising prices of food due to elimination of price supports, and decreased government spending for health services and for education, which appears to be strongly related to use of health services. In the international community, the United Nations Children's Fund (UNICEF) has taken the lead in sounding an alarm about the consequences of economic restructuring for children's health. The latest edition of *The State of the World's Children* (UNICEF, 1989) argues that increases in child mortality may already have occurred in some areas of the developing world.[6]

A considerable body of previous research (summarized in Palloni, 1989 and Behrman, 1988) suggests that a substantial decrease in standards of living is likely to bring about a deceleration of mortality decline and to raise mortality rates. However, it is difficult to evaluate whether structural-adjustment policies have altered or will alter families' economic status sufficiently to affect mortality rates, for several reasons. First, countries undertaking structural adjustment are not a random sample of developing countries: most adopted these programs in order to cope with serious economic problems. Thus, any effect on mortality rates may be due either to the original economic difficulties or to the changes made under structural adjustment, or both. Second, falling wages and rising commodity prices may adversely affect residents of urban areas, while in fact improving the financial situation of the rural commodity producers.[7] Adjustment may thus benefit the rural population with high child mortality at the expense of the urban population with lower child mortality. Third, governments may structure their economic stabilization program with the explicit goal of maintaining provision of basic social services to the poor.

In an extensive review of the economic mechanisms through which structural-adjustment policies may affect child health, Jere Behrman (1988) concluded that it is hard to predict the size and direction of the likely effects. In general, the data presented above provided no clear evidence that the overall pace of child mortality decline has changed greatly between the 1960s and the 1980s. Although the number of observations for the most recent period is small, the economic difficulties developing countries have experienced and/or the structural-adjustment policies countries have adopted in the early 1980s do not seem to have slowed mortality declines substantially, if at all. Individual exceptions exist, however. Child mortality does appear to have increased somewhat in Ghana from the late 1970s, at a time of severe economic recession. On the other hand, child mortality has declined rapidly in Jamaica and Chile, countries with negative growth of real per capita GNP from 1965 to 1985 (World Bank, 1988); and in Peru, another country with unfavorable recent economic conditions, the declines in child mortality appear to have continued unabated into the early 1980s.[8] The results shown earlier in Figures 2 and 3, which summarize regional changes over time, indicate that in the two regions most affected by economic problems and structural-adjustment policies, Latin America and Africa, the pace of child mortality decline does not appear to have slowed between the 1970s and 1980s.

Palloni (1989), examining data on infant mortality for individual Latin American countries in relationship to the seriousness of their economic crises, reaches somewhat different conclusions. His results seem to indicate that countries which suffered the most severe crises were less likely to have experienced the expected rate of mortality decline.[9] As Palloni admits, however, these results are suggestive at best. Indeed, we agree with his conclusion: "[A]lthough the levels of infant mortality show little response, morbidity and malnutrition may be on the increase but its consequences will be visible after lags longer than what we are able to analyze here" (1989, p. 30).

The effectiveness of public health interventions in averting child deaths

A major criticism of international child survival programs is their focus on elimination or control of a specific set of infectious diseases through immunization or palliative measures (especially the use of oral rehydration therapy) instead of provision of comprehensive primary health care. Critics of this approach assert that rather than prevent infant and child deaths, these programs may merely postpone deaths of children who will die from other causes later in childhood.

In general, an intervention targeted at a particular disease can have one of three effects, assuming it is at least minimally effective (Foster, 1984, p. 128). It can: (1) reduce mortality from the disease, with synergistic benefits for surviving or avoiding other diseases, thus reducing cause-specific mortality from the targeted disease and others, and thereby reducing overall mortality by more than would be expected from cause-specific mortality alone; (2) reduce mortality from the disease alone, lowering cause-specific mortality and overall mortality by a corresponding amount; or (3) postpone deaths from earlier to later childhood, either from the same or from different causes. A broad-spectrum intervention would not be expected to have the third effect, but would be expected to reduce mortality rates over a range of targeted causes.

