

International infant mortality rankings: A look behind the numbers

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The very unfavorable infant mortality ranking of the United States in international comparisons is often used to question the quality of health care there. Infant mortality rates, however, implicitly capture a complicated story, measuring much more than differences in health care across countries. This article examines reasons behind international infant mortality rate rankings, including variations in the measurement

of vital events, and differences in risk factors across countries. Its goal is to offer a broader context for more informed debate on the meaning of international infant mortality statistics. These statistics offer opportunities to identify strategies for improving the U.S. health care system and learn from other countries that have been more successful.

Introduction

Rankings of infant mortality rates (IMRs) are among the most commonly cited international comparisons of health status. The very low ranking of the United States—19th among industrialized countries in 1989 (Table 1)—is often used to question the quality of health care in the United States. The U.S. rate of infant mortality (defined as the number of deaths among children under 1 year of age, divided by the number of births in a given year, and multiplied by 1,000) was more than 50 percent higher than those of Japan, Finland, and Sweden. These statistics have helped to spur interest in bringing down the number of infant deaths in the United States. Despite improvements—including a drop in the rate from 9.7 in 1989 to 8.9 in 1991—there is still a long way to go to bring U.S. rates in line with those of other countries.

Infant mortality rates implicitly capture a complicated story, measuring much more than differences in health care across countries. For example, these rates are affected by the socioeconomic status of mothers and their children; we know that the age of the mother, birth weight of the child, quality of nutrition for the mother, and other factors are associated with mortality (Institute of Medicine, 1985; U.S. Congressional Budget Office, 1992; Hogue et al., 1987). Measurement differences in statistical reporting of vital events also figure into these comparisons. However, it would be a mistake to simply dismiss these measures. In assessing how the United States stacks up against other countries, these statistics offer opportunities to identify strategies for improving our health care system and to learn from other countries that have been more successful.

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NOTE: Throughout this article data were collected separately by East and West Germany.

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To expand our knowledge about the reasons behind international rankings, it is important to probe further. This article attempts some steps in that direction by taking a closer look at the statistics—sorting out real differences from artifacts of measurement, disaggregating the data where possible, and examining differences in risk factors across countries. Even industrialized countries differ substantially in approaches to treatment of health problems, use of resources, and presentation of data. Because of data limitations, we can only speculate on the impact of some of these differences and cite some of the important literature in the area. Much of the work in this area has focused on factors contributing to infant mortality in individual countries. This article

Table 1
Infant mortality rates in selected industrialized countries: 1989

Rank	Country	Infant mortality rate
1	Japan	4.4
2	Finland	5.8
3	Sweden	6.0
4	Switzerland	6.8
5	Netherlands	6.8
6	Canada	7.1
7	France	7.4
8	West Germany	7.5
9	Ireland	7.5
10	East Germany	7.6
11	Australia	7.7
12	Norway	7.8
13	Spain	7.8
14	Austria	8.3
15	Denmark	8.4
16	United Kingdom	8.5
17	Italy	8.6
18	Belgium	8.8
19	United States	9.7
20	Greece	9.8
21	Israel	10.0
22	New Zealand	10.2
23	Czechoslovakia	11.3
24	Portugal	12.2
25	Bulgaria	14.4

NOTE: The data were collected separately by East and West Germany.

SOURCE: Adapted from Wegman, 1991.

summarizes some of the important research findings and attempts to put them in a broader framework. Our goal here is to offer a context for more informed debate on the meaning and interpretation of infant mortality statistics.

This survey of what we know about international comparisons is divided into several major areas. First, we examine measurement issues that can affect the rankings. We disaggregate infant mortality statistics into components such as neonatal and post-neonatal rates to provide more information about causes of international differences, and examine the occurrence of non-uniform reporting of vital events across countries. These differences can affect the relative ranking of the United States, but do not change the basic finding that we do less well with infant deaths than do many other industrialized countries. Second, we examine risk factors that affect infant mortality and try to trace how these factors differ internationally. Third, we turn to some simple simulations that help illustrate why infant mortality is so different in the United States as compared with other countries. The article concludes with a discussion of what these comparisons mean and what policy challenges await us in the attempt to reduce the rate of infant deaths in the United States.

Measurement issues

International comparisons are often criticized on measurement grounds. The IMR is a very crude measure, capturing both too much and too little. When all deaths up to 1 year of age are combined, some critics argue that the measure captures too many different problems and further disaggregation is appropriate. However, infant mortality statistics also leave out some vital information, such as ignoring fetal deaths before birth, that may distort the picture in another way. This debate over which of several measures to use illustrates the complexity of factors surrounding infant mortality.

In addition, measurement problems arise in international comparisons because the data are not consistently gathered or reported. Although the World Health Organization (WHO) has a formal definition of what should be included in the infant mortality statistics, anecdotal evidence suggests that countries do not use consistent practices in measuring these data (Haub and Yanagishita, 1991; Hartford, 1992).

Whatever the reason for these measurement differences, they can bias the resulting international rankings and comparisons. Thus, international data need to be viewed with caution, recognizing that at least some of the differences may be statistical artifacts.

Neonatal and post-neonatal mortality

The IMR is generally the basis for international rankings, however, more informative comparisons could be made by examining its components. Two commonly accepted and complementary measures are neonatal mortality rate and post-neonatal mortality rate. The neonatal mortality rate is defined as the number of deaths per year of infants under 28 days of age, divided by the number of live births in that year, and multiplied by 1,000. The post-neonatal mortality rate is defined as the number of deaths per year, of infants between 28 days and just under 1 year of age, divided by the number of births in that year, and multiplied by 1,000. Hence, the neonatal mortality rate measures deaths that occur shortly after birth, and the post-neonatal mortality rate measures deaths of infants who have survived the first 28 days.

The importance of differentiating between neonatal and post-neonatal infant deaths is that the causes of death tend to be different in the two periods. The causes of death during the neonatal period include congenital anomalies incompatible with life, and conditions arising in the perinatal period such as pregnancy-related problems, complications of labor and delivery, slow fetal growth, and birth trauma. In contrast, causes of death in the post-neonatal period often have an environmental origin and include sudden infant death syndrome (SIDS), certain other congenital anomalies, and accidents. Hence, interventions to reduce the incidence of neonatal and post-neonatal infant deaths can be quite different.

