Mortality and Income Inequality Among Economically Developed Countries

*by Harriet Orcutt Duleep**

The absence of a correlation between age-adjusted death rates and the average income levels of economically developed countries has led researchers to conclude that income does not affect the mortality levels of economically developed countries. The mortality experiences of the former Soviet Union and some of the eastern European countries have further brought into question the importance of income's distribution in determining mortality among economically developed countries; prior to its breakup, the income distribution of the Soviet Union was as equal as that of Sweden, yet the life expectancy of the Soviets has been dramatically shorter than that of the Swedes. Using insights from a longitudinal microanalysis of U.S. mortality, this study presents evidence that, even for economically developed countries, the income distribution of a nation is an important determinant of its mortality. The results of this study also suggest that the relatively unequal income distribution of the United States is an important contributing factor to its low life expectancy relative to other high-income countries.

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Today's samurai are a shade sturdier than the new Vikings. Mr. Average Japan is the world's new long-life champion, with a span of over 73.5 years, while his Swedish, Norwegian and Dutch rivals bow out not quite a year before. The toughest person of the lot, however, is Mrs. Average Holland, who keels over a few months before her eightieth birthday. Captain America is not outstandingly hale-and-hearty, just failing to reach 70. Croakiest of all is Comrade Ivan Ivanov: he goes under before he is 62. (The Economist, October 1, 1983).[1]

The U.S. life expectancy lags behind many developed countries and some not-so-developed countries. It is particularly low for men. Although not as bad as Comrade Ivan Ivanov, the middle-aged Captain America falls behind his contemporaries in Iceland, Sweden, Japan, Switzerland, Israel, Australia, the Netherlands, Cyprus, Ireland, Norway, Greece, Italy, Hong Kong, Canada, the United Kingdom, New Zealand, Spain, Austria, France, Denmark, and Germany.[2]

As life expectancy has generally increased across the world in recent years, the low relative ranking of U.S. life expectancy among economically developed countries has persisted. During the 1975-77 period, middle-aged American men ranked 26th in the international comparison of death rates; in 1990-91, they ranked 23rd (table 1).

One hypothesis for the unfavorable U.S. mortality experience relative to other economically developed countries is the unequal income distribution of the United States relative to many other industrialized nations. Income may affect mortality through several multifaceted routes. One potential route is income's effect on the consumption of goods and services, such as nutrition, housing, and medical care. A low and uncertain level of income may affect mortality through its effect on stress (Brenner 1984). The social and economic environment associated with poverty may also affect mortality through its

effect on individuals' perceived returns to investments in health.[3] If income causally affects mortality, and if the magnitude of its effect varies with the level of income, then a nation's mortality will be affected by its income distribution.

The hypothesis that a country's income distribution may affect its mortality has not gained wide acceptance. Part I of this article presents concerns stemming from the lack of a relationship between average income and mortality across countries and across States within the United States that have led scholars to dismiss the potential role of income (its level and distribution) in creating intercountry variations in mortality among economically developed nations. Part II reconsiders these concerns and presents a theoretical reconciliation between findings based on individual data and the analysis of mortality rates across countries that underscores the potential importance of a nation's income distribution. Part III discusses the mortality experience of the former Soviet bloc countries that appears to be inconsistent with the relevance, for economically developed countries, of a nation's income distribution to its mortality. Building on insights developed in parts II and III, the following sections—parts

Table 1.—Cross-country comparison of life expectancy and male mortality, 1975-77 and 1990-91

	Death rates of men aged 50-54 in—				Life expectancy at birth for men and women, 1985-87	
	1975-77		1990-91			
Rank	Country	Rate	Country	Rate	Country	Age
1	Japan	6.2	Iceland	4.3	Japan	79.1
2	Greece	6.2	Sweden	4.8	Switzerland	77.6
3	Iceland	6.7	Japan	4.9	Iceland	77.4
4	Netherlands	7.0	Switzerland	5.2	Sweden	77.1
5	Sweden	7.1	Israel	5.3	Spain	76.6
6	Norway	7.2	Australia	5.3	Canada	76.5
7	Switzerland	7.2	Netherlands	5.5	Greece	76.5
8	Israel	7.4	Cyprus	5.5	Netherlands	76.5
9	Spain	7.5	Ireland	5.5	Australia	76.3
10	Cyprus	8.0	Norway	5.6	Norway	76.3
11	Denmark	8.3	Italy	5.7	France	75.9
12	West Germany	8.6	Greece	5.8	West Germany	75.8
13	East Germany	8.7	Hong Kong	5.8	Italy	75.5
14	Hong Kong	8.7	Canada	5.9	United Kingdom	75.3
15	United Kingdom	8.8	United Kingdom	6.1	Israel	75.2
16	Australia	8.9	New Zealand	6.1	Austria	75.1
17	Canada	8.9	Spain	6.3	United States	75.0
18	Italy	8.9	Austria	6.9	Denmark	74.9
19	New Zealand	9.0	France	7.0	Finland	74.8
20	Barbados	9.1	Denmark	7.0	Malta	74.8
21	Bulgaria	9.3	West Germany	7.1	New Zealand	74.2
22	Yugoslavia	9.4	Singapore	7.4	Luxembourg	74.1
23	Austria	9.6	United States	7.4	Portugal	74.1
24	Ireland	9.7	Luxembourg	7.7	Ireland	73.5
25	France	9.8	Venezuela	8.4	East Germany	73.2
26	United States	10.0	Finland	8.5	Bulgaria	71.5
27	Luxembourg	10.1	Barbados	9.3	Czechoslovakia	71.0
28	Venezuela	10.3	East Germany	9.3	Poland	71.0
29	Bahamas	10.7	Yugoslavia	9.8	Yugoslavia	71.0
30	Singapore	11.2	Bulgaria	11.4	Soviet Union	69.8
31	Hungary	11.6	Bahamas	13.1	Hungary	69.7
32	Poland	11.7	Czechoslovakia	13.6	. . .	. . .
33	Czechoslovakia	11.8	Soviet Union	14.7	. . .	. . .
34	Finland	12.3	Poland	15.1	. . .	. . .
35	U.S.S.R	12.4	Hungary	17.4	. . .	. . .

Notes: The 1975-77 statistics are primarily from United Nations (1982) with a few statistics from United Nations (1984). Most of the death rates refer to 1977. The reported rates for Canada, Denmark, and Poland are an average of the rates for 1976 and 1978 because 1977 rates for these countries were not available. For a few countries, the only available data refer to years not included in the 1975-77 time period. The countries, and the closest year for which information was available, are Iceland (1980), Spain (1978), Barbados (1978), Ireland (1976), and the Bahamas (1975). The 1990-91 statistics are from United Nations (1994, 1995). The countries for which death rate information was not included in the 1990-91 time period, and the closest year for which information was available, are Greece (1992), West Germany (1989), Luxembourg (1987), Barbados (1988), East Germany (1989), and the Soviet Union (1989). Information on life expectancy at birth for narrow year ranges, such as 1975-77 and 1990-91, is less readily available. The 1985-87 statistics are from the Center for Disease Control (1990). Using United Nations (1994) for (primarily) the years 1985-91, U.S. men ranked 21st in life expectancy at birth and U.S. women ranked 14th.

IV and V—present empirical evidence that suggests that, even for economically developed countries, a nation's income distribution is a key determinant of its mortality.

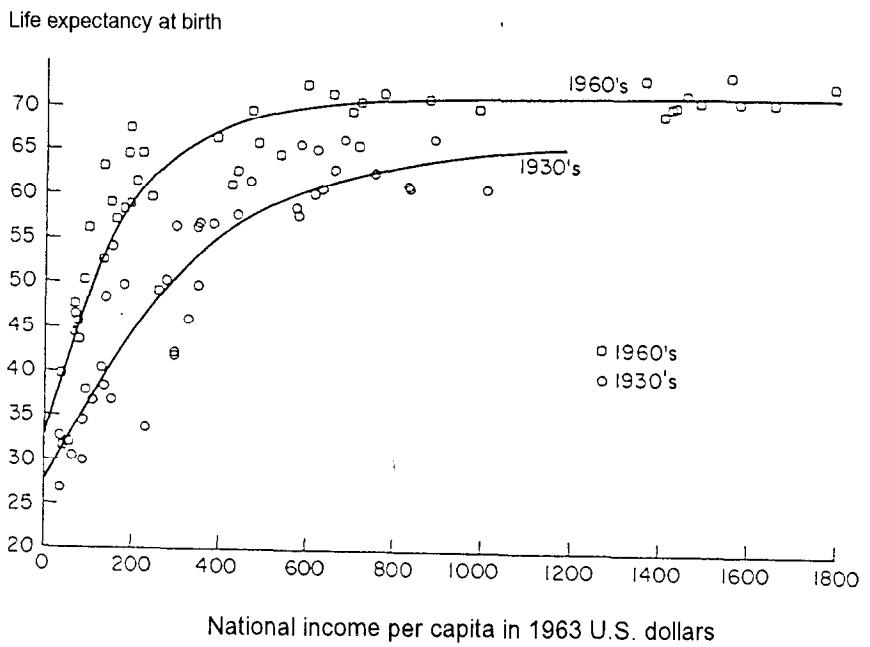
I. Cross-Country Comparisons of Average Income and Mortality

In their study of socioeconomic determinants of mortality in the United States, Kitagawa and Hauser (1973, pp. 178-179) concluded that, "The relatively high mortality of the United States compared with other advanced nations is undoubtedly in large measure a reflection of the high mortality of the disadvantaged in the nation—the lower socioeconomic groups of whites and the even more disadvantaged minority groups." Thus, one hypothesis for the relatively unfavorable mortality experience of the United States is that the welfare of those at the bottom of the economic ladder is lower in the United States than in some other industrialized nations.

The hypothesis that greater income support or income opportunities for those at the bottom reduces a country's overall mortality has not been widely accepted. Although scholars have generally accepted the importance of income (and its distribution) as a determinant of aggregate mortality for economically underdeveloped countries (for example, Adelman 1963, Fuchs 1974, Slama 1978), the relevance of intercountry variations in income for explaining mortality variations among economically developed countries has been questioned.

