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Double Jeopardy: Interaction Effects of Marital and Poverty Status on the Risk of Mortality*

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The purpose of this paper is to examine the hypothesis that marital and poverty status interact in their effects on mortality risks beyond their main effects. This study examines the epidemiological bases for applying an additive rather than a multiplicative specification when testing for interaction between two discrete risk factors. We specifically predict that risks associated with being nonmarried and with being poor interact to produce mortality risks that are greater than each risk acting independently. The analysis is based on men and women who were ages 25–74 during the 1971–1975 National Health and Nutrition Examination Survey I (NHANES I) and who were traced successfully in the NHANES I Epidemiologic Follow-Up Study in 1982–1984. Overall, being both poor and nonmarried places nonelderly (ages 25–64) men, but not women, at risk of mortality greater than that expected from the main effects. This study shows that for all-cause mortality, marital and poverty status interact for men but less so for women; these findings exist when interaction is assessed with either a multiplicative or an additive standard. This difference is most pronounced for poor, widowed men and (to a lesser degree) poor, divorced men. For violent/accidental deaths among men, the interaction effects are large on the basis of an additive model. Weak main and interaction effects were detected for the elderly (age 65+).

It is well known that married individuals live longer than the nonmarried, although the protective influences of marriage tend to accrue more to men than to women (Gove 1973; House, Landis, and Umberson 1988; Ross, Mirowsky, and Goldsteen 1990; Verbrugge 1979; Zick and Smith 1991a). Several explanations have been offered for this relationship (Litwak and Messeri 1989; Ross et al. 1990; Umberson 1987); they focus primarily on the higher levels of social and economic support and of healthy behaviors among the married in relation to the nonmarried.

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Studies of marital status differentials in mortality, with few exceptions, have not examined more explicitly the role of economic resources in this relationship. Moreover, studies that examine the relationship between socioeconomic status (SES) and mortality generally have not considered the possible role of marital status. The possible link between marital status and socioeconomic well-being, an important risk factor for mortality (Antonovsky 1967; Haan, Kaplan, and Camacho 1987; Marmot, Kogevinas, and Elston 1987; Waitzman 1988), is quite strong: the nonmarried have lower levels of financial and social resources (Carter and Glick 1976; Duncan 1984) than the married, as well as a higher risk of mortality. A clearer understanding of the mechanisms that link marital and socioeconomic status to mortality risk may be achieved by studying the joint effects of these two fundamental social characteristics.

The purpose of this paper is to examine the hypothesis that the risks of mortality associated with marital and economic status interact with each other such that persons who are both nonmarried and poor face excess mortality risks. The motive for this study is derived from the stress and health literature, which suggests that our understanding of the health effects of single stressors may be increased by studying how multiple stressors interact with each other.

OVERVIEW OF THE MAIN EFFECTS OF MARITAL AND SOCIOECONOMIC EFFECTS ON MORTALITY

Both being nonmarried and being poor have been shown to be strong risk factors for mortality. Although our purpose is to examine how these states interact with each other, this section briefly summarizes hypotheses and studies that have investigated their effects separately.

The literature emphasizes a direct relationship between marital status and risk-taking behavior. Several behaviors contribute significantly to an individual's risk of mortality; these behaviors may be affected by the presence of a marriage partner. Gove (1973) suggested that a spouse encourages healthier behaviors and compliance with medical treatments. Umberson (1987) and Venters (1986) found that both married men and married women engaged in fewer risky behaviors and generally had more orderly, more healthful lifestyles. Generally, wives tend to impose healthier medical regimens and eating habits on their husbands while also dissuading the use of alcohol and drugs (Ross et al. 1990). This finding may explain why men experience greater health benefits from marriage than do women.

Many observers have theorized that married individuals have access to more informal social support than do nonmarried individuals. This disparity, in turn, may create direct health effects by promoting a greater sense of well-being among the married (House et al. 1988; Litwak and Messeri 1989). In this scenario, health is enhanced regardless of exposures to stress levels. Alternatively, access to informal social support may produce indirect positive health effects by "buffering" the adverse effects of stress (Ross et al. 1990; Thoits 1982).

Some researchers have suggested that married individuals have lower mortality risks because marital selection mechanisms enhance marriage prospects among the healthy (Goldman 1993) and those who take fewer life-threatening risks. This explanation requires closer study because it suggests that people who are not married wish to be married. In most studies, the voluntarily never-married are included in the same group as those who wish to marry but have not yet done so. Moreover, in most large-scale surveys it is generally not known what proportions of never-married individuals consist of cohabitors and of homosexuals.

Measures of socioeconomic well-being also strongly predict the risk of adult mortality for both men and women (Catalano 1991). More than 20 years ago, Kitagawa and Hauser (1973) found that income was related inversely to mortality risk (but only for the nonelderly). Duleep (1986a) reported that for men, only those with the lowest levels of income had elevated risks of mortality.

Other studies have reported inverse relationships between SES and mortality risk based on other indicators of socioeconomic status. Feldman et al. (1989) found that mortality differentials across educational groups exist for both men and women during the middle and later years. Waitzman (1988) found a relationship between occupational status and mortality among mature men that persisted through the later years. Zick and Smith (1991a) showed not only that marital status affected mortality rates (mostly among men) but also that recent spells of poverty increased the risk of early death for both men and women. Haan et al. (1987) reported that residents of poor neighborhoods had a 70% higher mortality rate than residents of nonpoor areas. They suggested that the adverse effects of living in poor neighborhoods might be the result of poor housing, high crime, and unmeasured environmental contaminants. The Black Report concluded that the unemployed and those in lower-status occupations in the United Kingdom have significantly higher rates of morbidity and mortality (Black, Townsend, and Davidson 1982).

Several of these studies appear to support Syme and Berkman's (1976) argument that members of disadvantaged groups experience greater health risks across a variety of diseases because of generalized "compromised bodily defenses" above and beyond those which are attributable specifically to readily identifiable risk factors such as housing, diet, and access to high-quality medical care. Antonovsky (1987) argued that the positive association between social class and health may be related to a generalized "sense of coherence" (SOC) in people's lives, whereby SOC is affected by the comprehensibility, manageability, and meaningfulness of one's life. Both studies suggest that it is important to identify and describe subgroups within social classes in order to understand more clearly the mechanisms that lead to the generalized excess risk of mortality among the disadvantaged.