Table 2 presents 1986 components of neonatal mortality, post-neonatal mortality, and infant mortality rates for the United States and selected other countries that have lower IMRs than the United States. Neonatal rates are provided for various periods after birth (i.e., less than 1 day, 1-6 days, and 7-27 days of age). A striking comparison in this table is of the neonatal deaths in the first day of life. The U.S. rate for the first day of life was 3.88 per 1,000 live births, which was 2 to 3 times higher than those of many of the other countries, and more than 1 1/2 times higher than that of

Table 2
Neonatal and post-neonatal death rates: 1986

Country	Rate				
	Total	Less than 1 day	1-6 days	7-27 days	28-364 days
United States	10.35	3.88	1.72	1.11	3.64
United Kingdom (1987)	9.55	2.44	1.83	1.01	4.27
France	8.04	1.25	1.99	1.07	3.73
Norway	7.92	2.11	1.14	0.97	3.69
Netherlands	7.77	1.78	2.24	0.78	2.96
Sweden	5.90	1.40	1.93	0.59	1.97
Japan (1987)	5.24	1.19	1.15	0.76	2.14

SOURCE: World Health Organization Statistics Annual, 1988.

the United Kingdom which had the next highest rate in this category. The reasons behind the relatively higher U.S. rate can be manifold. However, the results are consistent with the notion that the United States may report as live births more low-birth-weight babies who are at high risk of dying in the first day, and then register those who die as infant deaths.

Comparisons of the other components of neonatal mortality (i.e., 1-6 days and 7-27 days) indicate that, with a few exceptions, there is considerably greater uniformity in rates across countries. The post-neonatal mortality rates in Table 2 varied from 1.97 for Sweden to 4.27 for the United Kingdom. Although the U.S. post-neonatal mortality rate of 3.64 was closer to United Kingdom's than to Sweden's, it is in the middle of the group.

Variation in registered events

In making international comparisons, an important reason for examining measures other than the IMR is that variations across countries in the registration of vital events may affect the overall rate. Because the number of deaths is always very small as a proportion of births, small differences in the way that deaths are measured can have particularly strong effects on the rates. Variations in the registration of live births indirectly affect the recording of infant deaths as well as live births; an infant death to be recorded as such, the infant must have been registered as a live birth. Death shortly after birth constitutes one reason an infant may not have been registered. Although registration of a live birth is supposed to be based on the WHO definition of any sign of life, not all countries subscribe to this definition (Haub and Yanagishita, 1991; Hartford, 1992). In France, a baby has to be alive at the time of registration, which could be 24-48 hours after delivery. If the infant does not survive to that point, it is recorded as a "false stillbirth." East Germany requires evidence of the functioning of both the heart and the lungs. The former Soviet Union excluded from live births infants of less than 1,000 grams in weight or less than 28 weeks of gestation, if they die within 7 days of birth.

Japan has been known for its classification of some infant deaths as late fetal deaths (stillbirths), although some observers believe steps have been taken to correct the situation (Haub and Yanagishita, 1991). However, to the extent that this practice exists, Japan's IMR may be artificially low. To demonstrate the effects of potential variations in the classification of fetal and infant deaths, Haub and Yanagishita (1991) compared the number of fetal and infant deaths in certain countries. For most of the 19 countries in their comparison, the ratio of stillbirths (i.e., fetal deaths) to infant deaths in 1985 was between 0.45 and 0.60. Japan, which has the world's lowest infant mortality rate, had an unusually high number of stillbirths per infant deaths, 0.98. Haub and Yanagishita (1991) raised the question of whether social and cultural customs favor the recording of an infant death as a stillbirth, in light of the fact that infant deaths, but not stillbirths, are

recorded in Japan's Family Registration System. This practice may occur because of a perception that the death of a child would be an undesirable entry in the registry.

The importance of these variations is that the births that may not be recorded in these cases are those that are at higher-than-average risk of dying shortly after birth. Hence, the non-registration of such high-risk births results in their exclusion from both the numerator and the denominator of the IMR. Because infant deaths are few relative to live births, exclusion of those cases would lower the overall IMR relative to what it would be if these events were registered as live births.

In light of the potential effects of variation across countries in distinguishing fetal and infant deaths, it is helpful to use measures that capture the incidence of both fetal deaths and infant deaths. Two such measures are the perinatal mortality ratio and the fetoinfant mortality rate. The perinatal mortality ratio is defined as the number of late fetal deaths (28 weeks or more gestational age), plus infant deaths within the first week of life, divided by the number of live births, and multiplied by 1,000. The fetoinfant mortality rate is defined as the number of late fetal deaths (28 weeks or more gestational age) plus infant deaths within the first year of life, divided by the number of live births plus fetal deaths, and multiplied by 1,000. Both measures serve the purpose of reducing the variations in IMR that may be due to whether a poor pregnancy outcome is classified as fetal death or infant death.

In their analysis, Haub and Yanagishita (1991) also compared the countries in terms of "total infant mortality rate" (essentially the fetoinfant mortality rate), which was derived by combining infant deaths and stillbirths, and dividing that number by the sum of live births and stillbirths. In that comparison, shifts occurred in the international rankings. For example, Japan's ranking dropped to third, while Finland had the lowest total infant mortality rate. The U.S. ranking was raised from 18, in terms of IMR, to 15, using the total infant mortality rate. In a similar type of analysis comparing rankings of countries, the U.S. Congressional Budget Office (1992) examined international rankings in fetoinfant mortality rates, as compared with IMRs. It found that, using fetoinfant mortality rates, the U.S. ranking improved from 22 to 19. Although the measures that combine fetal deaths and infant deaths altered the international rankings, they did not markedly change the U.S. position relative to other industrialized countries.

Potential variations in unregistered events

Besides the differences across countries that may be associated with how recorded events are classified, additional differences may exist in whether pregnancy outcomes are recorded at all. Fetal deaths occurring before the officially recommended gestational age of 28 weeks may not be recorded as any type of pregnancy outcome. Results from a recent analysis showed that the lower the recommended gestational age was for fetal

death registration, the greater the ratio was of late fetal deaths to live births. For example, fetal death registration is supposed to begin at 12 weeks of gestational age in Japan, which had a fetal death ratio (late fetal deaths divided by live births) of 0.9, but at 28 weeks of age in Sweden, which had a fetal death ratio of 0.2 (Alberman et al., 1989).

Because of the varying official registration practices across countries, it is not possible to make comparisons between many countries in terms of total—before and after 28 weeks of gestation—fetal deaths and infant deaths. To illustrate the importance of registration practices, however, one should consider that in 1981, the fetal death ratio for gestational age 28 weeks or over was 7.2 per 1,000 live births in Japan and 6.8 per 1,000 live births in the United States. In contrast, the fetal death ratio for 20-27 weeks of gestational age was 15 per 1,000 live births in Japan and only 2.6 in the United States. It is plausible that part of the difference between the two countries in these early fetal deaths is because of under-registration in the United States. On the other hand, these results raise the interesting question of how international rankings of feto-infant mortality would look if early fetal deaths were included in the measure.

The preceding discussion illustrates how variations in notification rules and practices can affect the registration of both births and deaths. The amount of variation in IMR differences between countries that is due to registration practices is difficult to quantify, although some observers (Howell, 1991) have noted that differences in completeness of reporting of low weight births and classification of fetal deaths may substantially bias international comparisons. As indicated by the illustrations previously noted, the registration-related reason for IMR differences between any two countries is itself a variable.

