THE IMPACT OF SPECIFIC OCCUPATION ON MORTALITY IN THE U.S. NATIONAL LONGITUDINAL MORTALITY STUDY*

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We compare mortality differences for specific and general categories of occupations using a national cohort of approximately 380,000 persons aged 25–64 from the U.S. National Longitudinal Mortality Study. Based on comparisons of relative risk obtained from Cox proportional-hazards model analyses, higher risk is observed in moving across the occupational spectrum from the technical, highly skilled occupations to less-skilled and generally more labor-intensive occupations. Mortality differences obtained for social status groups of specific occupations are almost completely accounted for by adjustments for income and education. Important differences are shown to exist for selected specific occupations beyond those accounted for by social status, income, and education. High-risk specific occupations include taxi drivers, cooks, longshoremen, and transportation operatives. Low-risk specific occupations include lawyers, natural scientists, teachers, farmers, and a variety of engineers.

Determining the impact of occupation on morbidity and mortality requires the understanding of a complex set of relationships involving the workplace, the environment, and the individual. Occupation consumes a large portion of daily activities, provides the means for material support, and is a determinant of lifestyle and social status. Because of inherent differences in occupations and exposures that accumulate over a lifetime, conditions in the workplace affect one's health and survival (Guralnick 1963; Kaplan, Parkhurst, and Whelpton 1961; Rosenberg et al. 1993). For example, farmers may be directly exposed to pesticides, construction workers may be exposed to dangerous heights and heavy machinery, coal miners may be exposed to coal dust, and air traffic controllers may be subjected to great stress. Occupations may also exert positive influences on health and survival. Both the income and prestige received from an occupation influence choice of community environment and a social circle of friends. These, in turn, influence access to quality medical care, the cleanliness and safety of surroundings, and the convenience of healthy foods—all factors important to better health and longer survival.

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Complex interrelationships exist between occupation, social status, income, education, and subsequent morbidity and mortality. Levels of social status are commonly defined in terms of occupational groupings. Miller (1991:327) stated that "Nearly 30% of all research articles in major sociological journals are devoted to social stratification. Occupation has been shown to be the best single predictor of social status, and overall occupational ratings have been found to be highly stable." Education is a key component to occupational opportunity. In the most prestigious occupations, such as doctors, lawyers, and engineers, education beyond a college degree is required; in highly labor-intensive occupations, educational requirements are generally less. Income derived from prestigious occupations tends to be high, although many highly labor-intensive occupations, such as crane and bulldozer operators, are high-paying.

In this paper we investigate relationships between occupational mortality differences and income, education, and social status. Social status may be viewed as consisting of two components: a prestige component and a socioeconomic component (Liberatos, Link, and Kelsey 1988). Guided by examples from the literature, we develop categories of social status based on occupational groupings. We use these groupings to assess the extent to which differences in occupational mortality reflect the prestige and socioeconomic components of social status; we assess whether there are important forces in specific occupations that, in addition to a social status component, affect survival.

The systematic monitoring of the impact of occupation on morbidity and mortality dates back over 140 years to the pioneering work of Farr, who used the 1851 Census of Great Britain (Registrar General 1864). Supplements on mortality by occupation, since produced by the British Registrar General (Offices of Population Censuses and Surveys 1978), have followed from Farr's work. In these publications, mortality rates are determined cross-sectionally: Counts based on occupational classifications from death certificates and counts based on occupational classifications from census records are used for the numerator and denominator frequencies, respectively. This census-based, cross-sectional approach of calculating mortality rates from separate sources suffers from an issue generally referred to as numerator-denominator bias (Goldblatt and Fox 1990). In both Great Britain and the United States, the use of broadly defined occupational categories in research may have lessened, but not eliminated, the detrimental impact of this bias (Kitagawa and Hauser 1973). A British study has even shown that the numerator-denominator bias was somewhat less severe in Great Britain than in the United States (Registrar General 1958).

The incorporation of a social status component into the occupational classification system followed the introduction of the social status concept by Farr in his report on the period 1861–1870 (Registrar General 1875). In 1913, the British Registrar General (Registrar General 1913) introduced a definition of social status based on groups of occupations to identify types of society according to the occupations common to them. These were used by Stevenson (1923) to study the social distribution of mortality. Several authors who assessed the validity of this approach pointed out potential difficulties in separating a social class effect, defined by a collection of occupations, from the direct occupational effect, defined from the same occupational definitions (Goldblatt and Fox 1990; Haug 1977; Stevenson 1923). Others have attempted to assess a social status component by comparing the health of working men with that of their wives (e.g., Benjamin 1965).