CONCEPTUALIZING THE INTERACTION OF MARITAL AND POVERTY STATUS

Three theoretical arguments are germane in discussing how marital status interacts with poverty status in affecting health status. First, Pearlin (1989) argued that stressful situations and enduring life problems do not arise independently from other problems; rather, disruptions in one domain of life are connected to other domains and affect them. Pearlin advanced the idea that events or chronic strains do not come one at a time but may arise in clusters: "primary" stressors lead to "secondary" stressors, which in turn create a new context that increases the adverse effects of both types of stressors. Pearlin argued that this point may explain why two persons suffering the same stressor may have different health responses: the social structural context in which the stressor occurs differs for these two individuals.

Second, marital status may affect mortality risks differentially through a different mechanism, depending on the individual's social context. Litwak and Messeri (1989) suggested that marital status affects the risk of mortality because spouses provide *informal* social support that is less available to the nonmarried. More formal organizations, such as the work place or a hospital, also may provide social support, although it is much more technical. Because *formal* social support is based on technical knowledge that is available only when conditions are somewhat more predictable, it may not be nearly as helpful for long-term behavioral problems that are addressed more effectively by informal social supports (e.g., asking one's spouse to stop smoking) or for problems that require immediate attention (e.g., pointing out imminent dangers while driving). In short, Litwak and Messeri (1989) argue that informal social supports are most effective when their influence can be marshaled quickly for problems requiring little technical expertise.

From this perspective, *informal* social support may have the greatest *relative* effect in reducing mortality rates when less *formal* social support is available. A poor person is likely to experience a health gain when he has access to informal social supports through a spouse because the spouse may provide a greater ongoing sense of social cohesion, orderliness, and certainty in an otherwise uncertain environment (Litwak and Messeri 1989). A more affluent person is likely to enjoy fewer *relative* benefits of informal social support because the conditions that are most responsive to informal social supports (i.e., uncertainty, unpredictability) may exist to a lesser degree.

Third, the mortality effects of informal social support also may interact with economic status for yet another reason, whereby the direction of the effects is different. Pearlin (1985) and Pearlin and Turner (1987) maintain, that in certain instances, marriages may increase social stress rather than alleviating it. If the job context is viewed as a potential stressor external to the marriage, marriage may act as a buffer when job stressors are temporary and do not impinge directly on the functioning of the household. If long-term employment prospects are bleak, however, resources critical to the functioning of the household may be threatened. More enduring job-related stressors may lead to chronic strains within the marriage, which can trigger additional secondary stress (Pearlin and Turner 1987). It is plausible that such external stressors are greatest among the poor or the near-poor, leading to more enduring external stress with potential carryover to the marriage and the family. The buffer that marriage might provide as a stress mediator among the poor may be overwhelmed more readily and thereby may threaten the stability of the marriage itself. In other words, marriage may provide weaker health benefits among the poor than among the nonpoor.

Conversely, a marriage may be a poor individual's most important or only source of meaningfulness in life, an important basis for enhancing one's sense of coherence (Antonovsky 1987) in view of the additional stresses of being economically disadvantaged. Therefore, the absence of this potential sense of coherence, due to the unmarried state, may have greater health consequences for the poor than for the nonpoor. This view suggests that the health benefits of marriage are greater for those who are less economically advantaged.

The mere presence of a spouse does not necessarily mean that health benefits automatically accrue to marriage partners. There is evidence that the (psychological) health advantage of married individuals over the nonmarried pertains more to the quality of the marriage than to marriage per se (Gove, Hughes, and Style 1983). Similarly, divorced and widowed individuals do not necessarily experience negative health effects, because divorce may be a liberating event and widowhood a blessing. Although most people expect to marry, some prefer to remain single; accordingly, never marrying may be an indicator of independence rather than of vulnerability or undesirability. Overall the health effects of marital status reported in this study are *net* effects of marriage because our data do not permit us to distinguish good from bad marriages. Similarly, we cannot determine whether a divorce or widowhood was a blessing or misfortune.

Finally, we recognize that the joint effects of marital and poverty status on the risk of mortality may be affected by other social dimensions. Given the unequal distribution of health-related resources and opportunities attributable to age and sex, we estimate separate models for various age-sex combinations.

ESTIMATING JOINT EFFECTS OF POVERTY AND MARITAL STATUS

We estimate two types of interaction models—additive and multiplicative—between two *discrete* risk factors (Koopman 1981; Rothman 1986: 311–326; Weed, Selmon, and Sinks 1988) for both all-cause and cause-specific mortality rates. We use some simple examples to illustrate the differences between additive and multiplicative interaction. In Table 1, hypothetical mortality data are presented for four poor/rich by married/single tables. The entries in the cells are relative risks (RR) for mortality, where RR = 1 for married, rich individuals. In the test for the presence of (multiplicative) interaction, a *product term* between the two discrete exposures is included, along with their main effects, when logistic regressions are used (Aiken and West 1991). If the regression coefficient for the product term is not different from 0, then no (multiplicative) interaction exists. This is true for the hypothetical data in Panel A (Table 1).

It is generally assumed that this criterion is the single yardstick with which to assess interaction. Surprisingly, little conceptual justification for this specification appears in the literature. Recent theoretical work in epidemiology suggests alternative models, which have been integrated into a general framework called epigenesis theory (Koopman and Weed 1990); this theory refers to the processes that explain disease patterns in populations. The basic ideas of epigenesis theory are outlined here.

People die (or become ill) for many reasons. Death may be the result of a single measurable cause with a single component (e.g., falling off a cliff), or "the" cause may have several measurable components (e.g., smoking in a high-stress job while being

Table 1. Hypothetical Data Illustrating Differences in Inferences When Multiplicative Versus Additive Interaction Models Are Used

Panel A: Consistent with Multiplicative Interaction Prediction (Complementary Model)

	Poor	Rich
Married	10	1
Single	50	5

Panel B: Consistent with Additive Interaction Prediction (Separate Process Model)

	Poor	Rich
Married	10	1
Single	14	5

Panel C: Results Lying between Additive and Multiplicative Interaction Predictions (Intermediate Model)

	Poor	Rich
Married	10	1
Single	30	5

Panel D: Example of Interaction Predictions That Are Similar for Both Additive and Multiplicative Models

	Poor	Rich
Married	1.40	1.00
Single	1.65	5.00

Note: Cell values are relative risks; the rich and married serve as the comparison group.

genetically predisposed to heart disease); all of the components must exist before death occurs. Any *set of components* that leads to a death is called a *sufficient cause*. Sufficient causes have two important dimensions. First, they are composed of both measured and unmeasured components. In the case of sufficient causes that contain only one measured component, other components may need to be present if the death is to occur, but these are unmeasured. Second, such causes may involve components that exist in more than one sufficient cause. For example, genetic predisposition to heart disease may be a component both of a sufficient cause that also includes cigarette smoking and of a sufficient cause that includes job stress.