The impact of synergism, the first effect, or reverse synergism, the third effect, is primarily associated with two major diseases—measles and malaria—and the issues in the two cases are somewhat different. Evidence from a study in eastern Zaire in the 1970s (Kasongo Project Team, 1981) and work by others (see WHO/EPI-GAG, 1987, for a review) suggested that immunization against measles would save the lives of both strong children (most of whom would have survived measles anyway) and weak children, but that many of the weak children would quickly succumb to other diseases. Thus, the apparent benefits of measles immunization would be overwhelmed by the effect of "replacement mortality." However, the published results of the Zaire study are ambiguous, do not appear to support the authors' conclusions, and have been severely criticized by others (Aaby et al., 1981; Manshande and De Caluwe, 1981). Furthermore, recent work (Stephens, 1984; Gadomski and Black, 1988) indicates that measles immunization actually seems to reduce child mortality by a greater amount than might be expected from reducing measles mortality alone. In other words, the synergistic impact of measles with other infections (and with malnutrition) seems to be important, and reducing the incidence of measles appears to lower mortality from other causes as well.[10]

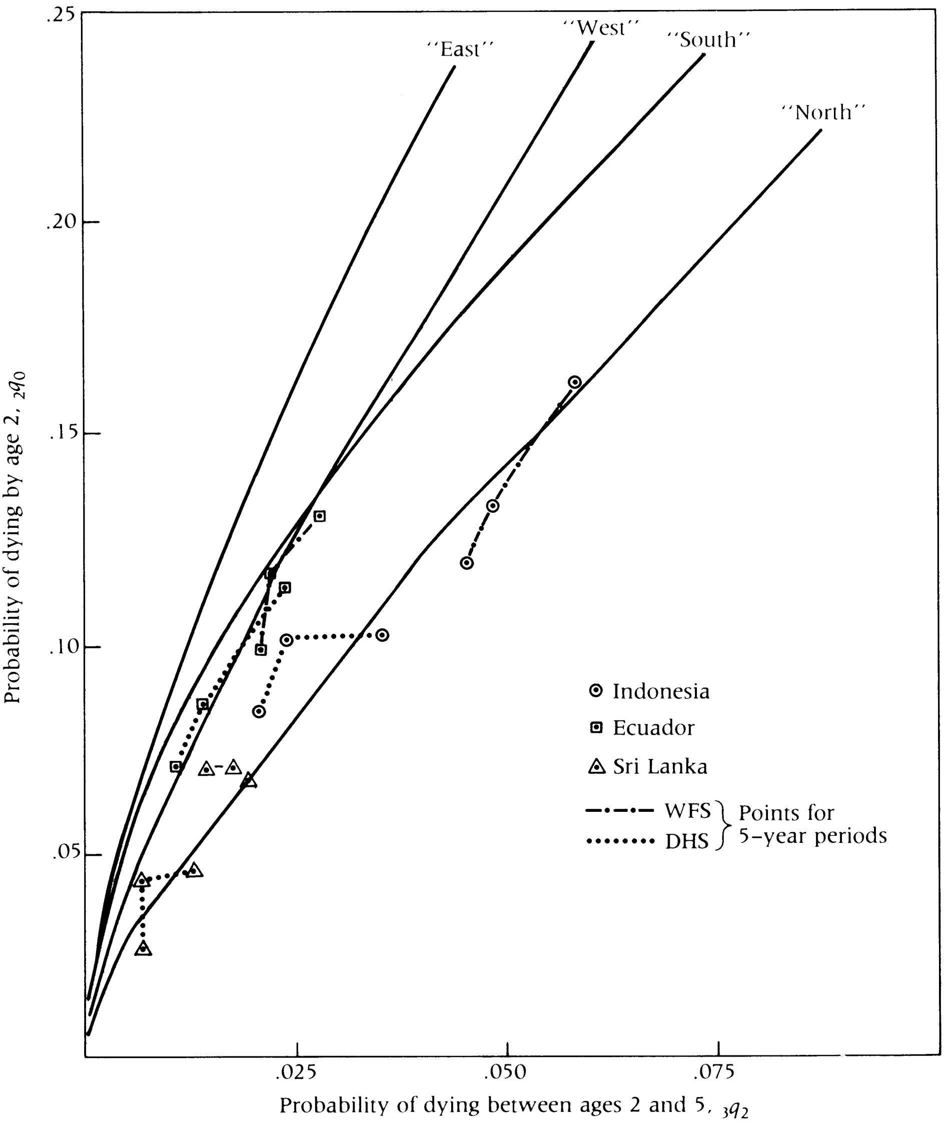
Some of the issues in the case of malaria are the same as for measles. For instance, will reduction in the incidence of malaria lower child deaths from other diseases as well, or will many children whose deaths are prevented by a malaria control program subsequently die in childhood of other diseases? Although a study in Garki, Nigeria suggested that control of *Plasmodium falciparum* malaria prevented fewer deaths than had been expected on the basis of malaria-specific mortality rates[11] (Molineaux, 1985, p. 35), other research indicates that reducing malaria mortality is more likely to reduce mortality from other causes as well. For example, Louis Molineaux (1985) reports a substantial decline in mortality from nonmalarial causes as a result of malaria eradication programs in Sri Lanka and Guyana. And two studies of mortality trends in Kenya and Tanzania during and after antimalarial spraying programs provide strong support for the idea that elimination of malaria reduces deaths from other causes as well (Pringle, 1967; Payne et al., 1976; Ewbank et al., 1986).