Determinants of infant mortality rates

Beyond IMR differences across countries that may be caused by variations in measurement principles and practices, real differences undoubtedly exist. The lack of extensive and uniform multinational data, however, has constrained international comparisons. Most of the available international information has been developed from specialized studies of particular facets of the problem. Examples of such studies include an analysis of teenage reproductive health in six countries (Jones et al., 1986) and an analysis of the health care services and financing systems of European countries (Miller, 1988). Recently, an ongoing research program, The International Collaborative Effort on Perinatal and Neonatal Morbidity and Mortality (ICE), involving 11 countries, has been studying questions of fetal growth retardation, and perinatal and infant illness and death (Alberman et al., 1989).

Despite the relative paucity of studies involving international comparisons of infant death risks, the association among risk factors, interventions, and infant mortality have been studied extensively within countries. The literature includes numerous

demographic, socioeconomic, behavioral, and health service use factors associated with pregnancy outcomes. The results of the studies suggest that there are very complex relationships among individual factors; alternative frameworks could be employed to organize the findings.

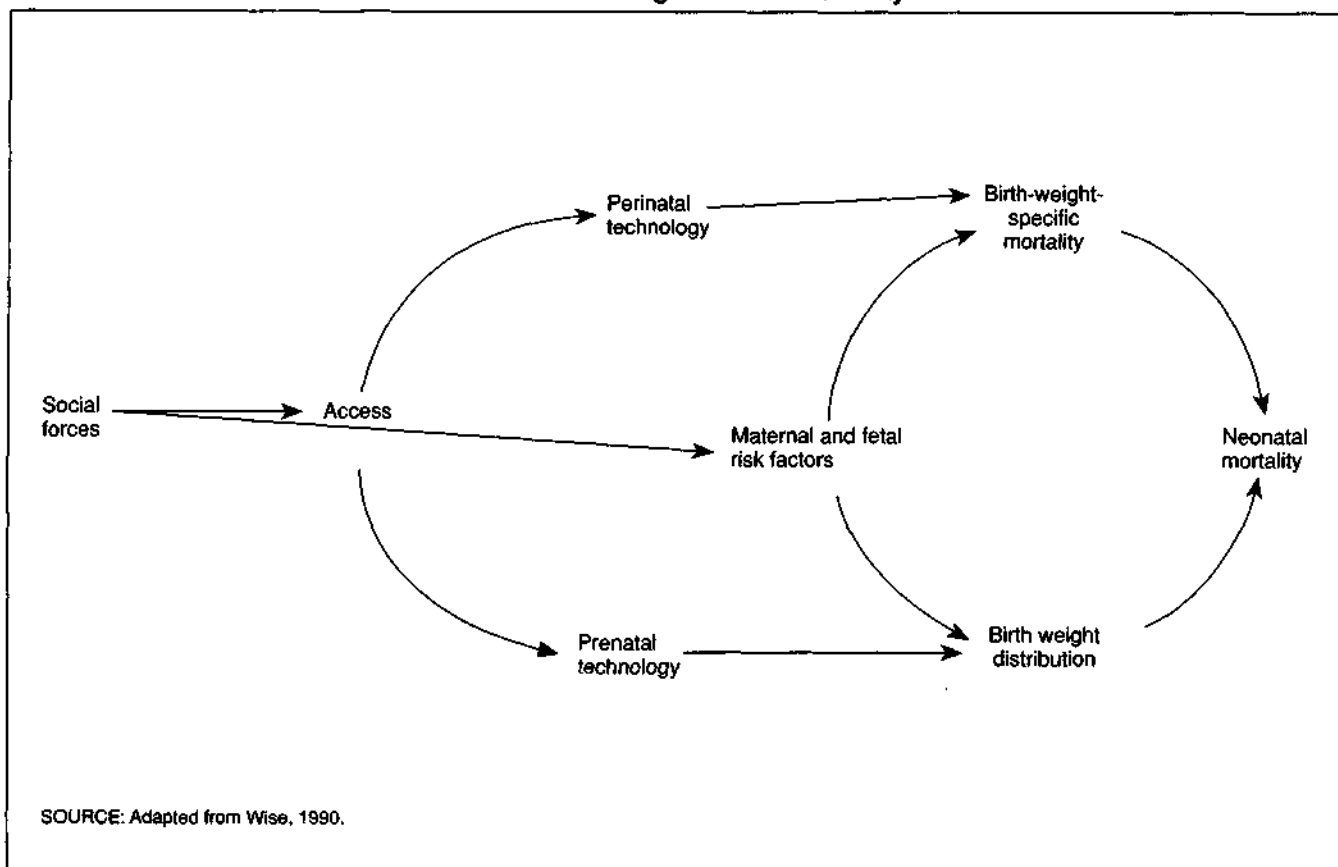
A particularly useful framework was suggested by Wise (1990), who examined the roles of poverty, technology, and infant mortality in the United States. Figure 1 presents an adaptation of the framework originally developed by Wise (1990). In brief, Wise viewed poverty as influencing the likelihood of infant death through two general mechanisms: elevation of risk, and reduction of access to (preventive and therapeutic) interventions that may be effective in minimizing the impact of the elevated risks. Elevated maternal and fetal risk can include increased prevalence of medical conditions (e.g., hypertension), demographic factors (e.g., young maternal age), or adverse maternal behavior (e.g., smoking and drug abuse). Reduced access implies socially-determined differences in the use of interventions capable of improving neonatal outcomes.

As an illustration of the effect of the two mechanisms, Wise (1990) noted the "social etiology of disparate neonatal mortality" in which social differences in risk can affect both birth weight distribution and birth-weight-specific mortality which, in turn, strongly affect neonatal mortality. Infants weighing less than 2,500 grams—a standard definition of low birth weight—for example, account for two-thirds of all neonatal deaths (Institute of Medicine, 1985). Social differences also affect access to perinatal and prenatal interventions. Whereas perinatal interventions (e.g., obstetrical care of high-risk deliveries and neonatal intensive care) affect birth-weight-specific mortality, prenatal interventions (e.g., family planning care, nutritional services, and prenatal health care services) affect birth weight distributions.

The framework described by Wise (1990) suggests a general pathway toward elevated neonatal mortality in which: (1) social conditions, such as poverty, affect levels of risk and access to appropriate interventions; (2) the dynamic interaction between risks and access results in variations in birth weight; and (3) birth weight and birth-weight-specific survival are major intermediate determinants of neonatal deaths.¹ Post-neonatal mortality, which accounts for about one-third of the infant mortality rate, would presumably also be affected by the same process, although birth weight would not necessarily be as strong an intermediate factor for this outcome as it is for neonatal mortality. The Wise model may not suit all of the hypotheses that have been posited about the relationships of the determinants of infant mortality. Nevertheless, it

¹Noted by McCormick (1988), low birth weight may result from one of two processes, either independently or in combination: shortened duration of gestation, or less growth than would be anticipated for a given duration of gestation. Although both birth weight and gestational age are related to mortality, birth weight tends to be more accurately measured and has, therefore, become the measure most frequently used in data from the United States.