Epigenesis theory relates "three aspects of pathogenesis involving how [multiple] measured [independent] variables interact" (Koopman and Weed 1990:366). These three aspects of components of sufficient causes determine how they interact with one another in their effects on disease risk. The salient qualities of the risk factors are determined by the responses to three questions. First, are the measured variables operating within the same illness-causing (pathogenic) process? Second, do the measured variables have the same causal action? And third, are the measured variables involved in the only pathogenic process at work or are there many such processes?

Koopman and Weed show that when two measured risk factors have different causal effects but are present in every pathogenic process leading to the disease, then one would predict that the relative risk (RR) of death for single, poor individuals will be equal to the relative risk of being exposed only to one risk factor times the relative risk of being exposed only to the other risk factor:

$$RR(s,p) = RR(s,r) \times RR(m,p), \tag{1}$$

where s = single, m = married, p = poor, and r = rich. In this case, the two risk factors have *complementary relations*, the basis for the traditional multiplicative interaction model. This circumstance is most likely to occur in studying very specific diseases (Koopman and Weed[1] 1990). The complementary relations model holds for the data shown in Table 1, Panel A: RR(s,p) = 50, RR(s,r) = 5, and RR(m,p) = 10, so that 50 = 5 x 10. This finding shows that the joint effects of marital and poverty status are exactly what would be predicted on the basis of the main effects (i.e., no multiplicative interaction).

The additive interaction model applies when measured risk factors have different pathogenic processes that may work in different disease processes. For our study, this would mean that poverty increases the risk of death for reasons other than nonmarriage.[2] Koopman and Weed (1990) define these variables as having *separate process relations*. In this situation, the *predicted* relative risk of death for single, poor individuals would be approximately:

$$RR(s,p) = RR(s,r) + RR(m,p) - 1. \tag{2}$$

The separate process relations model holds for the data shown in Table 1, Panel B: RR(s,p) = 14, RR(s,r) = 5, and RR(m,p) = 10, so that 14 = 5 + 10 − 1. This finding shows that the joint effects of marital and poverty status are exactly what would be predicted from the main effects (i.e., no additive interaction).

As health outcomes become less specific (e.g., all heart disease), it is more likely that several pathogenic processes will be at work and more likely that the two risk factors will complement one another for some processes but not for others. In this situation, the two risk factors would have a RR that would be *intermediate* between the two predictions above, as shown in Table 1, Panel C.[3]

As a practical matter, the predictions made by the multiplicative and additive interaction models are similar when the single-exposure RRs are small (RR<1.5). In Table 1, Panel D, for example, the multiplicative model predicts that the RR for the doubly exposed (poor, single) will be 1.4 x 1.2 = 1.68. The additive model predicts that the RR will be 1.4 + 1.2 − 1 = 1.60.

Epigenesis theory suggests that no single existing criterion or scale can describe the joint effects of two independent discrete risk factors for all situations. Koopman and Weed (1990) suggest using both the additive and the multiplicative scales because they establish benchmarks that allow one to assess whether the interactions are consistent with the complementary, the separate, or the intermediate relations model.

Finally, interaction effects between discrete risk factors exist only when the relative risk of persons doubly exposed differs from the relative risk predicted by the multiplicative or the additive model. In other words, interaction exists when the following conditions hold:

$$\text{Multiplicative interaction: } RR(s,p) > RR(s,r) \times RR(m,p);$$

$$\text{Additive interaction: } RR(s,p) > RR(s,r) + RR(m,p) - 1.$$

If the RR of the doubly exposed exceeds the multiplicative model prediction, then it also will exceed the additive model prediction. When the RR of the doubly exposed does not exceed the traditional multiplicative model prediction, however, then it is still not known whether interaction effects are present on an additive scale.

DATA

This investigation is based on the National Health and Nutrition Examination Survey (NHANES I) and the NHANES I Epidemiologic Follow-Up Study (NHEFS). Although extensive documentation on NHANES I and NHEFS is available elsewhere (National Center for Health Statistics 1987), some important survey characteristics are worth describing here. NHANES I was conducted between 1971 and 1975, and included 20,729 adults between 25 and 74 years of age. Numerous social, economic, and health-related variables were collected during this time by interview and through a physician's examination. NHEFS, conducted between 1982 and 1984, provides information on subsequent morbidity and mortality among NHANES I sample members who underwent the examination. Approximately 93% of the examined cohort was traced successfully; this procedure yielded 1,935 deaths. Individuals who were traced but were not interviewed were recorded as alive at the date of last contact.

The sample used for this study includes all adults who were either black or white and were between ages 25 and 74 at baseline. The sample sizes and the number of deaths used in the analyses are summarized in Table 2. Annual death rates by marital and poverty status for four age-sex categories are shown in Table 3.

All independent variables used in these analyses were measured during NHANES I. We measured marital status with three dummy variables: widowed, divorced/separated, and never married; married was the excluded category. Poverty status is based on the U.S. Census Bureau definition of poverty, namely the income-to-needs ratio. A ratio of 1 means that a household is at the poverty line (i.e., enough income to meet a minimal standard of living). A ratio of less than 1 signifies a household that is below the poverty line; a ratio of 2 indicates a household with income twice the designated minimal standard of living. For the analyses presented below, poor households are defined as having an income-to-needs ratio of 1.50 or less.

Potential confounder variables are smoking status (ever/never), physical activity (little or no activity at work or recreationally), race (black/white), serum cholesterol level, body mass index (kg/m^2 for men, $kg/m^{1.5}$ for women), and hypertension (systolic blood pressure greater than 140 mm Hg or diastolic blood pressure greater than 90 mm Hg).

Table 2. Unweighted Sample Sizes and Deaths by Age and Sex

				Cause-Specific Deaths		
Age	Sex	N	All Deaths	Heart	Cancer	Accidental
25–64	Men	3,586	361	158	97	37
	Women	5,789	231	93	79	25
	Subtotal	9,375	592	251	176	61
65–74	Men	1,729	811	427	165	29
	Women	1,905	572	279	117	19
	Subtotal	3,634	1,383	706	282	48
Grand Total		13,009	1,975	957	458	109

Note: Sample sizes and deaths are based on the number of respondents used in the survival analyses after deleting cases that had missing values for the dependent and independent variables.