Another concern in the case of malaria is that reducing the frequency of exposure to the disease (being bitten by mosquitos carrying parasites) as a consequence of a malaria control program may change the age pattern of infection. Populations exposed regularly to malaria develop a temporary immunity to infection that is continually reinforced by new exposure to the parasite. In a population living in a malarious area, infants are exposed to malaria at an early age, and if they develop an infection and survive, they begin to build up immunity. Therefore, malaria mortality is concentrated in fairly young ages, although not in the first months of life, when infants appear to be protected by residual maternal immunity (Molineaux, 1985). If malaria control is moderately effective, however, children are more likely to receive their initial exposure to the risk of infection at a later age. Therefore, a malaria control program may change the age distribution of malaria deaths from the first years of life to later in childhood. Evidence on this issue is scarce and contradictory. Nevertheless, since it is clear that effective control programs can bring about major reductions in malaria-related mortality, it is likely that the overall mortality rates from malaria would be substantially reduced at all ages throughout childhood, even if a shift occurred in the distribution of ages at death.

Returning to the general effects of a targeted intervention, the third effect—postponement of deaths to later ages—has to be defined by an upper age limit, since all deaths are, in reality, postponed rather than permanently averted. Postponement would leave unchanged the probability of dying by this age limit, but would reduce the probability of dying in the first part of the age interval and increase it in the second part of the interval. A reasonable upper age limit for childhood mortality, the one we use in this article, is age five, since the probability of dying between ages five and 15 is usually only a small fraction of the probability of dying before age five (typically around one-fifth), suggesting much lower frailty above age five and, thus, little chance of postponement to such ages. If a substantial portion of deaths is merely postponed, however, use of an index of child mortality such as the infant mortality rate, with its young age cutoff (below one year), could erroneously indicate a substantial decline in child mortality where no such decline occurred in under-five mortality.