Figure 1
Factors affecting neonatal mortality



presents a reasonable framework for highlighting findings from prior research.

Social forces

At the broadest level, the economic status of mothers and children and their access to social and support services are likely to influence infant mortality. These areas have been identified as likely causal factors in explaining mortality in the United States (Wise, 1990), although their impact occurs by influencing some of the other causal factors that can be more directly linked to infant deaths. Further, because major differences exist across countries in broad social factors, it is difficult to use them to explain international differences in mortality rates.

Income and poverty

Incomes in the industrialized countries of Europe vary considerably. At present, the United States ranks in the middle of countries in the Organization for Economic Cooperation and Development (OECD) on this statistic, a more favorable level than that for infant mortality. Simple correlations between income and the IMR would seem to indicate little direct relationship between these two statistics. For example, 1988 data on per capita gross national product (GNP) were available for 15 of the top 20 countries in terms of infant

mortality (U.S. Department of Commerce, 1991). Ten of these countries had per capita GNP figures lower than that of the United States, but only Greece had a higher infant mortality rate (and its rate is very close to that of the United States). Only four countries had higher levels of per capita GNP.²

Perhaps more significant, however, are differences in the proportion of children growing up in families whose incomes are below poverty—that is, below some basic subsistence income level. In the United States, such persons are less likely to have access to health care and may have problems with nutrition and other basic needs (which lead to elevated risk factors). For example, studies have found that low-income women are substantially less likely to receive prenatal care (Institute of Medicine, 1988). We also know that elevated infant mortality rates in the United States are associated with areas where rates of poverty are high (Davis and Schoen, 1978; U.S. House of Representatives, 1991).

Although different measures yield somewhat different numbers, the United States has child poverty rates strikingly higher than European countries. In

²Other analyses, which examined the association between infant mortality rates and health expenditures, in terms of per capita health spending and health spending to gross domestic product (GDP), found a stronger relationship, although the United States remained an outlier in these cases (Schieber, Poullier, and Greenwald, 1991).

contrast, Canada and Australia have rates that are close to the United States, but still lower (Smeeding, Torrey, and Rein, 1988; Smeeding, 1991). With respect to Europe, one measure used by Smeeding et al. (1988) found a 22.4 percent rate of children in poverty in the United States in contrast to rates of 4.8 and 4.9 percent for West Germany and Norway respectively. In that study, the four European countries with the lowest child poverty rates, according to two different measures, were Sweden, Switzerland, West Germany, and Norway. In terms of infant mortality rankings, these countries ranked third, fourth, eighth, and twelfth (Table 1). Norway, with the highest infant mortality of the four countries, was 7.8 as compared with 9.7 for the United States.

If infant mortality were related to income, in part because of the lack of access to health and social services, one would expect the problem to be more pronounced in the United States, where health care access is more dependent on ability to pay. Further, the greater availability of support services in other countries may compensate for some of the problems that poverty creates. Indeed, one recent paper comparing the United States with France concluded that the consequences of socioeconomic status are more severe in the United States (Howell, 1991).

Access to social services

Another way that the United States differs from other countries is in the availability of parental income and social supports for children beyond the provision of basic health care. Social programs that address this issue are largely confined to the very poor in the United States. Income support through Aid to Families with Dependent Children (AFDC) reaches less than one-half of all the poor children in the United States. In terms of Federal and State programs in which States determine eligibility levels, some areas of the country offer extremely low levels of benefits (U.S. House of Representatives, 1991). For example, in Alabama the maximum cash assistance benefit for a mother with two children is \$124 per month. Other programs, such as Food Stamps, do not provide enough additional assistance to ensure that most of these families reach even a poverty-level standard of living. The earned income tax credit in the United States provides additional help to low-income working families but it, too, is limited in scope and restricted to those with quite low levels of family income.

In contrast, almost all other industrialized countries provide benefits for children, either in cash or through refundable tax credits, regardless of family income (Kahn and Kammerman, 1988). These programs, which usually provide payments for each child in the family, are meant to help defray the additional costs to families for rearing children. In addition, many European countries provide cash benefits to replace income forgone because of the birth of a child, and protect the job of the mother while she is on maternity leave (Kahn and Kammerman, 1988; Miller, 1988). Cash benefits replace 80 to 100 percent of wages, and generally run

for at least 3 months and sometimes for as long as 1 year. Paid leave of 5 to 6 months is not uncommon. Consequently, one of the major differences between the United States and European countries is the availability of support even for those who are not poor.

These differences do not necessarily translate into enriched care for young children, but they reflect policy choices by European countries to provide additional support to families with children. They also mean that young, working families are much better protected than their counterparts in the United States against lowered incomes as a result of their decision to rear children. European families are more likely to be in a better position to meet the nutritional, housing, and other needs of children—all of which may have important impacts on health. Although not empirically demonstrated, it is plausible that these social and economic factors affect the overall health status of mothers and young infants, and may also be related to other risk factors that can be more closely linked to birth weight and infant mortality: demographic and behavioral characteristics of pregnant women.

Elevated maternal and fetal risks

As suggested by Wise (1990), elevated maternal and fetal risks can generally be categorized as demographic factors, medical conditions, and behavioral characteristics of mothers. Extensive research has been conducted on many characteristics in each of the groups. Moreover, major reviews have been conducted about the relationship of these factors to infant mortality, as well as to low birth weight and gestational age. The IOM report (1985) for example, represents a landmark effort to synthesize information on risk factors and low birth weight. In the following section, we discuss some of the findings on elevated maternal and fetal risk factors. Lacking from this discussion, however, are extensive international comparisons that could help indicate how much of the cross-country differences in infant mortality are explained by such factors.

Demographic characteristics

Demographic characteristics and elevated risks of infant mortality have been widely studied. In the United States, for example, black IMRs are approximately twice as high as those of white IMRs. When the overall rates are disaggregated into birth-weight-specific survival and birth weight distribution, it seems that the source of the difference in overall rates is principally in birth weight distributions. Sappenfield et al. (1987), for example, examined both the neonatal and post-neonatal infant mortality rates of black and white infants and found that, for birth weight and gestational age combinations of 3,500 grams or less and 38 weeks or less, the neonatal mortality rate was lower for black infants than for white infants. At levels above these measures, however, black infants had higher neonatal mortality rates as well as higher post-neonatal mortality rates.