Some researchers have suggested that the relationship between health and marital and poverty status may be the result of marital selection (Goldman 1993). This perspective suggests that poor health status reduces the chances of marriage or that it destabilizes

Table 3. Unweighted Annual Death Rates per 100,000 by Age, Sex, Marital Status and Poverty Status

				Cause-Specific Deaths					
		All Deaths		Heart		Cancer		Accidental	
Age	Sex	Nonpoor	Poor	Nonpoor	Poor	Nonpoor	Poor	Nonpoor	Poor
25–64	Men								
	Married	804	659	369	680	209	468	66	213
	Widowed	1,290	7,634	645	3,817	645	763[a]	[b]	[b]
	Divorced/sep.	577	2,063	346	688	173	275	173	550
	Never married	1,652	5,859	526	2,828	601	1,818	150	606
	Women								
	Married	304	483	123	157	121	133	36	48
	Widowed	785	1,092	392	578	56[a]	514	[b]	128
	Divorced/sep.	460	1,032	184	397	92	317	138	[b]
	Never married	462	663	178	221	249	126	36[a]	63
65–74	Men								
	Married	5,163	6,589	2,684	3,451	1,233	1,112	128	257
	Widowed	6,949	8,142	4,230	4,384	1,057	1,253	302	418
	Divorced/sep.	5,687	8,808	3,318	3,368	711	1,554	474	777
	Never married	6,130	7,886	4,215	4,101	1,916	1,262	383[a]	[b]
	Women								
	Married	2,848	3,566	1,350	1,748	592	856	166	71
	Widowed	3,404	4,070	1,639	1,974	567	780	126	73
	Divorced/sep.	1,945	3,022	1,135	824	486	1,099	[b]	[b]
	Never married	3,879	2,605	3,017	1,403	431[a]	601	[b]	200[a]

[a] Based on only one death.
[b] No deaths.

existing marriages. Similar arguments have been made with respect to economic status on the grounds that poor health might lead to more spells of poverty (Duleep 1986b; Rosen and Taubman 1982). To consider this possibility, we include a global baseline health measure from NHANES I among the mortality risk factors. The NHANES I survey included a global health status measure, but unfortunately not for all respondents. Therefore we constructed a simple health measure for all subjects, which measured whether the respondent had a history of heart problems, high blood pressure, diabetes, cancer, benign tumors, or musculoskeletal problems. Although this measure does not exhaust all possible health problems at baseline, it represents many of the major health conditions that might affect an individual's prospects for marriage or for remaining married, as well as his or her level of economic well-being.

The marital selection problem is less likely to be a factor for the poverty-mortality relationship based on these data because poverty generally is not measured near the time of death. When studies that rely on measures of economic status are taken near the time of death, they run the risk of measuring declines in economic status that are a consequence rather than a precursor of an impending death (Duleep 1986b; Zick and Smith 1991b).

All regression results are based on proportional hazards regression models. The outcome of interest is time between the NHANES I examination date and death. Death dates are obtained from death certificates. These regressions also include, as an independent variable, the respondent's age at the time of the NHANES I examination. All individuals who were alive at the time of NHEFS (1982–1984) were given a censorship time, defined as the difference between the date of the NHANES I interview and the date of the NHEFS interview or the date last seen alive.

The NHANES I and the NHEFS data are based on a nonsimple random sampling design. The analyses reported here are based on unweighted results without adjustments for variance estimation. According to a study by Makuc and Kleinman (1986) based on survival analyses using NHANES I and NHEFS, standard errors based on this simpler approach were very similar to those obtained using weighted and resampling (jackknife) methods.[4]

RESULTS

This analysis involves two general phases. First we estimate *main effects* models of marital and poverty status before and after making adjustments for major mortality risk factors. Both sets of models control for age and race. If married individuals continue to enjoy health advantages once these additional factors have been taken into consideration, this outcome suggests that marriage offers ongoing health benefits beyond its influence on these traditional risk factors (Umberson 1987; Venters 1988). If the poor persist in experiencing higher death rates once these adjustments have been made, then the poor may be viewed as having a "generalized susceptibility" (Syme and Berkman 1976) to poor health.

In the second phase of the analysis, we estimate *interaction* models before and after making similar statistical adjustments. We examine both multiplicative and additive interaction specifications to more fully assess the nature of the joint effects.

Main Effects of Marital and Poverty Status

Tables 4 and 5 list the relative risks for the main effects of marital and poverty status for four sex-age combinations for all-cause and cause-specific mortality. Four models are reported for each age-sex subsample, one for all-cause mortality, and one each for diseases of the circulatory system, cancer, and accidental mortality.

Among men (Table 4), the effects of marital and poverty status are substantial for the 25–64 age group but virtually absent for those over age 65, particularly after controlling for major mortality risk factors. Other researchers also have found weak effects of marital/poverty status at older ages (House et al. 1990; Kitagawa and Hauser 1973). Among the fully adjusted models for nonelderly men, being divorced or being poor nearly doubles the risk of all-cause mortality in relation to being married or being nonpoor (RR = 1.97 and 1.89 respectively).

We also estimated main effects models for deaths due to diseases of the circulatory system (ICD-9 390–459), malignant neoplasms (ICD-9 140–239), and all injuries (ICD-9 E800-E999). Because NHEFS provides information on all causes of death reported on the death certificate, we determined deaths for each cause by reviewing the multiple cause-of-death file for all underlying, associated, and contributing causes of death. We estimated regressions that model the time to death for a particular cause of death; we treated deaths from other causes as censored observations.