Data from the World Fertility Survey (WFS) and the Demographic and Health Surveys (DHS) allow us to examine patterns of mortality under age five during time periods when overall childhood mortality declined. If child survival programs were having substantial postponement effects, we would expect to see changes in the relationship between mortality under age two and mortality between ages two and five. Figure 8 shows the relationships between the probability of dying by age two ($_2q_0$) and the probability of dying between ages two and five ($_3q_2$) for three five-year periods prior to each survey for three countries, Indonesia, Sri Lanka, and Ecuador. Also

FIGURE 8 Age patterns of child mortality in selected developing countries compared with Coale–Demeny model patterns



SOURCES: WFS—Rutstein (1984); DHS—Country Reports.

shown are comparable relationships from the four families of Coale–Demeny (1983) model life tables. The observed relationships have conformed quite closely to the model patterns as child mortality has fallen. Indonesia and Sri Lanka appear to have followed the "North" family pattern of change, whereas Ecuador has followed the "West" family pattern. To avoid cluttering the figure, results for other countries with both WFS and DHS surveys are not shown, but they confirm the general contention that the age pattern of decline in child mortality in the developing world over the last two decades has closely followed expected model patterns. Thus the available data do not indicate any postponement of child mortality under age five. Results for other countries with measures of infant mortality (${}_1q_0$) and post-infant early childhood mortality (${}_4q_1$) over time suggest similar consistency with model patterns.

Conclusions

This review of levels, trends, and age patterns of child mortality in the developing world from the early 1960s to the present gives rise to several important conclusions.

First, the disparities in levels of child mortality between countries and regions of the developing world are very great and appear to have widened over the period. The difference between best and worst cases in the early 1960s seems to have been a factor of about seven, and by the early 1980s this factor had increased to about 15, even if we exclude two countries with mortality levels comparable to those of developed countries, Hong Kong and Singapore.

Second, rates of child mortality decline in Africa seem to be slower than those in the Middle East, the Americas, and Asia. Nevertheless, this result may be more closely associated with the initial high mortality level in Africa than with other characteristics of the region. Other high-mortality populations, such as those of the Indian subcontinent (excluding Sri Lanka) and Haiti, have also experienced below-average declines. However, even the success stories of Africa, such as Kenya and Zimbabwe, have not experienced rates of decline as rapid as those in countries of other regions with similar child mortality levels in the early 1960s.

Third, there seems to be a general pattern whereby percent declines in child mortality for countries with high initial levels are lower than such declines for countries with moderate or low initial levels. The dividing line seems to be a level of ${}_5q_0$ around 150 per thousand live births. Once this level is breached, declines appear to be rapid and sustained, whereas above this level, declines appear slower and more vulnerable to other factors. This third conclusion, however, has no very firm foundation in observation.

Fourth, from the available evidence we find little basis for postulating a general slowdown in the pace of mortality decline in the early 1980s, contrary to what might have been expected in light of the downturn in economic conditions. On the other hand, the effects on mortality of economic deterioration or of economic policies aimed at structural adjustment, if they occur, may take some time to become apparent. Furthermore, while other studies suggest some slowing of the pace of decline in the Americas in the 1960s relative to the 1950s, we conclude that this slowdown may have been limited to this region and time period, and did not signal that the potential of public health programs to reduce mortality in all areas of the Third World had been largely exhausted, as some observers suggested in the early 1980s.

Finally, we find little evidence to support the notion that public health interventions merely change the causes of or postpone child deaths rather than prevent them. The positive or negative synergism between health interventions and diseases of childhood requires further research. Nevertheless, the available evidence suggests that the interaction of diseases with each other, and with malnutrition, is very important, and that the net effect of eliminating or reducing the incidence of one disease is likely to be the reduction of mortality from several additional causes.

Appendix

TABLE A-1 Point estimates of the probability of dying between birth and age 5, by country and 5-year period (per 1000 live births)