In a strong statement, Fox and Adelstein (1978) supported the importance of social status in the determination of occupational mortality differences through an approach they called *social class standardization*. In their approach, the mortality rate for a specific occupation was compared with the expected mortality rate for the social group within which the occupation was classified, resulting in a chi-square statistic. By comparing these values with a chi-square statistic computed over all occupational categories, they determined that social status accounted for an overwhelming 82% of the variability in mortality; specific occupational variability accounted for just 18%. The Black Report, a report by a British government–commissioned working group on social class inequalities in health, extensively documented the impact of class definitions in Great Britain (Black Report 1980; Whitehead 1988; Wilkinson 1986).

In spite of Fox and Adelstein's (1978) strong evidence supporting social status as an important component in the determination of occupational mortality differences, other research shows that mortality rates differ across specific occupations and that specific occupations are important in understanding occupational mortality differences (Rogot et al. 1988, 1992; Rosenberg et al. 1993). Environmental influences on specific occupations, such as carcinogenic exposure, accidental injuries, psychological stress, and shared behavioral risk factors, have been shown to affect mortality differences (Borgia et al. 1994; Doll 1952, 1955; Jakobsson, Gsutavsson, and Lundberg 1997; Ore and Stout 1997).

The development of major databases containing many individual records has also played an important role in the promotion of research on mortality and specific occupations. A classic example is Kitagawa and Hauser's (1973) 1960 matched records study. They matched a cohort of 360,000 deaths to 1960 U.S. census records in order to obtain occupational and other socioeconomic information on individuals. The occupational group found to have the lowest mortality rate was agricultural occupations, followed by professional or white-collar occupations. The group with the highest mortality rate was laborers and service workers.

Although cross-sectional, Kitagawa and Hauser's study was based on individual records and was not affected by a numerator-denominator bias. However, the potential problem of causal direction of association (Moore and Hayward 1990) was left unresolved. At issue is the question, "Do lower-status occupations cause poor health or does poor health lead to lower-status occupations?" Prospective studies, on the other hand, allow for the direct assessment of morbidity or mortality of each record following an initial assessment of variables, thus eliminating the numerator-denominator bias (Moore and Hayward 1990). This approach also reduces, but does not eliminate, the problem of ambiguity in the implied causal direction of associations (Wilkinson 1986).

In this paper, we use the National Longitudinal Mortality Study (NLMS) to estimate the strength of the relationship between general and specific categories of occupation and mortality for persons in the prime working ages, 25–64. We asses the relative importance of social status components compared with the contribution of specific occupations in estimating occupational mortality differences. We also estimate the mortality risk for specific occupations after adjusting for social class, income, and education. Relevant occupational, demographic, social, and economic data were collected for this prospective study of 380,000 respondents and linked to up to 11 years of mortality follow-up data. The study, therefore, allows us to assess the magnitude of specific and general occupational effects on mortality using a large, prospectively followed national sample with occupations determined for individuals.

MATERIALS AND METHODS

The U.S. National Longitudinal Mortality Study is a prospective study of mortality occurring in combined samples of the noninstitutionalized U.S. population (Rogot et al. 1988, 1992; Sorlie, Backlund, and Keller 1995). It consists of samples taken from selected Current Population Surveys (CPS) conducted by the U.S. Bureau of the Census (1978). Each CPS is a complex, national probability sample of households surveyed monthly to obtain demographic, economic, and social information about the U.S. population, with particular emphasis on employment, unemployment, and other labor force characteristics. The surveys, which are conducted by personal and telephone interviews, have a response rate of close to 96%. The CPS, sponsored by the U.S. Bureau of Labor Statistics, is used, in part, to prepare monthly estimates of the national unemployment rate. For the current analysis, we selected approximately 380,000 persons aged 25 to 64 at the time of survey and followed them for mortality using the National Death Index (NDI). Persons selected are from 10 CPS surveys conducted from February 1978 to March 1985. CPS surveys are redesigned every 10 years, and households are sampled only once during that period. However, members of households may relocate. Therefore, there is a low probability that members will be sampled by the CPS more than once during the 10-year period.

Mortality follow-up information for the U.S. National Longitudinal Mortality Study was collected by computer matching its records to the National Death Index (NDI) for the years 1979 to 1989 (Rogot, Sorlie, and Johnson 1986). The NDI, a national file containing information collected from death certificates, is maintained by the National Center for Health Statistics (1990). The matching of records to the NDI has been shown to be an effective and accurate means of ascertaining mortality information using personal identifiers such as social security number, name, date of birth, sex, race, marital status, state of birth, and state of residence (Calle and Terrell 1993; Stampfer, Willet, and Speizer 1984; Wentworth, Neaton, and Rasmussen 1983; Williams, Demitrack, and Freis 1992). Mortality rates determined from the U.S. National Longitudinal Mortality Study are consistent with estimated rates for the noninstitutionalized population of the United States from other sources (Rogot et al. 1988, 1992). An independent validation study showed that only a small proportion of deaths, probably less than 7%, were missed using the study matching methods (Calle et al. 1993).