The significant mortality effects among divorced men exist for all three causes of mortality. Table 4 shows that the strongest effects of divorce are for accidental deaths (RR = 2.59). One could argue that risk-taking behavior or living in risky situations may lead to a greater chance of divorce as well as of accidental death. Insofar as the analysis controls

Table 4. Relative Risk Estimates of Marital and Poverty Status for All-Cause and Cause-Specific Mortality by Age, Based on Proportional Hazards Models: Males

	Age 25–64				Age 65–74			
	All Causes	Heart/ CVD	Cancer	Violent/ Accident	All Causes	Heart/ CVD	Cancer	Violent/ Accident
Controls for Age and Race								
Married	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Widowed	1.69*	1.85	1.31	[b]	1.18	1.31*	0.95	1.89
Div/Sep	2.29***	2.12***	2.81***	2.65**	1.19	1.36	1.31	0.82
Never married	1.25	1.29	0.99	2.75**	1.30*	1.18	0.97	3.69***
Nonpoor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poor	2.00***	1.83***	1.77**	3.38***	1.27***	1.20*	0.95	1.45
Controls for Age and Race and Other Mortality Risk Factors[a]								
Married	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Widowed	1.63*	2.06*	1.07	[b]	1.19	1.34*	0.95	1.84
Div/Sep	1.97***	1.89**	2.25***	2.59*	1.18	1.35	0.99	0.72
Never married	1.40	1.59	1.03	2.96**	1.28*	1.21	0.98	3.16**
Nonpoor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poor	1.89***	1.72***	1.69**	3.35***	1.08	1.01	0.87	1.25

[a] Model includes age, physical activity, serum cholesterol, hypertension, body mass index, baseline health status, and smoking status as control variables.

[b] The sample for this marital status/poverty status/cause of death category contained too few cases to generate reliable relative risk estimates.

* $p < .10$; ** $p < .05$; *** $p < .01$.

for some risk-taking behavior (e.g., smoking) and exposure to greater risks (e.g., being poor), we view the strong effect of divorce on mortality more as a cause than as the result of factors that lead to accidental death. A similar interpretation holds for the relationship between being never married and accidental death (RR = 2.96).

Experiencing a spell of poverty also increases significantly the risk of all-cause mortality for men age 25–64 (RR = 1.89). This risk is greatest for accidental death (RR = 3.35).

Table 5 reports similar figures for women. For those age 25–64, never-married women suffer the most significant mortality risks for all-cause and heart disease mortality. These risks are reduced slightly after controlling for multiple mortality risk factors. We find only suggestive evidence ($p<.10$), however, that recent spells of poverty elevate the all-cause mortality risk of these women above that of their nonpoor counterparts. The risk of mortality for elderly women is not affected by marital or poverty status except among the poor, who have a slightly elevated risk of dying of cancer (RR = 1.42, $p<.10$).

Interaction Effects of Marital and Poverty Status

The joint effects of being both nonmarried and poor on the excess risk of mortality are reported in Tables 6 through 9. For each table, estimated joint effects between four marital

Table 5. Relative Risk Estimates of Marital and Poverty Status for All-Cause and Cause-Specific Mortality by Age, Based on Proportional Hazards Models: Females

	Age 25–64				Age 65–74			
	All Causes	Heart/ CVD	Cancer	Violent/ Accident	All Causes	Heart/ CVD	Cancer	Violent/ Accident
Controls for Age and Race								
Married	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Widowed	1.14	1.35	0.90	1.70	1.08	1.10	0.87	0.70
Div/Sep	1.31	1.37	1.52	1.35	0.90	1.20	0.71	1.21
Never married	2.15***	2.44**	1.81	2.30	0.68	0.62	0.94	[b]
Nonpoor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poor	1.38**	1.45	1.40	1.45	1.15*	1.15	1.44*	0.53
Controls for Age and Race and Other Mortality Risk Factors[a]								
Married	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Widowed	1.13	1.25	0.78	1.73	0.99	1.02	0.81	0.68
Div/Sep	1.27	1.31	1.46	1.19	0.76	1.00	0.63	1.19
Never married	1.92***	2.43**	1.78	2.04	0.63	0.61	0.89	[b]
Nonpoor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poor	1.29*	1.20	1.47	1.35	1.15	1.13	1.42*	0.56

[a] Model includes age, physical activity, serum cholesterol, hypertension, body mass index, baseline health status, and smoking status as control variables.

[b] The sample for this marital status/poverty status/cause of death category contained too few cases to generate reliable relative risk estimates.

* $p < .10$; ** $p < .05$; *** $p < .01$.

status categories and two poverty groups are reported in the first two columns of RRs. We emphasize the RRs for each poor, nonmarried group relative to those for nonpoor, married individuals. The third and fourth columns list predicted RRs under the multiplicative and additive interaction models, respectively, with the assumption of no interaction beyond the main effects. Two large sets of RRs are estimated, one does not control for major mortality risk factors (Panel A), and the other does so (Panel B). The discussion focuses on the RRs marked with superscript b in Panel B.

Table 6 summarizes estimated RRs for all-cause mortality for poverty-marital status combinations among men and women. RRs also are presented for all nonmarried individuals collapsed into a single group. The results in Table 6 apply to men and women age 25–64. The weak effects of marital and poverty status reported in Tables 4 and 5 persisted for elderly men and women in interaction models; therefore these results are not shown.

For all-cause male mortality, two general patterns are clear: 1) for all marital status categories, the poor have higher mortality rates than the nonpoor and 2) for each poverty group, the nonmarried have higher mortality risks than the married.

The estimated RR for poor widowed men is 4.03. The multiplicative model shows that the estimated RR for this group must exceed 1.80 if an interaction exists between widowhood and poverty. The comparable RR in the additive model is nearly identical. Therefore the widowed poor experienced an excess risk of mortality beyond that suggested by the effects of poverty or widowhood alone.

Differences in the assessment of interaction effects are illustrated more clearly in the case of divorce. The multiplicative model predicted a RR of 3.42; the additive model predicted a RR of 2.70. The data show that poor, divorced men have a RR of 3.78. These results indicate a greater discrepancy between the estimated RR and the no-interaction prediction based on the additive model. This finding underscores a general phenomenon in assessing interactions: interaction effects between two risk factors are more likely to be detected with the use of an additive specification than with the use of a multiplicative specification.

The bottom half of Table 6 lists the results for women age 25–64. In Panel B, the estimated RRs for each poverty-marital status category are similar to those predicted when no interaction is assumed for either the additive or the multiplicative model. We find only slight evidence of an interaction effect for poor, never-married women.

We also estimated interaction models for mortality from diseases of the circulatory system (heart disease/cerebrovascular disease) for nonelderly men and women (Table 7) and for cancer and accidental deaths for men only (Tables 8 and 9). Models for these two latter causes of death are not reported for women because the weak main effects reported in Table 4 were also found in these female interaction models.