Wegman (1991) and others suggest that the differences in infant mortality between black and white infants in the United States are in part because of differences in access to prenatal care. This premise is consistent with findings from a recent study by Rawlings and Weir (1991) of infant mortality rates among dependents of soldiers at the Madigan Army Medical Center in Washington State. The study found that mortality rates among black infants were similar to those of white infants and dramatically lower than those of black infants in the general population. The authors concluded that the lower rates of mortality among black infants may be because of guaranteed access to health care and higher levels of family education and income as compared with the Nation as a whole. Although access to prenatal care may contribute to reducing black and white IMR differences, further research is needed to identify its particular role relative to the roles of other types of care (e.g., neonatal intensive care) and socioeconomic and behavioral factors.

Another demographic characteristic that has been found to differentiate infant mortality risks is marital status. Infant mortality rates of babies born to unmarried mothers are about two times higher than the rates of babies born to married mothers. Research suggests that even when other characteristics (such as education) are taken into account, marital status continues to predict infant mortality risks. For example, the IMR for mothers over 20 years of age has been found to be higher for unmarried, college-educated women than for married, high school dropouts (Eberstadt, 1991). The specific relationship between marital status and IMR, however, is complex and has not been delineated explicitly.

Higher than average IMRs have been recorded in the United States for women under 20 years of age (teenagers) and for older mothers. For example, babies born to teenagers had from 1.5 to 3.5 times the risk of mortality, compared with those born to mothers 25-29 years of age (Friede et al., 1987). Further analysis indicates, however, that much of the difference in IMR attributable to maternal age can be accounted for by birth weight distributions. Except in the case of very young teenage mothers (i.e., those under 15 years of age), controlling for birth weight eliminates the higher relative risk of neonatal deaths of infants of teenagers. Birth weight, however, does not account for much of the higher relative risk for post-neonatal deaths of teenage mothers.

Among the groups of maternal risk factors that are associated with infant mortality, demographic characteristics are the most accessible for international comparisons. For example, in a later section of this article, we examine the relationship between maternal age and infant mortality rates across various countries. Even when such demographic comparisons are made, however, it is important to keep in mind that variations by such characteristic reflects complex differences in sociocultural composition and social and health service systems. For example, the association between marital status of mothers and infant mortality risks in the

United States may not be as strong in Sweden, where cohabitation by unmarried couples is more common. In addition, some demographic characteristics, such as race, are important for comparisons within the United States but less so in international comparisons because many other countries are more racially homogeneous.

Medical conditions

The IOM report (1985) discussed many medical conditions that have been found to be related to low birth weight. Medical conditions include those that predate pregnancy and others that are present during pregnancy. The former are characterized, for example, by low maternal weight for height, presence of selected diseases such as diabetes or chronic hypertension, and a poor obstetric history (e.g., history of multiple spontaneous abortions). Medical risks in the current pregnancy include poor weight gain during the pregnancy, and development of hypertension and pre-eclampsia. In a meta-analysis of the results from 900 published studies on risk factors associated with prematurity and intrauterine growth retardation and low birth weight, Kramer (1988) established low prepregnancy weight of the mother as a determinant of low birth weight because of its effect on both prematurity and intrauterine growth retardation. He also found that poor gestational nutrition increased the risk of low birth weight because of its effect on intrauterine growth retardation. Although medical conditions have been identified as risk factors for infant mortality, it is not clear, at the present time, how differences in the prevalence of such medical conditions are associated with differences in IMR across countries.

Behavioral characteristics

The use of drugs, alcohol, and tobacco are factors that are associated with higher risks of infant death. The effect of smoking has been the most widely studied. Kleinman and Madans (1985) estimated, for example, that smoking contributes to 19 percent of the low-birth-weight rate in the United States. Smoking is also a factor that Kramer identified as a well-established independent determinant of birth weight. The impact of maternal cocaine addiction on infant health has been of concern because it is so prevalent in many areas of the United States. Its effects on infant mortality, however, remain unclear (Wise, 1990).

Data limitations largely preclude international comparisons of behavioral risk factors. The limited information that is available fails to indicate that these important risk factors necessarily explain international differences. For example, a six-country study of prevalence of smoking indicates that the United States was second only to Sweden in terms of low rates of smoking prevalence among young women (Pierce, 1989). Rates were higher in Great Britain, Canada, Norway, and Australia. This study was not tied to infant mortality issues, however. Further research is required to determine the role of smoking in international IMR comparisons.

Access to health services

The amount and quality of health services can influence outcomes. The influence may stem from overcoming negative risk factors, such as poor nutrition in young women living in poor areas, or from directly improving the survival chances of very low-birth-weight babies. The risk of having low-birth-weight babies may be increased because of poverty and other social problems, but health care interventions can make up for some of the deficiencies (Institute of Medicine, 1988). Access to health care for pregnant women and infants refers to many dimensions including their timing (onset and frequency of prenatal care, for example) and the availability of advanced perinatal technology (such as neonatal intensive care) for treating high-risk infants.

Compared with other countries, the United States does well in terms of general access to perinatal care, but poorly in terms of prenatal care and other rather routine health-care services. Many European countries (e.g., Norway, Netherlands, United Kingdom) have long-standing traditions of offering not only prenatal services but also followup home visits after the delivery (Miller, 1988). The philosophy is that the mother and baby are likely to need support, not to check up on problems but to provide good care. Some European countries even offer financial incentives for participating in prenatal programs. Because these countries offer nearly universal coverage for their citizens, even low-income families have access to available services. A study of 10 European countries (Miller, 1988) concluded that the incentives for participating in prenatal care were strong and the barriers were virtually non-existent in all of the study countries.

In the United States, women without insurance coverage are less likely to receive prenatal care or to start such care as early as is recommended. Even when the mother is eligible for Medicaid, which covers prenatal care, problems with finding physicians willing to participate in the program have resulted in spotty access to these services (Physician Payment Review Commission, 1991). The same factors that result in high risk of problem pregnancies are correlated with low rates of prenatal care. In addition, poor mothers who face problems of housing and transportation are also less likely to be able to get the services, even when they are offered (Institute of Medicine, 1988).

The availability of high-technology perinatal care in the United States has compensated, to some extent, for the large number of low-birth-weight babies. The availability and accessibility of this technology, however, varies across the United States. For example, mothers who are not privately insured or are not covered by Medicaid may have problems getting this level of care. Consequently, although the United States may invest more in perinatal technology than do other industrialized countries (Levin, 1990), full advantage of such technology will not be realized unless such care is universally accessible in the United States.

Low birth weight

As indicated by the preceding discussion, many of the risk factors related to infant mortality occur as a result of low birth weight. For this reason, causes of low birth weight have been the focus of extensive research (Institute of Medicine, 1985). The emphasis on low birth weight, and particularly very low birth weight, of infants is warranted in light of its pronounced effect on the risk of infant deaths. In the United States, for example, infants weighing less than 750 grams, although they constitute only 0.3 percent of all births, account for 25 percent of deaths in the first year of life (Overpeck, Hoffman, and Prager, 1992).