Region and country	1960–65	1965–70	1970–75	1975–80	1980–85
The Americas					
Argentina	72	68	58	48	42
Bolivia	*	*	244	*	*
Brazil	152	139	125	107	86
Chile	136	112	79	52	28
Colombia	135	119	89	64	42
Costa Rica	112	88	64	35	24
Cuba	77	61	45	28	21
Dominican Republic	*	*	132	98	88
Ecuador	175	156	136	116	90
Guatemala	*	193	162	139	118
Haiti	*	*	232	207	189
Honduras	*	195	171	*	*
Jamaica	77	62	48	32	*
Mexico	127	113	100	87	77
Panama	97	82	68	47	37
Peru	218	194	159	147	112
Puerto Rico	54	39	29	22	19
Trinidad and Tobago	53	50	37	32	28
Uruguay	53	54	52	49	34
Median	105	100	89	52	42
Percent of regional births covered	83	87	92	89	88
Asia					
Bangladesh	*	228	228	221	215
China	162	113	83	58	*
Hong Kong	47	32	21	16	12
India	*	*	218	199	*
Indonesia	225	201	175	146	122
Korea, Republic of	99	76	61	48	*
Malaysia	91	72	62	46	41
Nepal	290	260	240	*	*
Philippines	128	114	101	89	83
Pakistan	*	239	226	200	*
Papua-New Guinea	232	193	*	*	*
Singapore	42	31	23	16	12
Sri Lanka	101	87	79	66	*
Thailand	136	118	91	70	55
Median	128	114	91	68	55
Percent of regional births covered	50	59	90	89	16

TABLE A-1 (continued)

Region and country	1960–65	1965–70	1970–75	1975–80	1980–85
Middle East					
Egypt	*	280	240	190	155
Jordan	150	109	92	76	*
Kuwait	107	73	55	42	27
Syria	*	160	125	97	*
Tunisia	245	210	180	130	*
Turkey	239	206	184	159	141
Yemen	*	*	290	249	*
Median	195	183	180	130	141
Percent of regional births covered	25	52	56	56	43
Africa					
Benin	*	255	237	215	*
Botswana	165	155	133	105	70
Burkina Faso	283	273	269	*	*
Burundi	243	226	223	*	*
Cameroon	249	225	200	*	*
Central African Republic	293	257	220	*	*
Congo	180	161	*	*	*
Côte d'Ivoire	*	255	217	*	*
Gambia	347	343	*	*	*
Ghana	218	196	174	150	160
Kenya	199	177	158	*	*
Lesotho	197	188	183	*	*
Liberia	294	279	275	243	220
Malawi	355	344	333	*	*
Mali	*	*	325	302	272
Mozambique	*	282	282	*	*
Nigeria	196	182	161	161	*
Rwanda	229	222	234	230	*
Senegal	282	282	275	242	210
Sierra Leone	392	381	*	*	*
Sudan	200	200	*	*	*
Tanzania	237	229	219	*	*
Togo	267	227	*	*	*
Uganda	212	192	179	170	185
Zambia	207	187	*	*	*
Zimbabwe	155	153	145	137	*
Median	233	226	220	193	198
Percent of regional births covered	58	64	58	36	10

* = Not available.
SOURCE: Selected from United Nations (1988a) and Hill (1987), with updating as noted in Table A-2.

TABLE A-2 Data sources for child mortality estimates

Validated vital registration
The Americas
Argentina, Chile, Cuba, Puerto Rico, Uruguay
Asia
Hong Kong, Philippines, Singapore
Middle East
None
Africa
None
Vital registration in combination with censuses and surveys
The Americas
Costa Rica, Ecuador,[a] Guatemala,[a] Jamaica, Mexico,[a] Panama, Trinidad and Tobago[a]
Asia
Malaysia, Sri Lanka[b]
Middle East
Egypt,[a] Kuwait, Tunisia[b]
Africa
None
Censuses and surveys only
The Americas
Bolivia, Brazil,[a] Colombia,[a] Dominican Republic,[a] Haiti,[c] Honduras, Peru[a]
Asia
Bangladesh,[d] China, India, Indonesia,[a] Korea (Republic of), Nepal, Pakistan, Papua-New Guinea, Thailand[a]
Middle East
Jordan, Syria, Turkey, Yemen
Africa
Benin, Botswana,[a] Burkina Faso, Burundi,[b] Cameroon, Central African Republic, Congo, Côte d'Ivoire, Gambia, Ghana,[a] Kenya, Lesotho, Liberia,[a] Malawi, Mali,[a] Mozambique, Nigeria, Rwanda, Senegal,[a] Sierra Leone, Sudan, Tanzania, Togo, Uganda,[a] Zambia, Zimbabwe[b]

[a] Estimates take into account data from the Demographic and Health Surveys (DHS).
[b] Estimates do not take account of DHS data.
[c] Estimates take into account the 1987 Enquête Mortalité-Morbidité et Utilization des Services (EMMUS).
[d] Estimates take into account the 1985 Contraceptive Prevalence Survey and the 1987 Diarrheal Morbidity and Treatment Survey (DMTS).