In Table 7, Panel B for men, the poor widowed and the poor divorced experienced risks of mortality beyond the main effects of poverty and marital status. In particular, the predicted no-interaction RR thresholds in both the additive and the multiplicative model are around 1.7–2.0; the estimated RRs for the poor divorced and the poor widowed are twice these values. A key difference between these results for heart disease and those for all-cause mortality is that the values for the never-married poor are *below* the no-interaction thresholds. This finding may be a function of competing risks among poor never-married men, who may be at greater relative risk of mortality from other causes of death (i.e., violent or accidental death; see Table 9 below).

Among women, however, the poor never-married experience the greatest interactive effect, whether it is based on a multiplicative or an additive interaction model. In the main effects model (Table 5), the RR of being never married is 2.44 for heart disease mortality. In Table 7, Panel B, the female never-married RR for heart disease mortality is 1.87 for the nonpoor and 3.58 for the poor.

Table 6. Relative Risks of All-Cause Mortality by Marital and Poverty Status: Men and Women 25–64

Men, Panel A: Adjustments for Age-Race Only

	Nonpoor	Poor	Interaction Predictions: Multiplicative	Interaction Predictions: Additive
Married	1.00	1.86	—	—
Widowed	1.00	4.54[b]	1.86[b]	1.86[b]
Divorced	2.13	4.75[b]	3.96[b]	2.99[b]
Never Married	1.14	2.58[b]	2.12[b]	2.00[b]
All Nonmarried Combined	1.55	3.74[b]	2.84[b]	2.38[b]

Men, Panel B: Adjustments for Age-Race and Additional Mortality Risk Factors[a]

	Nonpoor	Poor	Interaction Predictions: Multiplicative	Interaction Predictions: Additive
Married	1.00	1.79	—	—
Widowed	1.01	4.03[b]	1.80[b]	1.78[b]
Divorced	1.91	3.78[b]	3.42[b]	2.70[b]
Never Married	1.30	2.73[b]	2.33[b]	2.09[b]
All Nonmarried Combined	1.53	3.41[b]	2.72[b]	2.31[b]

Women, Panel A: Adjustments for Age-Race

	Nonpoor	Poor	Interaction Predictions: Multiplicative	Interaction Predictions: Additive
Married	1.00	1.31	—	—
Widowed	1.15	1.51[b]	1.51[b]	1.46[b]
Divorced	1.29	1.80[b]	1.69[b]	1.60[b]
Never Married	1.80	3.40[b]	2.36[b]	2.21[b]
All Nonmarried Combined	1.33	1.88[b]	1.73[b]	1.63[b]

Women, Panel B: Adjustments for Age-Race and Additional Mortality Risk Factors[a]

	Nonpoor	Poor	Interaction Predictions: Multiplicative	Interaction Predictions: Additive
Married	1.00	1.27	—	—
Widowed	1.11	1.47[b]	1.41[b]	1.38[b]
Divorced	1.26	1.64[b]	1.60[b]	1.53[b]
Never Married	1.84	2.55[b]	2.34[b]	2.11[b]
All Nonmarried Combined	1.30	1.68[b]	1.63[b]	1.55[b]

[a] Smoking status, hypertension, obesity, cholesterol, baseline health status, and physical activity.
[b] Emphasized in text.

Table 7. Relative Risks of Heart Disease Mortality by Marital and Poverty Status: Men and Women 25–64

Men, Panel A: Adjustments for Age-Race Only

	Nonpoor	Poor	Interaction Predictions: Multiplicative	Interaction Predictions: Additive
Married	1.00	1.62	—	—
Widowed	1.06	4.50[b]	1.72[b]	1.68[b]
Divorced	1.46	4.68[b]	2.37[b]	2.08[b]
Never Married	1.55	1.85[b]	2.51[b]	2.17[b]
All Nonmarried Combined	1.43	3.50[b]	2.32[b]	2.05[b]

Men, Panel B: Adjustments for Age-Race and Additional Mortality Risk Factors[a]

	Nonpoor	Poor	Interaction Predictions: Multiplicative	Interaction Predictions: Additive
Married	1.00	1.52	—	—
Widowed	1.18	4.75[b]	1.79[b]	1.70[b]
Divorced	1.35	3.84[b]	2.05[b]	1.87[b]
Never Married	1.89	2.17[b]	2.87[b]	2.41[b]
All Nonmarried Combined	1.51	3.45[b]	2.30[b]	2.03[b]

Women, Panel A: Adjustments for Age-Race Only

	Nonpoor	Poor	Interaction Predictions: Multiplicative	Interaction Predictions: Additive
Married	1.00	1.05	—	—
Widowed	1.20	1.70[b]	1.26[b]	1.25[b]
Divorced	1.28	1.69[b]	1.34[b]	1.33[b]
Never Married	1.83	3.76[b]	1.92[b]	1.88[b]
All Nonmarried Combined	1.33	1.90[b]	1.40[b]	1.38[b]

Women, Panel B: Adjustments for Age-Race and Additional Mortality Risk Factors[a]

	Nonpoor	Poor	Interaction Predictions: Multiplicative	Interaction Predictions: Additive
Married	1.00	1.03	—	—
Widowed	1.10	1.58[b]	1.13[b]	1.13[b]
Divorced	1.29	1.52[b]	1.33[b]	1.32[b]
Never Married	1.87	3.58[b]	1.93[b]	1.90[b]
All Nonmarried Combined	1.28	1.75[b]	1.32[b]	1.31[b]

[a] Smoking status, hypertension, obesity, cholesterol, baseline health status, and physical activity.
[b] Emphasized in text.

The interaction effects on the risks of cancer mortality show that widowed and never-married men who are poor have lower than expected risks, on the basis of either interaction model (Table 8).[08] That is, poor men in these marital status categories have lower cancer mortality rates than their nonpoor counterparts. This finding was unanticipated but again may reflect the effects of competing risks (i.e., poor, nonmarried men may be more likely to die sooner from other causes) although other explanations cannot be ruled out. For divorced men, the adverse cancer effects of being poor rather than nonpoor persist. The interactive effects are present, however, only on the basis of the additive interaction model.

Overall, poverty-marital status interactions do not appear to be present in any systematic fashion for cancer mortality among men (or women). These results must be examined further on the basis of a more highly detailed description of various types of cancer, particularly those which have a strong behavioral component (e.g., lung cancer).