Using data for the 1960's, Fuchs (1974) found that there was no relationship between per capita income and age-specific adult mortality rates across economically developed countries. The seeming irrelevance of income as a determinant of mortality for economically developed countries was further buttressed by the absence of a correlation between average income and age-specific adult mortality rates across States within the United States (Auster, Leveson, and Sarachek 1969; Silver 1972; Grossman 1972; Fuchs 1974). Indeed, several of these studies found a positive correlation between average State income and State mortality rates. The estimated positive relationship suggested to some researchers that, for high-income countries, higher income may lead to higher mortality.

Chart 1.—The relationship between life expectancy at birth and per capita national income for nations in the 1930's and 1960's



Source: Preston (1976, figure 4.1, p. 67).

From the international and interstate comparisons, Fuchs (1974, pp. 179-181) concluded that, by 1965, there was no longer a negative relationship between adult mortality and income per capita across economically developed countries: "Although there is still considerable variability in age-specific death rates..., income is no more useful in explaining variability across developed countries than it is explaining variability of United States whites across states."

The conclusion that income is no longer an important determinant of mortality for economically developed countries received further support in a path-breaking study of international mortality by Preston (1976). Plotting the relationship between life expectancy at birth and per capita national income, Preston (1976, figure 4.1, p. 67) confirmed Fuchs' finding of no correlation between income and life expectancy for economically developed countries in the 1960's. This scatter plot is reproduced in chart 1 of this article. As shown, per capita income has a strong effect on life expectancy up to a per capita income of $600 in 1963 U.S. dollars ($2,906 in 1994 U.S. dollars). However, beyond that, the relationship is essentially flat. Preston (1976, p. 74) further found, in an analysis including both economically developed and underdeveloped countries, that changes in per capita income only accounted for a small portion of changes in mortality: "Analysis of the 30 countries for which data on both income and life expectancy are available during both periods [1930's and 1960's] confirms that income changes were of minor importance in mortality trends."

Fuchs observed that, in contrast to the cross-country and cross-State results, a negative relationship between income and mortality (lower income, higher mortality) does exist across individuals within the United States. However, he and others believed that the negative relationship between income and mortality at an individual level likely reflected a causality running from health to income rather than the reverse: poor health preceding death may reduce income, rather than income causally affecting health and mortality. As noted by

Fuchs, a reverse causality of this type, which plagues the interpretation of estimated relationships across individuals, is not a problem in comparisons across States and countries.

In summary, four issues have been brought up that cast doubt on the potential role of income for explaining mortality variation among economically developed countries and, in particular, the relatively high mortality of the United States: (1) there is no relationship across economically developed countries between average national income levels and age-specific mortality rates or life expectancy; (2) there is no relationship between average income and age-specific mortality rates across States within the United States; (3) changes in national income appear to have little effect on changes in mortality; and (4) the negative relationship between income and mortality measured across individuals may be due to a reverse causal effect from poor health to low income, rather than a causal effect of income on health and mortality. Each of these issues is reconsidered in part II.

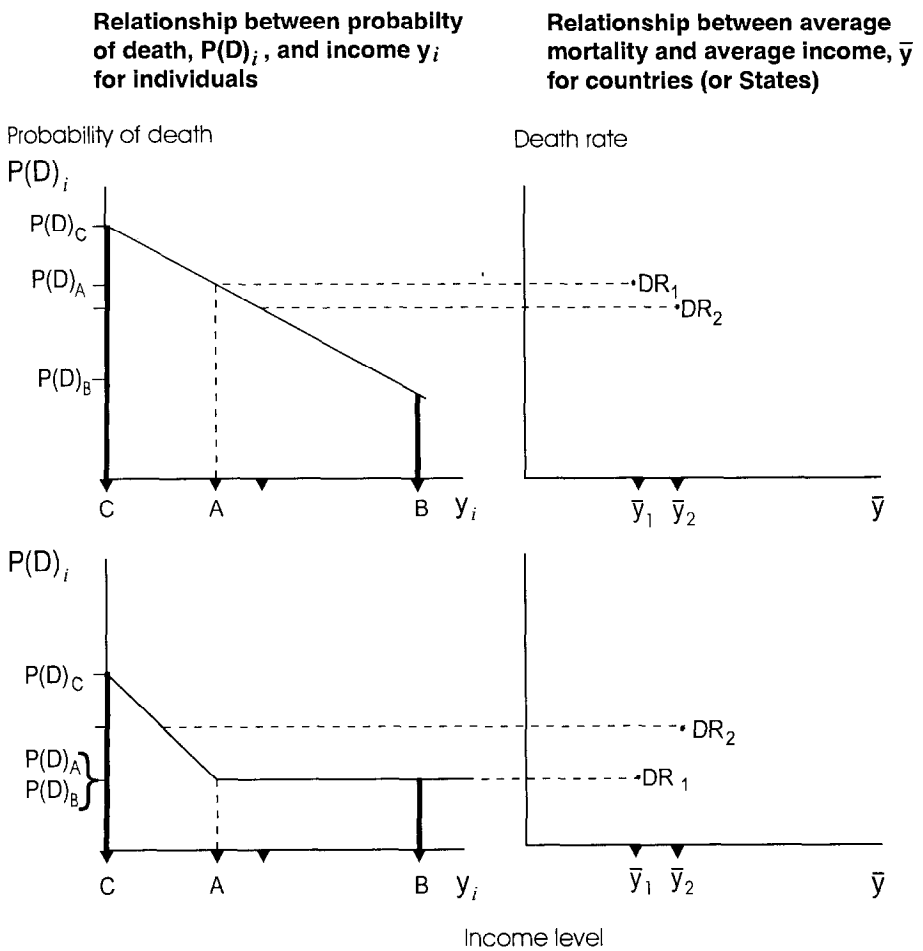
II. A Reconsideration of Past Findings on the Irrelevance of Income

The fact that income and mortality across economically developed countries (and across States within the United States) are uncorrelated suggests that either there is no causal relationship at the individual level between income and mortality in developed countries, *or* that the relationship at the individual level within developed countries is nonlinear. If the income of individuals affects their probability of death *and* if the relationship between individual probability of death and individual income is negative and linear, then (holding other variables constant) it would always be the case that countries (or States) with higher average incomes would have lower average mortality rates regardless of the underlying distribution of income in the countries.

To see this point, consider the top half of chart 2. The left side shows a linear relationship between probability of death, $p(D)_i$, and income, y_i, for individuals. Now suppose that a researcher wanted to estimate the relationship between incomes and mortality using the average incomes and mortality rates of countries (or States). Further imagine that in half of the countries considered by the researcher, all of the individuals within each country had an income equal to A, and in the remaining countries there was a highly unequal income distribution in which half the individuals of each country had an income equal to B, and the remaining half had no income at all (point C). The average income of each of the countries in the first set (denoted by $\bar{y}_1$) is equal to A, since all individuals in each of these countries have incomes equal to A. The average income of each of the countries in the second set of countries (denoted by $\bar{y}_2$) is simply the midpoint between income levels C and B, which is greater than A.

Since, at the individual level, income has a linear effect on mortality—that is, the effect of an income change is the same regardless of the level of income—and since the average income of the countries in the second set is higher than that of the first set, the average mortality of the countries in the second set will be lower than the average mortality of the countries in the first set, despite the very unequal income distributions of the countries in the second set: the death rate for each of the countries in the first set (denoted by DR_1) is equal to the point on the probability of death-income relationship directly above point A; the death rate for each of the countries in the second set (denoted by DR_2) is equal to the midpoint between the death rate of individuals with incomes equal to C and

Chart 2.—Relationship between income and mortality for individuals and countries (or States).



the death rate of individuals with incomes equal to B. The resulting aggregate relationship between average income and mortality across countries is shown on the top right side of chart 2.

If, however, the relationship between income and mortality at the individual level is nonlinear—that is, the effect of income on mortality depends upon the level of income—then cross-national (or cross-State) associations between average income and age-specific mortality rates may give a misleading impression about how income affects a nation's mortality, since the effect of income on a nation's mortality will depend upon how income is distributed. Indeed, it is entirely possible to find a positive association between average income and age-adjusted mortality across countries—that is, higher per capita income associated with higher mortality—and yet to have a very strong negative association between income and mortality (higher income associated with lower mortality) at the individual level. To see this point, consider the bottom half of chart 2.

Imagine that the individual relationship between probability of death, $p(D)_i$, and income, y_i, is as drawn on the left side. At low levels of income, an increase in individual income decreases mortality risk dramatically. But beyond a certain point, increases in income have no effect on individual mortality risk.

Now suppose that the researcher wanted to find out the effect of income on mortality using the average income and mortality rates of countries. As before, in our imaginary world, half of the countries have a completely egalitarian income distribution, with all individuals in each country having an income equal to A, and half of the countries have an inegalitarian income distribution, with half of the individuals of each country having zero income (point C) and the remaining half having incomes equal to B. The average income of each of the countries in the first set is equal to A, and the average income of each of the countries in the second set is equal to the midpoint between the income levels C and B. The death rate for each of the countries in the first set is equal to the point directly above point A; the death rate for each of the countries in the second set is equal to the midpoint between the death rate of individuals with incomes equal to C and the death rate of individuals with incomes equal to point B. The resulting relationship between income and mortality using national averages is positive as shown on the right side of the chart: $\overline{y}_1$ and DR_1 represent the average income and death rate for countries where all individuals have incomes equal to A, and $\overline{y}_2$ and DR_2 are the corresponding figures for the countries in the second set. In this case, the comparison of average income and mortality across countries provides misleading information about the role of income since the effect of national income on a country's mortality depends upon how income is distributed.

The same arguments, pictured in chart 2, can be applied to analyses that relate changes in average national income to changes in national mortality. $\overline{y}_1$ might refer to the average income in a country in an initial period and $\overline{y}_2$, its average income in a latter period. As long as the relationship between individual probability of death and individual income is linear, as pictured in the top half of chart 2, then increases in average income, *regardless of how this change is distributed*, will be accompanied by a decrease in the population's average mortality. If, however, the individual relationship is nonlinear, then whether an increase in average income for a particular country is accompanied by an increase, decrease, or no change in average mortality would depend on how the change in income is distributed. In the case presented in the bottom half of chart 2, the increase in average income is accompanied by an increase in mortality as the income distribution becomes less equal.