In international studies, both birth weight distributions and birth-weight-specific survival in selected countries have been examined. An analysis by Hoffman, Bergsjö, and Denman (1990) of birth-weight-specific perinatal deaths in Japan, Norway, and the United States illustrates the study of survival risks. That analysis showed that for most birth weight categories, the birth-weight-specific risks of both U.S. white infants and black infants are comparable to those of infants in Japan and Norway. Notably, in the birth weight categories under 2,500 grams, the U.S. rates were actually lower than those of the two other countries. In light of the fact that both Japan and Norway have much lower infant mortality rates than the United States, the finding of comparable birth-weight-specific mortality rates suggests that the relatively low ranking of the United States is largely because of a higher proportion of births that are of low birth weight.

International comparisons of the causes of the differences will continue to rely on specialized multinational studies because uniform data on measures such as birth-weight-specific death rates are not generally available. Only a few comparisons can be made with the available data. The next two sections present results from an analysis which relied on extant data from the United Nations and the United States. These data were used to estimate the effect of birth distributions by birth weight and maternal age on differences in IMR between the United States and other countries.

Birth weight distribution and infant mortality

United Nations data on birth weight distributions for numerous countries enable us to derive an estimate of the differences in IMRs between the United States and other countries that may be attributable to differences in birth weight distributions. U.S. birth-weight-specific infant death rates for 1985 were made available to us by the National Center for Health Statistics (1985) and 1985 birth distributions by birth weight were extracted from the United Nations Demographic Year Book (1984-87).

We used two strategies to conduct the simulations. First, birth-weight-specific infant death rates for the United States were standardized on the birth weight

distributions of a number of industrialized countries that had lower IMRs than the United States. The resulting adjusted U.S. infant mortality rates, therefore, reflect the expected U.S. rates if the United States had the birth-weight-specific distributions of the other countries. This approach has been applied in prior research (Guyer, Wallach, and Rosen, 1982; Madans, Kleinman, and Machlin, 1981).³ Second, we applied the percent of very low-birth-weight babies (i.e., less than 1,500 grams) of the comparison countries to the U.S. birth weight distribution and derived an adjusted U.S. rate. This strategy is similar in principle to the first, but simply dichotomizes the birth weight distribution (i.e., less than 1,500 grams and greater than or equal to 1,500 grams) to focus on the effect of percentage differences in very low birth weight babies on differences in IMRs.

The simulations assume that birth weight distributions and birth-weight-specific deaths are independent, and that the U.S. birth-weight-specific mortality curve is a good representative for the comparison countries. Wilcox and Russell (1983) pointed out that, because of correlations between birth weight distributions and birth-weight-specific mortality rates, standardization procedures could lead to biased results. In light of these methodological issues, the results of our simulations should not be viewed as a vehicle for reordering international rankings. Rather, they serve to illustrate the potentially important impact of birth weight distribution on the U.S. IMR when compared with those of other countries. They also show how the U.S. IMR would be affected if the U.S. birth weight distribution shifted to those currently existing in other countries. In other words, the simulations address the question, "What if the United States had the birth weight distribution of Canada or Japan?"

Table 3 presents percent of births of less than 1,500 grams (very low birth weight) and the percent of births less than 2,500 grams (low birth weight) in 1985. Six countries were selected as illustrative comparisons with the United States. All of the comparison countries had an IMR in 1985 that was lower than that of the United States, and had birth weight distributions published in the United Nations Demographic Year Book (1984-87).

The indicators of the total birth weight distributions of the countries in Table 3 highlight the higher incidence of low-birth-weight infants in the United States. For example, 6.7 percent of the live births in the United States were of low birth weight and 1.2 percent were of very low birth weight. These percentages were higher than those of the other countries in the comparison, with the exception of the United Kingdom. The third column of Table 3 gives the percentage of live births that were reported with birth weight "unstated." The percentage was low for all countries except Sweden.

Table 4 presents the results of the simulations. Column 1 in Table 4 lists the actual IMR of the

Table 3
Percent of births less than 1,500 grams,¹ less than 2,500 grams,² and unknown

Country	Percent		
	Less than 1,500 grams	Less than 2,500 grams	Unknown
United States	1.2	6.7	0.1
Canada	0.9	5.8	0.3
Japan	0.4	5.4	0.0
Norway	0.6	4.1	0.2
Sweden	0.7	4.4	1.3
United Kingdom	1.3	10.7	0.2
West Germany	0.2	5.7	0.2

¹Very low birth weight.

²Low birth weight.

NOTE: The data were collected separately by East and West Germany.

SOURCE: (United Nations, 1984-87).

Table 4
Estimated effects of birth weight distributions on infant mortality rate (IMR) comparisons: United States and selected countries, 1985

Country	Actual IMR ¹ (1)	Adjusted U.S. IMR ² (2)	Adjusted U.S. IMR ³ (3)
United States	10.4	—	—
United Kingdom	9.4	10.9	10.4
West Germany	8.9	8.1	6.3
Norway	8.5	7.5	7.8
Canada	7.9	8.9	8.9
Sweden	6.8	10.0	8.1
Japan	5.5	6.6	7.0

¹Recorded IMR, 1985. The actual calendar year rate for the United States was 10.6; we used 10.4 to be consistent with the schedule of birth-weight-specific rates derived from the linked birth-death records.

²Expected U.S. IMR based on birth weight distribution of country X.

³Expected U.S. IMR based on the percentage of births less than 1,500 grams of country X.

NOTE: The data were collected separately by East and West Germany.

SOURCES: (National Center for Health Statistics, 1985) and (United Nations, 1984-87).

7 countries in 1985. In contrast to the U.S. IMR of 10.4, the United Kingdom had an IMR of 9.4, Japan had the lowest rate of 5.5 per 1,000 live births. Column 2 presents the expected U.S. IMR if the United States had the birth weight distribution of each of the other 6 countries. Column 3 presents the results based on the percentage of births by very low birth weight.

Column 2 shows that, except in the case of the United Kingdom, using foreign birth weight distributions resulted in a lower U.S. IMR. The results indicate that, given the birth-weight-specific death rates in the United States, adjusting the U.S. birth weight distribution to reflect the more favorable ones of the comparison countries could have strong effects on the U.S. rate. For example, standardized for the birth weight distribution of Canada, the expected U.S. IMR would be 8.9 per 1,000 live births; and with Japan's birth weight distribution, the expected U.S. rate would be 6.6 per 1,000. These results indicate that approximately 60 percent of the difference between the United States and Canadian IMRs, and 75 percent of the difference in IMRs between the United States and

³The standardization procedure for this simulation strategy is described in greater detail in the Technical note.