Marital and poverty status have the largest interaction effects for accidental or violent causes among men age 25–64, but only on the basis of the additive model (Table 9). These findings are consistent with Koopman and Weed's (1990) intermediate model. For poor divorced and never-married men (too few accidental deaths occurred among widowed men age 25–64 to permit conclusions to be drawn), the observed RRs clearly exceed the no-interaction predictions from the additive model but are well below the thresholds for the multiplicative model. *This is the clearest instance in which the two types of interaction model produce opposing conclusions about interactions between marital and poverty status.*

DISCUSSION

Numerous studies have found a higher risk of mortality for nonmarried than for married individuals; similarly, the poor have been shown to have higher mortality risks than the

Table 8. Relative Risks of Cancer Mortality by Marital and Poverty Status: Men 25–64

Panel A: Adjustments for Age-Race Only

			Interaction Predictions	
	Nonpoor	Poor	Multiplicative	Additive
Married	1.00	1.91	—	—
Widowed	1.84	1.53[b]	3.51[b]	2.75[b]
Divorced	2.83	5.13[b]	5.41[b]	3.74[b]
Never Married	1.38	1.28[b]	2.64[b]	2.29[b]
All Nonmarried Combined	2.14	2.97[b]	4.09[b]	4.05[b]

Panel B: Adjustments for Age-Race and Additional Mortality Risk Factors[a]

			Interaction Predictions	
	Nonpoor	Poor	Multiplicative	Additive
Married	1.00	1.91	—	—
Widowed	1.62	1.11[b]	3.04[b]	2.50[b]
Divorced	2.33	3.85[b]	4.38[b]	3.21[b]
Never Married	1.50	1.24[b]	2.82[b]	2.32[b]
All Nonmarried Combined	1.95	2.42[b]	3.67[b]	2.83[b]

[a] Smoking status, hypertension, obesity, cholesterol, baseline health status, and physical activity.
[b] Emphasized in text.

Table 9. Relative Risks of Accidental Death by Marital and Poverty Status: Men 25–64

Panel A: Adjustments for Age-Race Only

			Interaction Predictions	
	Nonpoor	Poor	Multiplicative	Additive
Married	1.00	3.42	—	—
Widowed	[c]	[c]	[c]	[c]
Divorced	2.52	9.34[b]	8.62[b]	4.94[b]
Never Married	2.94	8.93[b]	10.05[b]	5.36[b]
All Nonmarried Combined	2.47	8.33[b]	8.45[b]	4.89[b]

Panel B: Adjustments for Age-Race and Additional Mortality Risk Factors[a]

			Interaction Predictions	
	Nonpoor	Poor	Multiplicative	Additive
Married	1.00	3.65	—	—
Widowed	[c]	[c]	[c]	[c]
Divorced	2.79	8.66[b]	10.18[b]	5.44[b]
Never Married	3.58	9.26[b]	13.07[b]	6.23[b]
All Nonmarried Combined	2.87	8.12[b]	10.48[b]	5.52[b]

[a] Smoking status, hypertension, obesity, cholesterol, baseline health status, and physical activity.
[b] Emphasized in text.
[c] No Deaths.

nonpoor. To our knowledge, no one has studied how these two important socioeconomic characteristics may generate joint, synergistic effects, despite conceptual arguments suggesting that such joint effects might exist. Pearlin (1989), for example, wrote that health risks for one chronic stressor may vary depending on the presence of another important chronic stressor; one stressor, in fact, may be related to a second so that their coexistence is the crucial characteristic. Litwak and Messeri (1989) stated that the health benefits of informal social support may occur only in the presence of conditions that are amenable to the influences of such support. Syme and Berkman (1976) recommended that we identify subgroups across socioeconomic classes (i.e., groups representing the joint effects of class and other sociomedical risk factors) which are at risk of mortality, so as to understand more clearly the processes leading to a generalized excess risk of mortality among the poor. This study was motivated by these arguments; it represents the first attempt to estimate empirically the joint effects of marital and poverty status on mortality risk.[5] Moreover, the bases for assessing joint effects of risk factors in epidemiology and medical demography were discussed, elaborated, and applied to a large national longitudinal data set by using principles from epigenesis theory.

Overall we found that exposure to both risk factors creates a particularly high risk of both all-cause and heart disease mortality for widowed and divorced nonelderly men and for never-married nonelderly women. On the basis of epigenesis theory, results for the men show that joint effects of being both previously married and poor are more consistent with the multiplicative than with the additive model, although these effects exceed the prediction made in the multiplicative model. This finding suggests that marital and poverty status play roles, both direct and indirect, in all processes leading to all-cause and heart disease mortality, although these causal roles differ. More important, when these two risk factors exist together, they generate synergistic effects. Less clear, according to this study, is why synergistic effects exist among poor nonelderly women, but only among the never married.

What do these findings suggest about the role of marriage and poverty in altering men's risks of mortality? Because heart disease is the greatest contributor to all-cause mortality, we focus on it here. For nonelderly men, the ability of a marriage to confer relative health benefits is greatest when other health-enhancing conditions are absent. Nonpoor men are more likely to have access to resources that promote health and make treatment available for illnesses that do occur. Marriage may be viewed as only one of several health-enhancing resources; thus the relative health benefits that are produced through marriage are more incremental than substantial. For the poor, who have fewer health-enhancing resources, marriage is likely to play a larger role because it may be one of only a few important sources of support available. For example, poor widowed men are three times as likely as poor married men to die of heart disease (RRs of 4.75 and 1.52; see Table 7); the comparable RRs are 1.18 and 1.00 among the nonpoor. For poor women, those who have never married are 3.5 times as likely to die of heart disease as those who are married; this figure is .87 among the nonpoor. Further work is needed to explore more fully the reasons for these gender differences in joint effects.

For male cancer mortality, the observed joint effects are less than that predicted by the additive model. This occurs when RR>1 for the first variable in one category of the second variable, while RR<1 for the other category of that variable. In Table 8, for example, among the nonpoor, the never-married men are 50% more likely to die of cancer than the married men; among the poor, the married men have a 50% greater chance of dying from cancer than the never-married. This finding is potentially important but unexpected because it suggests that some segments of the poor population (i.e., the never-married) appear to fare better than their nonpoor counterparts. These results are only suggestive because they are not entirely consistent across all married categories and are based on treating all cancer deaths in the same way.

Marital and poverty status interact with respect to accidental or violent death among men in a way that is consistent with the intermediate model. This finding suggests that several pathogenic processes are at work (e.g., the process of drowning is different from the process for suicide) and that the two risk factors complement one another for some processes but not for others.