The preceding discussion suggests that, despite the absence of a correlation between average income and mortality across economically developed countries, income may be an important determinant of a country's aggregate mortality if there is a *causal* association between income and mortality for individuals and if the underlying individual-level relationship is nonlinear. Whether or not income has a causal effect on mortality and the shape of that relationship (linear or nonlinear) may be learned by using longitudinal data on individuals.

Evidence from Longitudinal Individual Data

The first data column of table 2 shows the coefficients on income from a model that relates income to the mortality experience of U.S. men aged 35-64 during the 6 years following measurement of their income.[4] The income coefficients represent the difference between the probability of death for persons in each income category and the probability of death of persons with incomes exceeding $63,462 in 1994 U.S. dollars, holding education and age constant.[5] Thus, the estimated probability of death (during a 6-year period) for a man in the lowest income category ($0 - $10,635 in 1994 U.S. dollars) exceeds that for a man in the highest-income category ($63,462 or more in 1994 U.S. dollars) by about 11 percentage points. These coefficients suggest that the association between income and mortality at the individual level is negative and nonlinear; as the level of income increases, its "effect" on mortality decreases, with little effect above average levels of income.[6] Thus, the distribution of income may be an important determinant of a country's mortality, even when average income and mortality are uncorrelated across countries. However, as pointed out by Fuchs and others, the estimated income "effects" using data on individuals may reflect the reverse effect of poor health, preceding mortality, on income rather than a causal effect of income on mortality.

The reverse causality problem in the estimated income effects can be overcome if we control for health conditions that may have affected income (Duleep 1986a).[7] Health problems, potentially affecting a person's propensity to work or wages, that occurred in the past but disappeared before the year (or years) in which income is measured, need to be controlled for as well as health problems that are concurrent with the time period in which income is measured; both could

affect the income that is related to mortality. To control for health problems that may have affected income, a dummy variable was included in the model that equals 1 if the person was ever recorded as disabled on Social Security records prior to or concurrent with the year of income used in the estimation, or if the individual reported on the Current Population Survey, in the year in which income was measured, that health prohibited or limited work. The income coefficients from this model are shown in the second data column of table 2.[8]

Comparing the income coefficients in the first two data columns of table 2, we see that the estimated adverse effect on mortality associated with low income decreases when health problems that may have affected income are controlled for, thereby providing evidence that some of the negative income-mortality association is due to the effect of poor health on income. Yet, a strong inverse relationship between income and mortality risk persists up to an average level of income. This suggests that income does have a causal effect on mortality. As shown in the last column, which also controls for health conditions that occurred before or during the period in which income is measured, the magnitude of the income effect is larger when mortality is related to income averaged over several years.[9]

The nonlinear causal effect of income on mortality at an individual level means that simple bivariate comparisons of average national income and mortality across countries are inadequate. How a nation's income is distributed must be taken into account.

III. Income Distribution, Mortality, and the Former Soviet Bloc Countries

The potential importance of income distribution as a determinant of national mortality rates has received empirical support from analyses that have included in their data sets economically developed and underdeveloped countries. Slama (1978); Rodgers (1979); Weatherby, Nam, and Isaac (1983); Waldmann (1992); and Crenshaw and Ameen (1993) found that income distribution was significantly related to mortality with the more unequal the income distribution, the higher the mortality rate.[10] However, as these analyses included economically underdeveloped countries, their relevance for economically developed countries has been questioned.

Preston (1976) also noted the potential importance of income distribution in determining a country's mortality. He observed, for instance, that Mexico and Columbia—countries noted for their unequal income distributions—had life expectancies several years below levels predicted for them on the basis of their mean incomes. For economically developed countries, however, the experience of the former Soviet bloc countries (given their historically relatively equal income distributions) runs counter to what one would expect if a more equal income distribution decreased mortality. In particular, Preston found that the U.S.S.R., East Germany, Hungary, Czechoslovakia, and Poland had higher mortality rates than other countries at equivalent average income levels. Preston (1976, p. 80) concluded: "In general, there is no compelling evidence that greater income equality... raised the life expectancy in Soviet bloc countries above that level to be expected on the basis of their mean incomes." As such, for economically developed countries, the experience of the Soviet bloc countries appears to be inconsistent with the relevance of a nation's income distribution to its mortality.

Another possibility, however, for the Soviet enigma is that other factors have counteracted the potentially beneficial effects of a relatively equal income distribution. The work of Preston (1976) suggests that certain aspects of increased industrialization, such as reduced exercise associated with nonagricultural employment, may have a detrimental effect on male mortality.[11] In addition to the potentially salubrious effect of agricultural work on male mortality, noted by Preston, industrial activity may also increase mortality to the extent that it is accompanied by unhealthy and unsafe working conditions and pollution.[12] Thus, the extent and nature of industrial activity may be one factor that contributes to high male mortality in the former Soviet bloc countries.

Compared with the United States and many other economically developed countries, the Soviet Union has had a high level of industrialization. For instance, the percent of the Soviet work force employed in manufacturing, mining, and construction in the early 1970's was 54.8 percent, compared with 39.6 percent for the United States.[13] In addition, Soviet bloc industrialization has been characterized by relatively unsafe working conditions[14] and perhaps by high levels of industrial pollution as well. Rather than necessarily being inconsistent with the potential importance of income distribution to a nation's mortality, the high mortality rates of the

Table 2.—The estimated effect of income on probability of death for men aged 35-64[1]

Income categories (in 1994 U.S. dollars)	Not controlling for health status	Controlling for health status	Using earnings averaged over several years and controlling for health status
$0-$10,635	0.113054 (8.68)*	0.069306 (5.01)*	0.097366 (8.15)*
$10,636-$21,271	.064065 (4.89)*	.043444 (3.28)*	.024725 (2.26)*
$21,272-$31,908	.020797 (2.13)*	.011121 (1.41)	.002043 (0.25)
$31,909-$42,544	.005282 (0.62)	.000064 (0.07)	. . .
$42,545-$63,462	.000091 (0.01)	-.001987 (0.28)	. . .

[1] t-test statistics are in parentheses.
* Significant at 0.05 level.

Source: Duleep (1986a, table 1, p. 243).

former Soviet bloc countries may alert us to other relevant explanatory variables, of which the extent and nature of industrial activity is but one.[15]

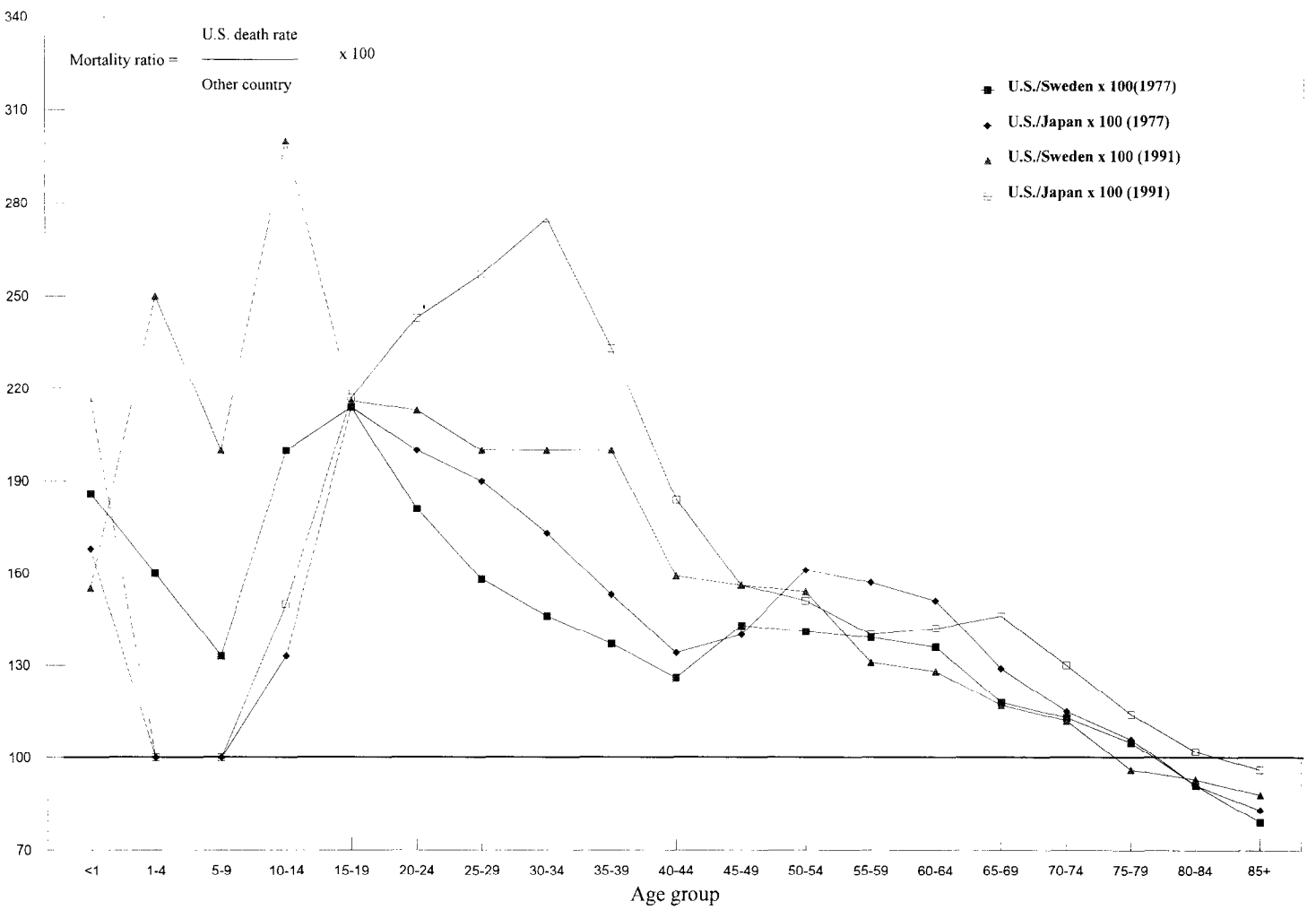
IV. International Mortality Differences and U.S. Mortality Differentials by Socioeconomic Status

One way to assess the potential role that the U.S. income distribution may play in our relatively low life expectancy is to compare the ages at which the mortality rates of Americans of low socioeconomic status are largest, relative to Americans of high socioeconomic status, with the ages at which U.S. mortality rates are largest, relative to other high-income countries with more equal income distributions than our own. If the ages at which relative socioeconomic mortality differentials within the United States are largest correspond with the ages at which U.S. mortality is largest relative to the mortality of other high-income countries with more equal income distributions than the United States, then this suggests—consistent with the Kitagawa and Hauser thesis—that a key reason for the relatively high mortality of the United States is the high mortality within the United States of low socioeconomic status persons relative to high socioeconomic status persons.