Japan, could be because of differences in birth weight distributions.⁴ In light of the methodological issues previously noted, the precision of these results must be viewed cautiously. Nevertheless, the results do suggest that birth weight distributions account for a sizable proportion of the difference in IMRs between the United States and other countries.

The adjusted U.S. IMR of 10.0 per thousand, based on Sweden's birth-weight-specific distribution, resulted in a minor reduction from the actual U.S. rate. This result seemed unlikely in light of the low actual IMR of Sweden and its birth distribution by birth weight. The discrepancy appears to be because of the relatively high proportion of Swedish births with birth weights that were reported as "not stated" in the United Nations Demographic Year Book (1984-87), because the U.S. birth-weight-specific infant death rate for this category is relatively high (i.e., 23 per 1,000, compared with, for example, a total of 10.4 per 1,000).

Column 3 of Table 4 shows that the adjusted U.S. IMR, based on the percentage of births that are of very low birth weight in the comparison countries, is very similar, in many cases, to that derived by standardizing on the full range of birth weight values. Hence, it appears that much of the birth-weight-associated differences in IMRs between the United States and other countries is because of the higher proportion of very low-birth-weight babies born in the United States.

These simulations serve to estimate the extent of the differences in IMRs between the United States and other countries that may be because of birth weight distributions. The results should serve principally to provide guidance in identifying areas for more detailed comparative analyses. For example, it would be helpful to understand the reasons behind the more favorable birth weight distributions of some countries such as Norway or Japan relative to the United States. Because birth weight distribution differences do not explain all of the differences in IMRs, it is also important to understand the reasons behind better birth-weight-specific death rates of some countries.

Maternal age and infant mortality

Another factor associated with infant mortality is maternal age. The relationship between infant death risks and maternal age is less direct than that between such risks and low birth weight. For perinatal mortality, at least, the higher risks of babies born to teenage mothers is attributable to the tendency for teenage mothers to have lower-than-average birth weight babies. However, a separate analysis of maternal age-specific distributions can provide additional information for the consideration of approaches to reduce the difference in infant mortality rates between the United States and other industrialized countries.

⁴This proportion is calculated as the difference between the actual and expected (based on country X's birth weight distribution) U.S. IMR rates, divided by the difference between the actual U.S. IMR and the actual IMR of country X.

Fortunately, international data on maternal age are available.

Table 5 shows the effects of differences in maternal age distributions between the United States and other countries on IMRs. The information in this table is analogous to that in Table 4 for birth weight and was derived in a similar fashion. Standardizing U.S. maternal age-specific mortality rates on the maternal age distributions of the other countries resulted in lower adjusted rates for the United States in all cases. Hence, all of the comparison countries appear to have a maternal age distribution that favors infant survival. Although such data are not directly presented in Table 5, the maternal age distributions account for approximately one-fourth of the difference between the IMR of the United States and many of the comparison countries.

The lower adjusted U.S. IMRs, relative to the actual U.S. IMR, in Table 5 are in part because of the higher proportion of infants born to teenage mothers in the United States. This is illustrated in Table 6 which presents the percent of births to mothers younger than 20 years of age and older than 40 years of age. For example, 13 percent of the U.S. births were to teenage mothers, in contrast to 6.1 percent to teenage mothers in Canada. On the other hand, the United States has a lower proportion of births born to older, and higher risk, mothers than many of the other countries in the comparison.

As a result of the prior research on the elevated risks of infant deaths among babies born to teenage mothers, many analysts have argued for new strategies to lower the mortality risk of babies born to teenagers. For neonatal mortality, initiatives would include reducing the risk of low birth weight, providing adequate family planning services to reduce unwanted pregnancies, and renewing efforts to provide teenagers with early and complete prenatal care. Reducing the risk of postneonatal mortality may depend on assisting

Table 5
Estimated effects of birth distribution, by maternal age on infant mortality rate (IMR) comparisons: United States and selected countries, 1985

Country	Actual IMR ¹	Adjusted U.S. IMR ²
United States	10.4	—
United Kingdom	9.4	10.2
West Germany	8.9	9.7
Norway	8.5	9.8
France	8.3	9.8
Netherlands	8.0	9.5
Canada	7.9	9.9
Sweden	6.8	9.7
Japan	5.5	9.4

¹Recorded IMR, 1985. The actual calendar year rate for the United States was 10.6; we used 10.4 to be consistent with the schedule of maternal age-specific rates derived from the linked birth-death files.

²Expected U.S. IMR based on maternal age-specific birth distribution of country X.

NOTE: The data were collected separately by East and West Germany.

SOURCES: (National Center for Health Statistics, 1985) and (United Nations, 1984-87).

Table 6
Percent of births to mothers younger than 20
years of age and older than 40 years of age:
1985

Country	Younger than 20 years of age	Older than 40 years of age
	Percent	
United States	12.7	0.8
United Kingdom	8.7	1.1
West Germany	3.5	1.3
Norway	4.2	1.3
France	3.2	1.2
Netherlands	2.3	1.0
Canada	6.1	0.7
Sweden	3.2	1.7
Japan	1.3	0.6

SOURCE: (United Nations, 1984-87).

teenagers to enhance their parenting skills (Friede et al., 1987).

Other analysts have argued that policies designed to reduce adverse neonatal outcomes should disregard maternal age and address "proximate determinants" of neonatal mortality including poor nutrition, sexually transmitted diseases, inadequate access to medical services, lack of day care, low wages, and inadequate housing, education, and welfare services. In other words, those analysts argue that changes in social policy should take into account the social reality of those who bear children early (Geronimus, 1987).

The results of the simulation provide an estimate of the amount of the difference in IMRs between the United States and other industrialized countries that is associated with maternal age. The challenging question, for both teenage and non-teenage mothers, is how much of the difference can be affected by health related programs, both preventive and therapeutic, and how much remains a function of other determinants reflecting broader social relations and quality of life.

Discussion

The very low IMR ranking of the United States as compared with other industrialized countries is a statistic often used to cite problems with the quality of health care in the United States. The premise of this article is that infant mortality rates reflect many factors in addition to the quality of the U.S. health care system. Our analysis suggests that many factors, ranging from how vital events are registered to broad social and economic policies, contribute directly or indirectly to observed differences in infant mortality.

Although the influences of registration practices on infant mortality rankings are unlikely to be fully understood, anecdotal information suggests that this source of variability between countries may account for a significant amount of the differences in IMRs. Use of measures such as fetio-infant mortality rates helps to provide more uniform comparisons by reducing subjectivity in the determination of late (over 28 weeks of gestation) fetal deaths versus infant deaths. Fetio-infant mortality rates, however, do not account for

variations in early fetal deaths, which could be a greater source of measurement-related differences internationally.