Notes

This article is a revised and expanded version of a paper first presented at the Workshop on Child Survival Programs: Issues for the 1990s, held at the School of Hygiene and Public Health, Johns Hopkins University, 21–22 November 1988, with financial support from the United States Agency for International Development. The authors acknowledge the useful comments and suggestions made by Birgitta Bucht, Noreen Goldman, and James Trussell.

1 GOBI is the United Nations Children's Fund's program of growth monitoring, oral rehydration therapy of dehydration consequent upon watery diarrhea, breastfeeding, and immunization. EPI is the World Health Organization's Expanded Programme of Immunizations. CCCD, Combatting Childhood Communicable Diseases, is a joint program carried out by the US Centers for Disease Control and national governments, primarily in sub-Saharan Africa. The CCCD programs often incorporate antimalarial treatment as well.

2 Samuel Preston's (1985) analysis of the association of life expectancy and infant mortality with socioeconomic factors shows that the relationships found for infant mortality rates are entirely consistent with those for life expectancy as a whole.

3 Although Gwatkin recognizes that these data may not be highly reliable, he uses them as the basis of his argument and of a discussion about the progress (or lack of progress) in public health programs.

4 China's crude death rate has been below 10 per thousand population since the mid-1960s.

5 Malaria eradication may also account for part of the post–World War II mortality decline in Sri Lanka and for the subsequent slackening off in the pace of decline. The size of the contribution of malaria eradication to mortality decline in Sri Lanka has been the subject of considerable debate; see Molineaux (1985) for a summary.

6 As evidence, this UNICEF report cites a study by Becker and Lechtig showing apparently increasing mortality rates in Northeast Brazil during 1981–83. Other evidence (Fundação Instituto Brasileiro de Geografia e Estatística, 1987) suggests, however, that this trend in one of the poorest areas of Brazil was of very short duration and may have been due to improvements in the vital registration system.

7 The differential effects on urban and rural residents are likely to vary from country to country according to the degree of dependence of rural consumers on the market for food and other goods.

8 There is some indication that the most recent data for Peru, from the 1986 Demographic and Health Survey, may have underestimated child mortality. However, the internal structure of the DHS data on proportions dead among children ever born, classified by age of mother, shows continuing rapid decline in child mortality in the 1980s. Although the level of child mortality in the 1980s may thus be controversial, it seems clear that a strong downward trend has continued well into that decade.

9 Palloni calculated the expected decline in the infant mortality rate during the 1980s on the basis of each country's mortality level in 1980 and on the assumption that declines in infant mortality would occur at the same pace as that of Costa Rica, chosen because that country has achieved levels of mortality which are comparable to those in industrialized countries. He contrasted this expected rate of mortality decline with the actual rate of decline.

10 A recent study by Peter Aaby et al. (1988) indicates that reduction in the incidence of measles as a consequence of immunization programs also results in less severe cases of measles among unvaccinated children who contract the infection. Aaby et al. hypothesize that this effect is due to exposure to a lower dose of measles virus—as a result of fewer children in the population having measles.

11 It is not clear whether death *rates* from other causes increased or whether only the *number* of deaths from other causes increased. It would not be at all surprising (or necessarily worrisome) if the number of deaths increased, since the population at risk of dying from causes other than malaria (i.e., the number of children not dying of malaria) would be larger in the presence of a successful eradication program. What is important is whether mortality rates from other causes increase.

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