Research on relative socioeconomic mortality differentials within the United States has found these differentials to be large for infants (using an indicator of family socioeconomic status), substantially less for early childhood, but then increasing up through early adulthood, continuing at a high level through the working years, and decreasing in the early retirement years. Beyond age 75, there are indications of a reversal in which persons of high socioeconomic status experience higher mortality rates than persons of low socioeconomic status.[16] Recent research by Preston (1995) on mortality differences by education, in comparison with earlier research, suggests that the age at which individuals of lower socioeconomic status have higher mortality than persons of high socioeconomic status has increased over time.[17]

A causal interpretation of the reduction in the relative socioeconomic mortality differential at older ages is that income's effect on mortality is a function of the extent to which death is preventable; at older ages, the income effect decreases as death becomes less prevent-

Chart 3.—Ratio of age-specific male death rates of the United States to Sweden and Japan, 1977 and 1991



able (Antonovsky 1967, Duleep 1983). Preston's finding of an increase in the age at which socioeconomic mortality differentials exist is also consistent with the thesis that socioeconomic mortality differentials are a function of the extent to which death is preventable: as the potential to decrease mortality grows over time, so will the potential for socioeconomic mortality differentials to exist increase (Antonovsky 1967, Duleep 1986c). The reversal in the socioeconomic status/mortality relationship at the oldest ages may reflect a process whereby only the hardiest of low socioeconomic persons survive to these ages.

An international comparison of age-specific death rates reveals that the relative difference between American death rates and those of countries with higher life expectancies varies according to age. Chart 3 displays the pattern of age-specific death rates that collectively contribute to the lower life expectancy of U.S. males relative to males in Sweden and Japan, two countries with more equal income distributions than that of the United States.[18] Each line of chart 3 represents the ratio of U.S. male age-specific death rates in 1977 and 1991, to those of Sweden and Japan, respectively.[19] The horizontal line at 100 is where there is no difference between the United States and another country's mortality rate. "Excess U.S. mortality" occurs when the U.S. age-specific mortality rate exceeds the corresponding mortality rates of Sweden and Japan.

With the exception of a couple of outlying points (the 1991 U.S.-Swedish ratios for the early childhood years), each comparison in chart 3 reveals a similar pattern. A peak in excess U.S. mortality occurs for infants. Another peak in excess U.S. mortality emerges for teens and young adults. During the labor-force years and continuing through early retirement, American males continue to experience significantly higher mortality, although the extent of the excess mortality decreases at the older ages. By age 75, for the 1977 comparisons and at older ages for one of the two 1991 comparisons, the death rates of American males are in accord with those of Sweden and Japan. Beyond that, American death rates actually dip below those of their foreign contemporaries. Thus, the pattern of excess mortality in the United States relative to Sweden and Japan generally corresponds to the age-specific pattern of relative socioeconomic mortality differentials within the United States. Although only conjectural, the comparison of international mortality differentials and U.S. socioeconomic mortality differentials does raise the possibility that socioeconomic variables may be partially responsible for mortality variations among economically developed countries and for the relatively high mortality of the United States.

V. Income Inequality and Mortality Among Economically Developed Countries

The relationship between income distribution and mortality rates can be explored by estimating a regression model across countries. The data set used to estimate the model was limited to economically developed countries so that the results are applicable to the United States and to the issue of whether income distribution contributes to mortality variation among economically developed countries. Thirty-seven countries are included in the data set.[20] The empirical analysis is limited to men.

The dependent variable used in the initial estimation is the natural logarithm of the death rate (deaths per 1,000) of men aged 50-54 (lnDR5054), generally for the year 1977.[21] Using an age-specific mortality rate eliminates the problem of adjusting for the different age structures of the countries in the data set.[22]

To control for the extent of industrialization, the percent of the work force employed in manufacturing, mining, and construction (IND) is included as an explanatory variable in the model. The data for this variable refer to the early 1970's.

In formulating the equation to be estimated, special attention was given to the measurement of income distribution. As discussed earlier, the analysis of longitudinal data on individuals indicates that income has a strong causal effect on mortality at low levels of income, but little effect at higher income levels. The nonlinear income effect suggests that, for economically advanced countries, the distribution of income above average levels will not be an important determinant of a country's mortality. Thus the Gini coefficient, a commonly used measure of income distribution, which is affected by the degree of inequality among both high and low incomes, may not capture the most relevant variations in country-specific income distributions. To capture the nonlinear effect of income on mortality, I used an estimate of the average income received by the bottom 10 percent of the population in each country. This measure, denoted by $\overline{Y}_{10}$, was calculated as $^{1}/_{10}$ (P10 x $\overline{Y}$) where P10 is the percent of national income received by the bottom income decile and $\overline{Y}$ is the nation's per capita income.[23] As such, in the model specification pursued in this article, national mortality rates are related to variations in the absolute level of income received by the lowest decile rather than the distribution of income per se.[24]

Information on income shares for different countries generally has been computed either by using information from tax records or from survey information. The tax data usually apply only to those who pay taxes. Since the poor are often exempt from taxation, tax information gives a distorted picture of the bottom decile's income share in several countries. Because of this limitation, the income share data used in this analysis were based on survey data only.[25] Included in the computation of the bottom decile's share (P10) was all income including transfer income. Most of the income distribution figures are for the mid-1960's and early 1970's. However, the range of years to which the share data refer is 1957-73.[26] Data on per capita national income ($\overline{Y}$), used to compute the variable $\overline{Y}_{10}$, refers to the early 1970's.

The model, estimated by ordinary least squares, is given below.[27,28] The number in the parentheses below each estimated parameter is the t-test statistic,

a measure of the statistical significance of the estimated parameter. Both the industrial composition variable and the average income level of the lowest decile are statistically significant at conventional levels.[29]

$$\ln DR5054 =$$

$$\underset{(11.98)}{2.01614} + \underset{(2.22)}{.00869\,(IND)} - \underset{(3.00)}{.00212\,(\overline{Y}_{10})}$$

$$R^2 = .22$$

The estimated coefficient on the industrial composition variable (IND) indicates that increasing the percent of the labor force employed in manufacturing, mining, and construction by 10 percentage points will increase a nation's death rate for men aged 50-54 by about 8.7 percent. The estimated coefficient on the income distribution variable indicates that increasing the average income of the lowest income decile by $100 in 1970 U.S. dollars ($382 in 1994 U.S. dollars) would lower a nation's death rate by about 20 percent.

Previous analysis of income's effect on mortality in the United States using data on individuals found that increases in income at the lowest levels of income are associated with large decreases in mortality but that income's effect decreases at higher levels and has little or no effect at above-average levels of income. We would expect, therefore, that across economically developed countries, the average income received by the bottom decile of the population, $\overline{Y}_{10}$, would likely be much more important in determining the mortality rates of economically developed countries than the average income, $\overline{Y}$, of the population. This expectation can be easily tested by adding average national income as an explanatory variable to the model of international mortality rates, as shown below:

$$\ln DR5054 =$$

$$\underset{(11.69)}{1.99007} + \underset{(2.24)}{.00918(IND)} - \underset{(2.04)}{.00262(\overline{Y}_{10})} + \underset{(0.47)}{.00013\overline{Y}}$$

$$R^2 = .22$$

Comparing the above estimation with the earlier estimation reveals that the inclusion of average national income has little effect on the estimated effects of the industrial composition variable and the variable measuring the average income of the lowest decile. Consistent with the analyses of Fuchs and Preston (relating average national income to the mortality of economically developed countries) and with expectations based on analyses of U.S. data for individuals (revealing that income's mortality effect exists primarily at low levels of income), the estimated effect of average income is statistically insignificant.

As discussed earlier in the article, there has been little debate about the effect of income, and its distribution, on the mortality of countries with low average levels of income. It is for economically developed nations that questions about income's role in determining national mortality rates have arisen. Although poor countries are excluded from the data set used in the analyses in this study, the estimated negative association between the income of the lowest decile and mortality could still reflect the experiences of the least economically developed countries in the data set. If this were the case, then we would expect that as the countries with the lowest average income levels were deleted from the data set, the estimated effect of $\overline{Y}_{10}$ would lessen or disappear.

Table 3 shows the estimated effects of the model's two explanatory variables as countries with relatively low average incomes are deleted from the data set.[30] Rather than decreasing, as progressively higher-income countries are considered, the estimated effect of $\overline{Y}_{10}$ generally increases. One possible interpretation of the increase is that it is a manifestation of the hypothesized phenomenon discussed in part III in which socioeconomic mortality differentials are a function of the extent to which death is preventable, with the richest nations having the greatest potential to prevent death.

The international comparisons shown in chart 3 revealed that excess U.S. mortality varies according to age, with a peak occurring for the early adult years and high relative mortality persisting throughout most of the adult years, but steadily declining with the onset of middle age. As such, we might expect that if we extended the international regression estimation to other adult ages, we would find the estimated effect of $\overline{Y}_{10}$ to be greatest for the young adult years, continuing through most of the adult years, but steadily declining with the onset of middle age, and eventually becoming insignificant at the oldest ages.