This "intermediate" joint effect is compatible with Litwak and Messeri's (1989) prediction that the largest beneficial health effects of informal social support (e.g., access to a spouse) occur when individuals live in more unpredictable conditions and when technical expertise is less effective or less useful, as is the case with accidental deaths. Their analysis focuses only on the main effects of social support, although their approach suggests how other social dimensions may play a role. In particular, poor individuals are more likely than nonpoor persons to satisfy the relevant conditions (e.g., unpredictability) and hence would benefit most from the higher levels of informal social support derived from being married. Others have reported that the nonmarried have higher rates of accidental and violent death (Kaprio, Koskenvuo, and Rita 1987; Smith, Mercy, and Conn 1988), but they have not assessed how this relationship might be exacerbated by socioeconomic circumstances.

In future studies testing for the interaction between poverty and marital status, investigators should seek to obtain additional measures of life conditions that specify further the characteristics of poverty which may make the poor more responsive to the health benefits of informal social supports or which alter the type and effectiveness of social support used by the poor. Although we find that mortality rates for divorced, widowed, and never-married individuals are higher among nonelderly poor men than among others, it is possible that these individuals may develop other forms of informal social supports to compensate for the foregone benefits of marriage (Kasl and Wells 1985).

The weak interaction effects for women of all ages may be partly a function of our inability to measure social support beyond what is indicated by their marital status. Also, this finding may also be a result of the modest main effects of marital and poverty status. Others (e.g., Umberson 1987) also found that women, regardless of their marital status, tend to have healthier lifestyles than men; this finding suggests that marriage per se confers fewer health benefits on women than on men, poor or not. Ross et al. (1990) and Gerstel, Riessman, and Rosenfield (1985) noted that the adverse health effects of being nonmarried may exist because among women, those who are married enjoy greater economic well-being than those who are not. Therefore the weaker marital status effects among women in this study may be present because economic status has been controlled. Zick and Smith (1991a) also found weak mortality effects of marital status among women when poverty status was controlled. In addition, Kotler and Wingard (1989) reported weak main effects of marital and socioeconomic status on mortality among women. Our findings are consistent with these earlier studies, although we find *both* weak main effects and weak interaction effects among women. Further work is needed to explore the larger array of socioeconomic factors that may help to explain women's mortality patterns and how they might interact with one another.[6]

The weakness of the main and interaction effects of marital and poverty status among the elderly for both men and women suggests some explanations. First, older individuals may be less sensitive to the benefits of marriage and to higher economic standing than the young because they are a hardier group, as shown by their surviving to an advanced age. Second, the income distribution among the elderly may vary less; thus it may be more difficult to detect the effects of poverty on the risk of mortality. Third, the generally high rates of mortality among nonpoor married elderly persons make it difficult to detect *relative* effects due to being poor or not married. If poverty or marital dissolution is to generate significant mortality effects beyond the effects of being neither poor nor married, the absolute increase must be quite large in order to reveal a small relative effect.

Possibly the use of a single poverty threshold accounts for some of the weaker mortality effects because some individuals may be near this threshold and thus may be more like the poor than like the non-poor. We estimated the interaction effects of poverty as a trichotomy (i.e., income-to-needs ratio <1.5, 1.5–2.5, >2.5) and as a continuous variable. On the basis of these alternative approaches, we found that the mortality effects (main and interaction) are concentrated among those with an income-to-needs ratio of less than 1.5.

Income-to-needs ratios incorporate the effects of family size and the number of children. To assess the effects of children plus spouses, rather than spouses only, on mortality risks, we estimated models that included family size and number of children as regressors and replaced poverty status with total family income. These alternative measures of household structure have weak effects on mortality risk both before and after controlling for other mortality risk factors.

We assessed the interaction effects of poverty and marital status presented here using both multiplicative and additive models. Demographers may wish to consider using both specifications when studying the effects of discrete risk factors on mortality. Epigenesis theory suggests that nonspecific health outcomes, such as all-cause mortality or all-heart-disease mortality, which in effect have several underlying potential pathogenic processes, are examined most accurately by using both interaction models. By applying both models, one can determine whether the results are consistent with the multiplicative, the additive, or the intermediate model.

We find, then, that marital and poverty status interact to create, in general, an especially harmful force that diminishes an individual's health status, primarily among nonelderly men. Nonpoor persons simply enjoy fewer health benefits if they are not married. Those who are married have fewer health benefits if they are poor. Among those who are both poor and nonmarried, however, the lack of one source of support is compensated less fully by a second source of support. This finding is consistent with that of Pearlin (1989), who argues that it is important to study the joint rather than the separate health effects of stressors. As summarized by Ross et al., "—poverty and low support feed each other, magnify each other's impact on sickness in the family, and magnify the impact of sickness in the family" (1990: 1072). Further study is needed to examine why men's, but not women's, risk of mortality is more sensitive to the joint effects of marital and socioeconomic conditions.

NOTES

[1] For the sake of presentation, all the models discussed here assume that the effects of the risk factors are not confounded by other unmeasured variables.

[2] This assumption does not preclude the possibility that individuals who are prone to premature death because they are poor are also susceptible to the adverse effects of being single; that is, an individual's susceptibility to poverty and his or her singlehood are correlated.

[3] Koopman and Weed (1990) note a potential limitation of their epigenesis theory when the exposures under study are social: "When a variable is not directly causal, for example, age or socioeconomic status, there is an additional type of relation that is possible between two variables. . . . This type of relation can arise because one of the variables may be associated with both causal and preventive factors. The causal factors may predominate in one subsegment of the population and the preventive factors in another. This would produce what has been called 'crossover' statistical relations. . . . In general, the use of noncausal or surveillance type variables will not be helpful for an epigenesis theory analysis. Some insight is gained, however, by considering these variables within an epigenesis context "(p. 371). We take this caution seriously, but we believe that it forces us to examine whether a variable is truly causal rather than justifying our ignoring the potential benefits of the epigenesis approach.

[4] Makuc and Kleinman (1986) remark that the "relatively small design effects of the unweighted analysis, the highly skewed sampling weights, and the complexity of incorporating the design into the analysis indicate that, at least for this analysis, it may be appropriate to ignore the survey design" (p. 6).

[5] Koskenvuo et al. (1980) conducted a study on the interaction effects between marital status and occupation on ischemic heart disease mortality. They found that the main mortality effects of marital status and occupation were predicted largely from the main effects.

[6] It is also possible that because women have lower rates of mortality and higher rates of morbidity than men, morbidity outcomes may prove to be a more sensitive health indicator for women than mortality.

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