It is plausible that the character of the health care system strongly influences the registration of infant deaths that might otherwise not be included in the designation of "live born." The United States, for example, has had a very aggressive posture toward neonatal intensive care (Levin, 1990). Under this practice, very low-birth-weight infants who are at high risk of dying within the first day tend to be counted as live births. In countries where the health care system does not place the same emphasis on neonatal intensive care, the outcomes of such pregnancies are not likely to be recorded as live births. Hence, it appears that the more resources a country's health care system places on saving high-risk newborns, the more likely its registration will report a higher IMR.

Besides measurement issues, differences in the international rankings of infant mortality can be better understood by comparing variations in the complex set of factors that elevate or mitigate infant mortality risks. The ICE study showed that birth-weight-specific perinatal death rates in the United States are comparable to those of Japan and Norway, two countries with considerably lower overall IMRs than the United States. This result suggests that perinatal care in the United States can be successful in enhancing survival of high-risk infants. As noted by Wise (1990) and others, a major effort of the U.S. health care system directed toward reproductive health care in the past 20 years has focused on technological means to improve perinatal mortality risks. Progress in this area appears to be continuing. For example, as reported by Wegman (1991), much of the decline in IMRs in the United States between 1989 and 1990 can be attributed to surfactant therapy, which contributed heavily to the decline of infant deaths because of respiratory distress syndrome; the mortality rate for this cause declined by about one-third.

Although perinatal interventions, and particularly the regionalization of high-risk delivery and neonatal intensive care, have been a primary force behind the declining U.S. neonatal mortality rate, (Wise, 1990) the fact that variations still exist within this country in perinatal mortality rates indicates that further efforts are needed to broaden access to such levels of care. Moreover, some observers have noted that the changing financial structure of medical care in the United States has created differentials in access by whether health insurance coverage is available (Wise, 1990). Under this scenario, particularly vulnerable persons would be those neither covered by private health insurance nor eligible for coverage by Medicaid.

Besides improving access to perinatal interventions, it appears that substantial future improvements in infant mortality rates in the United States may depend on the achievements of prenatal interventions which more directly affect the distributions of births by birth weight. As our simulations demonstrated, improvements in our birth weight distribution approach those of many other industrialized countries and can

greatly improve the U.S. IMR, and by implication, our international ranking. A focus of this type of service might be on nutrition, which could lead to improved birth weight distributions.

Future developments in prenatal care interventions could be viewed in two stages. The first should be to ensure uniform access to services, a supply-oriented effort. The U.S. health care system, in comparison with those of other industrialized countries, differs substantially in terms of systematic versus selected access to health and social services. This difference in the type of health care system undoubtedly contributes, to some extent, to the differences in birth weight outcomes that are observed. One indicator of the importance of this factor is the finding of the Madigan study, which suggests that a universal health care system (for military personnel) helps to produce uniform IMRs for all members of the system.

Given the supply effort, the effectiveness of prenatal interventions will depend on ways to change the socioeconomic forces that contribute to elevated maternal risks and, most likely, to a reduced use of prenatal care. The same socioeconomic forces that affect demand for prenatal care also influence prepregnancy decisions and behavior. As our simulations on maternal age suggest, a change in the pattern of childbearing by maternal age could cause a reduction in the U.S. IMR. The extent to which changes in timing of pregnancies, and demand for prenatal care, affect the overall U.S. IMR would depend on changes in such socioeconomic forces. Some observers have suggested that broader social and economic changes, such as reducing poverty and improving economic opportunities, are required to reduce residual excess IMRs in the United States. Changes in these factors are more difficult to accomplish than augmenting the availability of health services, but improvements in this area would have an important impact on the U.S. IMR

as well as on other measures of quality of life and economic success implicit in the IMR.

In conclusion, although international rankings of IMRs are frequently made to spur policy debate, such comparisons are most helpful if we can develop a better idea of what is behind them. This article surveyed a host of factors behind the U.S. ranking in international comparisons. Although we were unable to assign weights to the manifold reasons for our relatively low ranking, our goal was to highlight the fact that policy response to the rankings could be enhanced by a clearer understanding of what the rankings mean and do not mean. However, we do conclude that the IMRs should be viewed as reflective of health and socioeconomic status and not just health care, and that to achieve improvements in the IMR will require more than just new technology.

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Technical note

Table 7 illustrates the standardization procedure in which birth-weight-specific infant death rates of the United States are applied to the birth-weight-specific live birth distribution in Canada. The U.S. birth-weight-specific infant death rates in column 2 are multiplied against the corresponding number of U.S. births in column 3 and Canadian births in column 4, respectively. The products of this function are presented in column 5 for the United States, and in column 6 for Canada. The sum of the rows in column 5 is the actual number of U.S. infant deaths which, when

Table 7
Standardization to derive expected U.S. infant mortality rate (IMR) based on Canadian birth weight distribution: 1985

Birth weight in grams (1)	U.S. birth-weight-specific infant death rate (2)	U.S. live births (3)	Canadian live births (4)	Expected infant deaths	
				U.S. (5)	Canada (6)
Total	—	3,760,833	367,227	39,042	3,250
Less than 501	0.8932	4,860 (0.1)	215 (0.1)	4,341	192
501-1,000	0.5522	17,743 (0.5)	1,161 (0.3)	9,798	641
1,001-1,500	0.1419	23,118 (0.6)	1,732 (0.5)	3,279	246
1,501-2,000	0.0526	48,404 (1.3)	3,923 (1.1)	2,546	206
2,001-2,500	0.0203	159,588 (4.2)	14,014 (3.8)	3,240	284
More than 2,500	0.0042	3,502,342 (93.1)	345,204 (94.0)	14,710	1,450
Not stated	0.2360	4,780 (0.1)	978 (0.3)	1,128	231

NOTES: Numbers in parentheses in columns 3 and 4 are percents. Actual U.S. IMR (total column 5 ÷ total column 3) = 0.0104. Expected U.S. IMR based on Canadian birth distribution (total column 6 ÷ total column 4) = 0.0089.

SOURCES: (National Center for Health Statistics, 1985) and (United Nations, 1984-87).

divided by the number of U.S. births, yields the actual U.S. IMR. The sum of rows in column 6 is the expected number of U.S. infant deaths if the United States had the Canadian birth weight distribution. This sum is divided by the total number of Canadian births to derive an expected U.S. IMR, when U.S. infant death rates are standardized on the Canadian birth distribution.

The resulting IMR 0.089 (8.9 per 1,000 live births) is the expected U.S. IMR if the United States had the same birth weight distribution as Canada. A comparison of the expected rate with the actual U.S. IMR of 0.0104 (10.4 per 1,000 live births) shows that Canadian births are distributed, in general, in lower risk categories. For example, 7 percent of the U.S. births were less than 2,500 grams compared with 6 percent in Canada.

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