Table 4 shows the estimated effects of the model's two explanatory variables, IND and $\overline{Y}_{10}$, for the 20-24 age group through the 80-84 group.[31] Table 5 shows the same estimations based on a data set that excludes countries with per capita incomes lower than $3,000 in 1970 ($11,459 in 1994 U.S. dollars). The left sides of tables 4 and 5 show estimates based on analyses in which mortality is measured during the years 1975-77. Using the same values for the explanatory variables, the right sides of these tables show estimates based on analyses in which mortality is measured during the years 1988-90. Underlying the estimations with more recent mortality data is the assumption that the relative positions of countries, in terms of their industrial composition, income distribution, and income level have remained fairly stable over time.[32]

For men aged 20 to 24, the effect of the income variable is generally small and statistically insignificant. Thus, although there is a very large relative socioeconomic mortality differential at young adult ages in the United States (and high excess U.S. mortality at these ages in the international comparison shown in chart 3), the lack of a statistically significant effect of $\overline{Y}_{10}$ suggests that the level of income received by the lowest decile does not generally contribute to higher mortality across nations for this age group.[33]

At all other age groups, except for the oldest group, the estimated effect of $\overline{Y}_{10}$ is statistically significant (at a 10-percent level or better) and is important in terms of the size of its mortality effect. Furthermore, in keeping with our previous expectations, the estimated effect of $\overline{Y}_{10}$ generally decreases with increasing age, eventually diminishing into statistical insignificance for the oldest age groups.[34]

Comparing the estimated coefficients for the 1975-77 period with the 1988-90

period suggests that the effect on national mortality rates of the level of income received by the lowest decile ($\overline{Y}_{10}$) has generally increased over time, consistent with the thesis that the importance of income differentials is likely to increase the more preventable death becomes. Also consistent with this thesis is some evidence of a possible increase in the age at which changes in the level of income received by the lowest decile have an important effect on national mortality rates: according to the 1975-77 results, the estimated percentage effect of $\overline{Y}_{10}$ peaks at ages 30-34 (in both tables 4 and 5) and then decreases, becoming statistically insignificant (at a 5-percent level) at ages 70-74 in table 4, and statistically insignificant in both tables at ages 80-84. According to the 1988-90 results, the estimated effect of $\overline{Y}_{10}$ peaks at the 40-44 age group or the 50-54 group and is still statistically significant (at a 5-percent level) in both tables at ages 70-74 and, in table 5, still exerts a statistically significant effect (at a 10-percent level) at ages 80-84. Comparing tables 4 and 5, we see that, for both time periods, and at all ages, the estimated effect of $\overline{Y}_{10}$ increases when lower-income countries are dropped from the data set, thereby confirming the relevance of the estimated results for economically developed countries such as the United States.

The estimated effects from the regression analysis suggest answers to several international puzzles. One puzzle is the very high mortality of the former Soviet Union and eastern European countries despite the relatively equal income distributions of these countries. This observation has led researchers to conclude that income distribution is not a determinant of mortality in economically advanced nations. The results from this analysis suggest that the high mortality, particularly for men, of the Soviet Union and the eastern European countries may be due, in part, to the level and nature of industrial activity in those countries (and to other variables particular to these countries).[35] The level of industrial activity may also contribute to the unfavorable mortality experience of men in the United States—a country with one of the highest per capita incomes in the world—compared with the mortality experience of men in countries with much lower per capita incomes such as Greece and Cyprus; their lower male mortality rates may reflect, in part, the beneficial health effects suggested by Preston of agricultural work.[36]

Most importantly, the analysis suggests that income distribution may be one factor underlying variations in the age-specific mortality rates of economically developed countries. Using the estimated coefficient on the model's income distribution variable we can ask, what would be the effect on the relative U.S. mortality rates of men aged 50-54 if the income distribution in the United States were similar to that of Sweden or Japan? As shown in chart 3, the mortality ratios (times 100) of U.S. to Swedish and Japanese men aged 50-54 in 1977 are 141 and 161. Keeping the U.S. industrial structure and national income constant and using the estimated coefficient on $\overline{Y}_{10}$ for mortality occurring during 1975-77, we find that instead of the mortality ratios of 141 and 161, the mortality ratios for the United States versus Sweden and Japan would be 127

Table 3.—Estimated percentage effects of industrial composition and the lowest decile's average income on the 1975-77 mortality rates of men aged 50-54[1]

Selection of countries	Explanatory variables		R^2	Number of countries
	IND	$\overline{Y}_{10}$		
All[2]	0.00869*	-0.00212*	0.22	37
	(2.22)	(3.00)		
Per capita income (1994 U.S. dollars) exceeding—				
$7,639	.01207*	-.00299*	.31	32
	(2.64)	(3.52)		
$9,549	.01113*	-.00340*	.33	24
	(2.00)	(3.19)		
$11,459	.01563*	-.00457*	.47	22
	(2.93)	(4.10)		
$13,369	.01344*	-.00403*	.36	20
	(2.22)	(3.06)		
$15,278	.01849*	-.00522*	.46	17
	(2.50)	(3.47)		
$17,188	.01509*	-.00501*	.49	15
	(2.10)	(3.42)		
$19,098	.01876*	-.00527*	.62	13
	(3.04)	(4.01)		

[1] t-test statistics are in parentheses.

[2] The cutoff amount for inclusion in the data set was a 1970 per capita income of $5,118 in 1994 U.S. dollars.

* Significant at 0.05 level.

Notes: The estimated model included an intercept. Full regression results are available from the author.

and 129, respectively.[37] Using the regression estimation for 1988-90, we find that instead of mortality ratios of 154 and 151 (shown in chart 3), the mortality ratios for the United States versus Sweden and Japan would be 124 and 94, respectively.

Conclusion

A major contribution of this article is that it utilizes insights from longitudinal microanalytical research to test for the effect of income on the mortality of economically developed countries. The nonlinear effect of income on mortality at an individual level means that intercountry comparisons of average national income and mortality may be misleading, since the effect of a nation's income on its mortality depends upon the distribution of income. A more appropriate measure, the level of income received by the bottom income decile, does appear to be inversely associated with national mortality rates.

This work, which extends a previous analysis of international mortality by Duleep (1984b, 1986c), is consistent with the results of Wilkinson (1986, 1990, 1992a,b) and Le Grand (1987) who related measures of income distribution to the 1971 and 1981 mortality of OECD countries and 17 economically developed countries, respectively.[38] The fact that each of our efforts uses a different data source for income distribution, and yet similar conclusions are reached, suggests that the importance of income distribution to the mortality of economically developed nations is not the spurious result of a correlation between errors in the measurement of income distribution and mortality.[39] Furthermore, the fact that each of our data sets covers a different collection of countries suggests that the estimated mortality effect of income distribution is not the result of a particular selection of economically developed countries.

The research presented in this study is also consistent with what appears to be an emerging European perspective that the best way to raise a nation's life expectancy is to decrease socioeconomic mortality differentials within the nation (Power 1994, Wilkinson 1990). More generally, the results are consistent with a theme articulated by Sen (1993, p. 40) that mortality data can be used to illuminate critical aspects of the economic organization of society:

> *Despite unprecedented prosperity in the world as a whole..., avoidable diseases and preventable deaths remain widespread in industrialized countries as well as in the Third World. Economic arrangements are central to these problems. By supplementing traditional indicators with statistics that relate more directly to well-being, the benefits and deficiencies of alternative economic approaches can be fruitfully assessed. For example, one country can have a much higher gross national prod-*

Table 4.—Estimated percentage effects of industrial composition and the lowest decile's average income on adult male mortality rates, 1975-77 and 1988-90[1]

Age group	1975-77			1988-90		
	IND	$\overline{Y}_{10}$	R^2	IND	$\overline{Y}_{10}$	R^2
20-24	0.00768 (0.88)	-0.00020 (0.13)	0.03	0.00170 (0.22)	-0.00169 (1.21)	0.05
30-34	.02795** (2.21)	-.00414* (1.81)	.14	.01682 (1.62)	-.00395** (2.08)	.12
40-44	.01201** (2.09)	-.00296** (2.85)	.20	.01827* (1.87)	-.00369** (2.07)	.13
50-54	.00869** (2.22)	-.00212** (3.00)	.22	.02144** (2.93)	-.00444** (3.31)	.28
60-64	.01027** (2.71)	-.00174** (2.54)	.21	.01751** (3.56)	-.00291** (3.23)	.31
70-74	.01486** (3.98)	-.00110* (1.72)	.36	.01286** (3.30)	-.00149** (2.07)	.26
80-84	.01460** (3.37)	-.00092 (1.23)	.30	.00933** (2.12)	-.00115 (1.51)	.17

[1] t-test statistics are in parentheses.
** Significant at 0.05 level.
* Significant at 0.10 level.

Notes: The estimated model included an intercept. Full regression results are available from the author.

uct per capita than another; at the same time, it can have much lower life expectancy than its less wealthy counterpart because its citizens have poor access to health care and basic education. Mortality data can be used to evaluate policy and to identify vital aspects of economic deprivation in particular nations and in specific groups within nations.

Even though the results presented in this study are based on intercountry variations in absolute income amounts received by the lowest decile, it cannot be concluded that simply raising the income of the lowest decile will result in a mortality diminution in accordance with the reported coefficients of the mortality model. Indeed, the estimated effects of the income variable are so large as to make such a conclusion implausible. Rather, the results are strongly suggestive that U.S. mortality could approach both the level and the age-specific pattern of mortality that exists in other economically developed nations through greater attention to the health effects of social and economic factors associated with a relatively unequal income distribution, including the effects of such factors on individual behavior.[40]

International comparisons are one approach for learning about the relationship between income and mortality. Although there are several disadvantages of cross-national comparisons, an advantage, as pointed out by Fuchs,[41] is that comparisons of income and mortality across aggregates of individuals, such as States or countries, are not affected by the reverse causality issue that has concerned analysts using data on individuals. As such, the results of this study are another indication that the income-mortality relationship estimated with individual data primarily reflects the effect of income on mortality, rather than solely being the product of poor health affecting income, or a third variable (such as genetics) affecting both income and mortality.

The results of this study are also relevant to Social Security (Duleep 1984a). The financial status of Social Security rests upon the ratio of contributions flowing into the system to benefits flowing out of the system. Mortality is a key ingredient to this ratio since it determines how long individuals will contribute into and benefit from the system, along with the size and composition of earnings and beneficiary populations. As such, assessments of future patterns of mortality experience are of great importance to any prognosis of the system's future health.

A potential source for significant changes in future U.S. mortality that has

Table 5.—Estimated percentage effects of industrial composition and the lowest decile's average income on adult male mortality rates, excluding countries with per capita incomes less than $11,459 (1994 U.S. dollars) in 1970: 1975-77 and 1988-90[1]

	1975-77			1988-90		
Age group	IND	$\overline{Y}_{10}$	R^2	IND	$\overline{Y}_{10}$	R^2
20-24	0.00240 (0.26)	-0.00169 (0.88)	0.05	0.00830 (0.74)	- 0.00446* (1.89)	0.18
30-34	.01991** (2.11)	-.00645** (3.28)	.36	.01334 (1.14)	-.00596** (2.41)	.25
40-44	.01374* (1.79)	-.00558** (3.47)	.40	.02397** (2.07)	-.00794** (3.26)	.37
50-54	.01563** (2.93)	-.00457** (4.10)	.47	.02666** (2.75)	-.00703** (3.45)	.41
60-64	.01671** (2.96)	-.00344** (2.92)	.35	.02390** (3.89)	-.00467** (3.60)	.49
70-74	.01932** (4.49)	- .00195** (2.17)	.53	.01780** (3.34)	-.00251** (2.24)	.38
80-84	.02097** (4.94)	-.00142 (1.59)	.62	.01703** (3.83)	-.00163* (1.68)	.48

[1] t-test statistics are in parentheses.
** Significant at 0.05 level.
* Significant at 0.10 level.

Notes: The estimated model included an intercept. Full regression results are available from the author.

received little attention in discussions of national mortality is the enormous variation in mortality rates that exists among socioeconomic groups. Wolfson, Rowe, Gentleman, and Tomiak (1993, p. S170) concluded that "...the elimination of cancer would have roughly the same impact on mortality... as bringing the mortality experience of the bottom 80 percent [of earners, based on an average of their career earnings] up to the average of the top 20 percent," using estimates from their study of differential mortality in Canada.

The experience of other countries suggests what might be possible for U.S. mortality levels given the current level of economic development and medical technology. In particular, most of the comparisons shown in chart 3 suggest that there is room for improvement at all ages except for pre-teenage children and the very old. The multivariate analyses presented in this article, focussed solely on adult men, suggest that changes in the economic welfare of those in the bottom income decile could reduce U.S. mortality at most adult ages, with the extent of *relative* improvement declining at the oldest ages. Such changes, if they were to occur would have implications not only for Social Security's financial status, but also for the redistributive effects of the system (Leimer 1995; Duggan, Gillingham, and Greenlees 1992). Given the potential importance of socioeconomic mortality variations on national mortality levels, probably more thought should be given to the incorporation of socioeconomic variables in Social Security forecasts of mortality for population cohorts. To the extent that socioeconomic variables are used in forecasts of future mortality, the analyses presented here underscore the importance of using distributional measures, such as the percent of the population in poverty, rather than average measures alone. Finally, an important aim of Social Security policies is to promote health and well-being. The results of this study suggest that programs and policies that improve the economic status of the lower socioeconomic strata reduce mortality.

Notes

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[1]Life expectancy information cited in *The Economist* was obtained from Jean-Claude Chesnais of the National Institute of Demographic Studies in Paris.

[2]Refer to the second column of table 1. An issue that has arisen is whether the analyses of this article should exclude blacks. In a comparison of age-adjusted mortality across countries, Zarate (1994) found that excluding blacks improved the relative position of the United States. This finding is of substantial interest in and of itself. However, analysis of individual data suggests that the black-white differential in the United States is explained almost entirely, if not entirely, by socioeconomic variables (Rogers 1992; Keil, Sutherland, Knapp, and Tyroler 1992; Sorlie, Rogots, Anderson, Johnson, and Backlund 1992; and Behrman, Sickles, Taubman, and Yazbeck 1991). Since the analyses in this study are focussed on the effect on national mortality rates of income distribution (and in particular, the level of income received by the lowest decile), it would be inappropriate to exclude blacks (or any other low-income group) from the computation of U.S. mortality rates.

[3]Routes in which income may affect mortality are discussed in Duleep (1986c, chapter 6).

[4]The coefficients in all three columns of table 2 are based on a model that includes education and age. The models in the first two columns use Internal Revenue Service tax return data on family income, for the year 1972, which is the sum of the individual's earnings, his wife's earnings, and all other types of income subject to Federal income tax. The models in all three columns are linear in the parameters and estimated by ordinary least squares. The estimated effects of income on probability of death based on a logit model estimated by maximum likelihood estimation are similar. For further information concerning the results presented in table 2 and their interpretation, refer to Duleep (1986a).

[5]The differentials are given in recent dollar values even though the analysis upon which these estimates are based related 1972 income to 1973-78 mortality. Other research finds that mortality differentials by income and education in the United States have widened over time (Pappas, Queen, Hadden, and Fisher 1993; Duleep 1986c, 1989; Feldman, Makuc, Kleinman, and Cornoni-Huntley 1989).

[6]Wolfson, Rowe, Gentleman, and Tomiak (1993), in an analysis of Canadian administrative data that did not control for education, found that although there was a positive association of longevity and earnings at all earnings levels, the effect of changes in income decreased as earnings rose, consistent with the pattern shown in table 2. Also, Attanasio and Hoynes (1995) find the effects of wealth are most concentrated at the low wealth levels. Interestingly, the nonlinear relationship between increases in income and reductions in the probability of death for individuals shown in table 2 closely approximates the shape of the relationship between changes in income and changes in subjective levels of satisfaction with income: Vaughan and Lancaster (1980) found that increases in income above the median had a small effect on increasing subjective welfare relative to changes in income below the median. Also refer to Rainwater (1974).

[7]Other relevant studies include Rosen and Taubman (1979); Caldwell and Diamond (1979); Fox and Jones (1985); Duleep (1986b,c); Rogot, Sorlie, Johnson, Glover, and Treasure (1988); Townsend, Davidson, and Whitehead (1988); Mare (1990); Moore and Hayward (1990); Zick and Smith (1991); Menchik (1993); Wolfson, Rowe, Gentleman, and Tomiak (1993); and Smith and Zick (1994). Conditioning on health status may also help to control for unmeasured variables, such as motivation and genetics, that may affect both the probability of death and socioeconomic status (Nakamura, Nakamura, and Duleep 1990).

[8]Note that this approach underestimates the adverse effect of low income on mortality to the extent that low income affects mortality through its effect on the health problems that are controlled for in the estimation. A

methodology for measuring income's total effect on mortality—including the indirect effect, which is ignored in the estimation shown in table 2—while controlling for the effect of poor health on income was proposed in Duleep (1986a).

[9]The coefficients in the last column are from a model that uses Social Security earnings data averaged over the years 1968 through 1972 instead of 1972 Internal Revenue Service income data. These earnings data were only available up to a taxable ceiling of $31,909 in 1994 U.S. dollars. For further details on this estimation, refer to Duleep (1986a). On the issue of the relative importance of permanent and transitory income, also refer to Zick and Smith (1991); Wolfson, Rowe, Gentleman, and Tomiak (1993); and Smith and Zick (1994).

[10]Weatherby, Nam, and Isaac (1983), who analyzed age-specific mortality of women, found that the effect of income distribution varied according to age.

[11]Within the United States, employment in agriculture has been associated with lower than average mortality, controlling for other individual characteristics such as income and education (Moriyama and Guralnick 1956, Burtless 1987).

[12]Studies of mortality within the United States are inconclusive as to whether occupational experience contributes to the high mortality of persons of low socioeconomic status relative to persons of high socioeconomic status (Burtless 1987; Hayward, Grady, Hardy, and Sommers 1989; Mare 1990; Duleep 1995). The absence of such a finding, however, is not inconsistent with the possibility that different levels of industrial activity across nations may contribute to cross-national mortality variations in mortality in general.

[13]The data for the Soviet Union and the United States are for the years 1970 and 1971, respectively (International Labour Office 1971, 1972).

[14]Reported fatal injury rates (both overall and for specific industries, such as manufacturing) are higher for the former Soviet bloc countries than for the United States (International Labour Office, 1992).

[15]Other potentially confounding factors include differences between the former Soviet bloc countries and other economically developed countries in life-style variables such as smoking, diet, and alcohol consumption.

[16]See Kitagawa and Hauser (1973) for information on U.S. socioeconomic mortality differentials for infants and adults. See Duleep (1983), Christenson and Johnson (1995), and Elo and Preston (1995) for a comparison of adult mortality by socioeconomic status before and after retirement age. For infant mortality, see National Center for Health Statistics (1972). For information on child mortality, ages 0-19, see Mare (1982).

[17]Over-time comparisons of mortality differentials by income for those over age 65 also support this conclusion (Duleep 1983, 1986c).

[18]According to the income distribution estimates used in the analyses of this article (see note 25), the percentages of national income received by the lowest decile in the United States, Sweden, and Japan are 1.5 percent, 2.2 percent, and 3.0 percent, respectively.

[19]The data used to construct chart 3 are from United Nations (1982, 1994, 1995). Other graphical comparisons of U.S. mortality with other high-income countries are available from the author.

[20]The countries (and one U.S. territory) included in the data set are: Australia, Austria, the Bahamas, Barbados, Belgium, Bulgaria, Canada, Cyprus, Czechoslovakia, Denmark, Finland, France, the German Democratic Republic (the former East Germany), the Federal Republic of Germany (West Germany), Greece, Hong Kong, Hungary, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Puerto Rico, Singapore, Spain, Sweden, Switzerland, the United Kingdom, the United States, U.S.S.R., Venezuela, and Yugoslavia.

[21]The mortality data were obtained from several editions of the *Demographic Yearbook* of the United Nations. Refer to Zarate (1994) for a very comprehensive international comparison of age-adjusted mortality for males and females, by cause, and over time. The mortality information from this source was not used in the analyses of this article; age-specific mortality rates were chosen as the dependent variable so that the effects of the explanatory variables at different ages could be learned. Refer to Weatherby, Nam, and Isaac (1983) for a discussion of and empirical results illustrating the importance of examining age-specific death rates in addition to summary measures of mortality.

[22]The information on the explanatory variables is not age or sex specific.

[23]The information available to me was each country's per capita income and the percent of national income received by the lowest decile. Note that the average income of individuals in the bottom income decile would be the total amount of income received by the lowest income decile divided by the number of persons in the lowest income decile, or $^{1}/_{N10}$ (P10 x Y), where N10 is the number of persons in the lowest income decile, P10 is the percent of national income going to the bottom 10 percent of the population, and Y is national income. The number of persons in the lowest income decile, N10, equals .10 x N, where N is the total number of persons in the country. Thus, an estimate of the average income received by individuals in the lowest decile, $\overline{Y}_{10}$, is $^{1}/_{(.10 \times N)}$ (P10 x Y) = $^{1}/_{.10}$ (P10 x Y/N), which is the percent of national income going to the lowest decile times a nation's per capita income, divided by .10.

[24]For further discussion on this issue, refer to note 28.

[25]Two principal sources were consulted—Jain (1975) and Sawyer (1976). Many of the income-share estimates cited in Jain are based on tax data. However, he provides an appendix that gives the source of data for each estimate, thus facilitating a selection of those estimates based on survey data. Several other sources, including Wiles (1974), Michal (1973), and Schnitzer (1974), were consulted as well in constructing the data set used in this article's analysis.

[26]An underlying assumption is that the income distribution of a country is fairly stable over time. Measurement error is introduced into the analysis to the extent that this is not true.

[27]These estimates for mortality in 1977 for middle-age men were previously presented in Duleep (1984b, 1986c).

[28]The model specification does not identify to what extent the estimated effect of $\overline{Y}_{10}$ represents the beneficial effect of a higher absolute amount of income received by the lowest decile per se or the beneficial effect of a more equal income distribution that accompanies a higher level of income received by the lowest decile. An alternative specification, death rate = $\alpha + \beta_1 \overline{Y} + \beta_2$ P10, explicitly includes the share of income going to the lowest decile in the model. An ambi-

guity with this specification is that controlling for the share of income going to the lowest decile (P10), the greater $\overline{Y}$ is, the greater the income that is received by the lowest decile. As such, this specification also fails to separately identify the effect on mortality of the level of income received by the lowest decile from the effect of the share of income received by the lowest decile. Although beyond the scope of this article, some light on this issue is shed by including both $\overline{Y}_{10}$ and P10 in the model specification. Supplementary regressions including both $\overline{Y}_{10}$ and P10 reveal a complex picture in which the relative importance of these two variables varies by age group, time period, and the average income cutoff point for inclusion in the data set. In general, $\overline{Y}_{10}$ (controlling for P10) has a large and statistically significant negative effect on mortality except for men in the two youngest age groups (20-24 and 30-34), whereas P10 (controlling for $\overline{Y}_{10}$) only has a statistically significant negative effect on mortality for the two youngest age groups.

[29]This means that had their true effects been zero, there would have been a very small probability of obtaining coefficients of magnitudes this large.

[30]Each of the regressions presented in table 3 was also estimated including $\overline{Y}$. Regardless of the income cutoff point for the sample, the estimated effect of $\overline{Y}$ is small and statistically insignificant and its inclusion has almost no effect on the estimated coefficients of IND and $\overline{Y}_{10}$.

[31]Regressions were not estimated for age groups 25-29, 35-39, 45-49, 55-59, or 65-69.

[32]To the extent that this assumption is not true, measurement error (which generally biases the estimated coefficients towards zero) will be greater in the analyses with more recent mortality data. It is also likely that the explanatory variables affect mortality with substantial time lags.

[33]However, the estimated coefficient of $\overline{Y}_{10}$ for men aged 20-24 is negative and statistically significant at a 10-percent level in the 1988-90 regression limited to high-income countries (shown on the right side of table 5). As discussed in note 28, the share of income received by the lowest decile, as opposed to the level of income received by the lowest decile, may be more relevant for this age group.

[34]These results are consistent with the cross-national analysis of female mortality at older ages by Weatherby, Nam, and Isaac (1983).

[35]It should be borne in mind that the industrial activity variable is likely picking up the effect of several factors. As Preston (1976, p. 157) noted in his analysis of international mortality: "Of the many standard components of economic modernization, nonagricultural employment and population concentration are the two having largest association with mortality differentials.... Nevertheless, it is not plausible to argue that mere presence in a large city or pursuit of nonagricultural work causes by itself excessive male mortality. Undoubtedly these variables are acting as proxies for unmeasured variables...."

[36]In the United States in 1971, 39.6 percent of the labor force was employed in manufacturing, mining, and construction, compared with 28.5 percent for Cyprus and 29.1 percent for Greece.

[37]These ratios are calculated in the following way. The observations shown in chart 3 are the ratios of the U.S. actual death rates to the actual death rate of each of the comparison countries, or $DR_{U.S.}/DR_{Sweden}$ and $DR_{U.S.}/DR_{Japan}$, each ratio multiplied by 100. Let $\overline{Y}_{U.S.}$ be the U.S. average national income, $P10_{U.S.}$ the percent of income going to the bottom decile in the United States, and $P10_C$ the corresponding percent for another country. Then, according to the model's estimated parameters for 1975-77 mortality, the change in the natural logarithm of the U.S. death rate that would occur if the percent of the national income that went to the bottom decile were $P10_C$ instead of $P10_{U.S.}$ would be the estimated effect of $\overline{Y}_{10}$ from the model multiplied by the change in the income level of the bottom decile that would result from imposing the other country's distribution, or $-.00212 \times [{}^{1}/_{10}(P10_{U.S.} \times \overline{Y}_{U.S.}) - {}^{1}/_{10}(P10_C \times \overline{Y}_{U.S.})]$. Subtracting this value from the logarithm of the U.S. death rate and taking the antilog gives an estimate of the death rate that would occur if the percent of income going to the lowest decile were the same in the United States as in that in the other country.

[38]Wilkinson (1992a) also related changes in income distribution for several countries, such as Japan and the United Kingdom, to changes in mortality.

[39]Random measurement error would cause analysts to underestimate the effect of income distribution on mortality.

[40]Examples of studies, from a variety of perspectives, seeking to identify the causal links between poverty and mortality in the United States, including the effects of poverty on motivation and time preferences, include Leigh (1983, 1986), Duleep (1986c), Fuchs (1982), Rosenzweig and Schultz (1982), and Grossman (1972).

[41]Refer to the discussion in part I.

References

Adelman, Irma. 1963. "An Econometric Analysis of Population Growth." *American Economic Review*, Vol. 52 (June), pp. 314-339.

Antonovsky, Aaron. 1967. "Social Class, Life Expectancy and Overall Mortality." *The Milbank Memorial Fund Quarterly*, Vol. 45 (April), pp. 31-73.

Attanasio, Orazio P. and Hilary W. Hoynes. 1995. "Differential Mortality and Wealth Accumulation." Working Paper No. 1526. Cambridge, MA: National Bureau of Economic Research (May).

Auster, Richard, Irving Leveson, and Deborah Sarachek. 1969. "The Production of Health: An Exploratory Study." *Journal of Human Resources*, Vol. 4, pp. 411-436.

Behrman, Jere R., Robin Sickles, Paul Taubman, and Abdo Yazbeck. 1991. "Black-White Mortality Inequalities." *Journal of Econometrics*, Vol. 50 (October/November), pp. 183-203.

Brenner, Harvey M. 1984. "Estimating the Effects of Economic Change on National Health and Social Well-Being." Joint Economic Committee, Washington, DC: Government Printing Office (S. PRT. 98-198).

Burtless, Gary. 1987. "Occupational Effects on the Health and Work Capacity of Older Men." *Work, Health, and Income Among the Elderly*, Gary Burtless (ed). Washington, DC: The Brookings Institution, pp. 103-142.

Caldwell, Steven and Theodore Diamond. 1979. "Income Differentials in Mortality: Preliminary Results Based on IRS-SSA Linked Data." *Statistical Uses of Administrative Records with Emphasis on Mortality and Disability Research*, Linda Delbene and Fritz Scheuren (eds.). Washington, DC: Social Security Administration, Office of Research and Statistics, pp. 51-60.

Center for Disease Control. 1990. *Morbidity and Mortality Weekly Report* (April 6).

Christenson, Bruce A. and Nan E. Johnson. 1995. "Educational Inequality in Adult Mortality: An Assessment with Death Certificate Data from Michigan." *Demography*, Vol. 32, No. 2 (May), pp. 215-229.

Crenshaw, Edward and Ansari Ameen. 1993. "Dimensions of Social Inequality in the Third World." *Population Research and Policy Review*, Vol. 12, pp. 297-313.

Duggan, James E., Robert Gillingham, John S. Greenlees. 1992. "Progressive Returns to Social Security? An Answer from Social Security Records." Unpublished paper. Office of Economic Policy. Washington, DC: Department of the Treasury.

Duleep, Harriet Orcutt. 1983. "The Socioeconomic Determinants of Mortality: The Role of Income." Paper presented at the Annual Meeting of the American Economic Association, 1983.

—. 1984a. "Implications for Social Security Policy-Making of Research in Mortality." *International Social Security Review*, No. 4. Geneva: International Social Security Association.

—. 1984b. "Social Security and International Differences in Mortality." Working Paper. Division of Retirement and Survivors, Office of Research and Statistics. Washington, DC: Social Security Administration.

—. 1986a. "Measuring the Effect of Income on Adult Mortality Using Longitudinal Administrative Record Data." *Journal of Human Resources*, Vol. 21, No. 2 (Spring), pp. 238-251.

—. 1986b. "Incorporating Longitudinal Aspects into Mortality Research." *Journal of Economic and Social Measurement*, Vol. 14, No. 2, pp. 121-134.

—. 1986c. *Poverty and Inequality in Mortality*. Unpublished doctoral dissertation. Department of Economics. Cambridge, Mass.: M.I.T.

—. 1989. "Measuring Socioeconomic Mortality Differentials Over Time." *Demography*, Vol. 26, No. 2 (May), pp. 345-351.

—. 1995. "Occupational Experience and Socioeconomic Variations in Mortality." ORS Working Paper No. 65. Division of Economic Research, Office of Research and Statistics. Washington, DC: Social Security Administration.

Elo, Irma T. and Samuel H. Preston. 1994. "Educational Differentials in Mortality: United States, 1979-85." Unpublished paper.

Feldman, Jacob J., Diane Makuc, Joel C. Kleinman, Joan Cornoni-Huntley. 1989. "National Trends in Educational Differentials in Mortality." *American Journal of Epidemiology*, Vol. 129, No. 5, pp. 919-933.

Fox, A. J. and D. R. Jones. 1985. "Social Class and Mortality Differentials: Artifact, Selection, or Life Circumstances?" *Journal of Epidemiology and Community Health*, Vol. 39, pp. 1-8.

Fuchs, Victor. 1974. "Some Economic Aspects of Mortality in Developed Countries." *The Economics of Health and Medical Care*, Mark Perlman (ed.). New York: John Wiley and Sons, pp. 174-193.

—. 1982. "Time Preference and Health: An Exploratory Study." *Economic Aspects of Health*, V. R. Fuchs (ed.). Chicago: University of Chicago Press, pp. 93-120.

Grossman, Michael. 1972. *The Demand for Health: A Theoretical and Empirical Investigation*. New York: Columbia University Press.

Hayward, Mark D., William R. Grady, Melissa A. Hardy, and David Sommers. 1989. "Occupational Influences on Retirement, Disability, and Death." *Demography*, Vol. 26, No. 3 (August), pp. 393-409.

International Labour Office. 1971. *Yearbook of Labor Statistics*. Geneva: International Labour Office.

—. 1972. *Yearbook of Labor Statistics*. Geneva: International Labour Office.

—. 1992. *Yearbook of Labor Statistics*. Geneva: International Labour Office.

Jain, Shail. 1975. *Size Distribution of Income*. Washington, DC: The World Bank.

Keil, Julian E., Susan E. Sutherland, Rebecca G. Knapp, and Herman A. Tyroler. 1992. "Does Equal Socioeconomic Status in Black and White Men Mean Equal Risk of Mortality?" *American Journal of Public Health*, Vol. 82, No. 8 (August), pp. 1133-1136.

Kitagawa, Evelyn M. and Philip M. Hauser. 1973. *Differential Mortality in the United States: A Study in Socioeconomic Epidemiology*. Cambridge: Harvard University Press.

Le Grand, J. 1987. "An International Comparison of Inequalities in Health." Welfare State Programme Discussion Paper No. 16, London School of Economics.

Leigh, J. Paul. 1983. "Direct and Indirect Effects of Education on Health." *Social Science and Medicine*, Vol. 17, No. 4 (September), pp. 227-234.

—. 1986. "Accounting for Tastes: Correlates of Risk and Time Preferences." *Journal of Post Keynesian Economics*, Vol. 9, No. 1 (Fall), pp. 17-31.

Leimer, Dean. 1995. "A Guide to Social Security Money's Worth Issues." *Social Security Bulletin*, Vol. 58, No. 2 (Summer).

Mare, Robert D. 1982. "Socioeconomic Effects on Child Mortality in the United States." *American Journal of Public Health*, Vol. 72, No. 6 (June), pp. 539-547.

—.1990. "Socioeconomic Careers and Differential Mortality among Older Men in the United States." *Measurement and Analysis of Mortality*, Jacques Vallin, Stan D'Souza, and Alberto Palloni (eds.). Oxford: Oxford University Press.

Menchik, Paul L. 1993. "Economic Status as a Determinant of Mortality Among Black and White Older Men: Does Poverty Kill?" *Population Studies*, Vol. 47, pp. 427-436.

Michal, Jan. 1973. "Income Distribution of Earnings and Household Incomes in Small Socialist Nations." *Review of Income and Wealth*, Vol. 19, pp. 407-428.

Moore, David E. and Mark D. Hayward. 1990. "Occupational Careers and Mortality of Elderly Men." *Demography*, Vol. 27, No. 1 (February), pp. 31-53.

Moriyama, Iwao M. and Lillian Guralnick. 1956. "Occupational and Social Class Differences in Mortality." *Trends and Differentials in Mortality*. New York: Milbank Memorial Fund, pp. 61-73.

Nakamura, Alice, Masao Nakamura, and Harriet Orcutt Duleep. 1990. "Alternative Approaches to Model Choice." *Journal of Economic Behavior and Organization*, Vol. 14, No. 1 (July), pp. 97-125.

National Center for Health Statistics. 1972. "Infant Mortality Rates: Socioeconomic Factors, United States." *Vital and Health Statistics*, Series 22, No. 14 (March).

Pappas, Gregory, Susan Queen, Wilbur Hadden, and Gail Fisher. 1993. "The Increasing Disparity in Mortality between Socioeconomic Groups in the United States, 1960 and 1986." *New England Journal of Medicine*, Vol. 329, No. 2 (July 8), pp. 103-109.

Power, Chris. 1994. "Health and Social Inequality in Europe." *British Medical Journal,* Vol. 308 (April), pp. 1153-1156.

Preston, Samuel H. 1976. *Mortality Patterns in National Populations*, New York: Academic Press.

—. 1995. "Presentation to the 1994-95 Advisory Council on Social Security." (February). Washington, DC: Social Security Administration.

Rainwater, Lee. 1974. *What Money Buys: Inequality and the Social Meanings of Income*, New York: Basic Books.

Rodgers, G. B. 1979. "Income and Inequality as Determinants of Mortality: An International Cross-Section Analysis." *Population Studies*, Vol. 33, pp. 343-351.

Rogers, Richard G. 1992. "Living and Dying in the U.S.A.: Sociodemographic Determinants of Death Among Blacks and Whites." *Demography*, Vol. 29, No. 2 (May), pp. 287-304.

Rogot, Eugene, Paul D. Sorlie, Norman J. Johnson, C. S. Glover, and D. W. Treasure. 1988. *A Mortality Study of One Million Persons by Demographic, Social, and Economic Factors: 1979-1981 Follow-up*. Department of Health and Human Services, NIH Publication No. 88-2896. Bethesda, MD: National Institutes of Health (March).

Rosen, Sherwin and Paul Taubman. 1979. "Changes in the Impact of Education and Income on Mortality in the U.S." *Statistical Uses of Administrative Records with Emphasis on Mortality and Disability Research*, Linda Delbene and Fritz Scheuren (eds.). Washington, DC: Social Security Administration, Office of Research and Statistics, pp. 61-66.

Rosenzweig, Mark and T. Paul Schultz. 1982. "The Behavior of Mothers as Inputs to Child Health: The Determinants of Birth Weight, Gestation, and Rate of Fetal Growth." *Economic Aspects of Health*, Victor R. Fuchs (ed.). Chicago: The University of Chicago Press.

Sawyer, Malcolm. 1976. "Income Distribution in OECD Countries." *OECD Economic Outlook: Occasional Studies*. Paris: Organization for Economic Cooperation and Development (July).

Schnitzer, Martin. 1974. *Income Distribution: A Comparative Study in the United States, Sweden, West Germany, East Germany, the United Kingdom, and Japan*. New York: Praeger.

Sen, Amartya. 1993. "The Economics of Life and Death." *Scientific American* (May), pp. 40-47.

Silver, Morris. 1972. "An Econometric Analysis of Spatial Variations in Mortality Rates by Race and Sex." *Essays in the Economics of Health and Medical Care*, Victor R. Fuchs (ed.). New York: Columbia University Press.

Slama, Jiri. 1978. "A Cross-Country Regression Model of Social Inequality." *Income Distribution and Economic Inequality*, Zvi Griliches, Wilhelm Krelle, Hans-Jurgen Krupp, and Oldrich Kyn (eds.). New York: John Wiley and Sons.

Smith, Ken R. and Cathleen D. Zick. 1994. "Linked Lives, Dependent Demise? Survival Analysis of Husbands and Wives." *Demography*, Vol. 31, No. 1 (February), pp. 81-94.

Sorlie, P., E. Rogots, R. Anderson, N. Johnson, and E. Backlund. 1992. "Black-White Mortality Differences by Family Income." *Lancet*, Vol. 340 (August 8), pp. 346-350.

Townsend, P., N. Davidson, and M. Whitehead. 1988. *Inequalities in Health.* London: Penguin.

United Nations. 1982. *Demographic Yearbook 1980*, New York: United Nations.

—. 1984. *Demographic Yearbook 1982*, New York: United Nations.

—. 1994. *Demographic Yearbook 1992*, New York: United Nations.

—. 1995. *Demographic Yearbook 1993*, New York: United Nations.

Vaughan, Denton R. and Clarise G. Lancaster. 1980. "Income Levels and Their Impact on Two Subjective Measures of Well-Being: Some Early Speculations From Work in Progress." *1979 Proceedings of the Social Statistics Section.* Washington, DC: American Statistical Association, pp. 271-276.

Waldmann, Robert J. 1992. "Income Distribution and Infant Mortality." *Quarterly Journal of Economics*, Vol. 107, No. 431 (November), pp. 1283-1302.

Weatherby, Norman L., Charles B. Nam, and Larry W. Isaac. 1983. "Development, Inequality, Health Care, and Mortality at the Older Ages: A Cross-National Analysis." *Demography*, Vol. 20, No. 1 (February), pp. 27-43.

Wiles, Peter. 1974. *Distribution of Income: East and West.* Amsterdam: North Holland.

Wilkinson, Richard G. 1986. "Income and Mortality." *Class and Health: Research and Longitudinal Data*, R. G. Wilkinson (ed.). London: Tavistock.

—. 1990. "Income Distribution and Mortality: A 'Natural' Experiment." *Sociology of Health and Illness*, Vol. 12, No. 4, pp. 391-412.

—. 1992a. "Income Distribution and Life Expectancy." *British Medical Journal*, Vol. 304, pp. 165-168.

—. 1992b. "National Mortality Rates: The Impact of Inequality?" *American Journal of Public Health*, Vol. 82, No. 8 (August), pp. 1082-1084.

Wolfson, Michael, Geoff Rowe, Jane F. Gentleman, and Monica Tomiak. 1993. "Career Earnings and Death: A Longitudinal Analysis of Older Canadian Men." *Journal of Gerontology: Social Sciences*, Vol. 48, No. 4 (July), pp. S167-S179.

Zarate, Alvan O. 1994. *International Mortality Chartbook: Levels and Trends, 1955-91.* Hyattsville, Maryland: Public Health Service. 1994

Zick, Cathleen D. and Ken R. Smith. 1991. "Marital Transitions, Poverty, and Gender Differences in Mortality." *Journal of Marriage and the Family*, Vol. 53, pp. 327-336.