During the CPS household interview, information about occupation was collected through detailed series of questions. If the response to these questions indicated that the person was in the labor force or had held a job within the last five years, specific questions relevant to the job description or business were asked. These responses were later coded to a basic three-digit occupation and three-digit industry code, as documented by the U.S. Bureau of the Census (1971), by highly specialized coders.

In order to obtain categories of occupations containing a sufficient number of observations for analyses, we used three classification systems of the original three-digit occupation code. We determined the most detailed definition, specific occupation, by grouping occupations similar in type of labor and working environment in order to obtain the smaller of either an expected or an observed total mortality of at least 50 deaths. The resulting variable, *specific occupation*, contains 69 categories for males and 32 for females. A detailed list of these occupations and their correspondence to the original three-digit occupational definition is available from the authors upon request. Acronyms used in the tables and figures as labels give some indication of the three-digit occupations contained in the category. We also use a second group of occupations, referred to here as *major occupation*, according to the U.S. Bureau of the Census's (1971) classification. This classification consists of 11 categories.

Finally, a third group of occupations, *approximate BRG occupation*, is used to identify social status. We formed this variable as a reasonable approximation to the British Registrar General's (BRG) definition of social status (Offices of Population Census and Surveys 1970; Registrar General 1864, 1913; Stevenson 1923) and created it by directly combining selected categories from the definition of major occupation. The resulting classification consists of only four categories compared with seven of the British Registrar General's classification, but it is based on the separation of professional technical, clerical, skilled crafts, and labor occupations as is the British classification. No analytical effort has been made to study true compatibility of this classification with the British Registrar General's definition. A table showing the correspondence between the approximate BRG, specific, and major occupation classifications is available from the authors upon request.

To incorporate, as much as possible, a well-known sociological measure of social status into these analyses, we determined the average Nam-Powers socioeconomic status scores for both major and specific occupational classifications. The Nam-Powers scale is one of a variety of measures currently available in the social sciences literature that attempt to assign to occupations a measure of socioeconomic status and/or occupational prestige (Miller 1991). Separate Nam-Powers scores for both men and women were determined for occupations from the multiple regression of the median education and median income on North-Hatt prestige scores for the occupation (Miller 1991).

Three socioeconomic variables—income, education, and household size—obtained by the CPS were used as control variables in these analyses. Previous publications based on analyses of the NLMS have shown the substantial impact of both income and education on overall mortality (Sorlie et al. 1995). We measured education as a six-category variable for the highest grade completed: completed grade 8 or less, completed to grades 9 through 11, completed high school, completed one to three years of college, completed a college education, and completed some years of graduate-level studies. The income variable, which measures total family income adjusted to 1980 dollars, is a seven-category variable: less than $5,000; $5,000 to $9,999; $10,000 to $14,999; $15,000 to $19,999; $20,000 to $24,999; $25,000 to $49,999; and $50,000 or more. Finally, because the income identified by the CPS is a measure of family income, we adjusted analyses in which an income adjustment was used by household size in order to reflect a per capita income more directly. Household size adjustments were made according to the sizes of 1,2,3,...,8 or more person groupings. We denote this adjustment to income with the term *household-adjusted*.

To analyze mortality differences by occupation, we used two basic analytical methodologies. First, we used person-year death rates, age-adjusted by the indirect method (Fleiss 1981). The indirect method was chosen because the number of deaths in certain age-specific categories is small (Ahlbom 1993; Monson 1980). Second, because the NLMS data include the exact time of death, the Cox proportional-hazards regression model can be used to determine relative mortality differences among occupational groups after adjustment for income and education (Collet 1994; Lee 1992). All models are sex specific and include adjustments for age (in years) and race (as black, white, and other). We used indicator variables in these models to study the impact of each specific, major, and approximate BRG occupation, as well as to adjust for income, household size, and education. In order to incorporate the effect of social class and specific occupation into a single model, we used an indicator for approximate BRG group and an indicator for each specific occupation that is nested within the approximate BRG group. The nested design is appropriate because every specific occupation is contained within one and only one approximate BRG group (Neter, Wasserman, and Kunter 1985). Thus, the total occupational effect can be broken into one component representing an approximate BRG group effect and another component representing occupational effects beyond the approximate BRG group effect.

To compare results for Cox proportional hazards models composed of different sets of independent variables, we used the function −2 times the log-likelihood (Collet 1994). To determine if a set of variables is statistically significant, we subtracted from the log-likelihood function of the model that includes specific variables of interest along with adjustment variables, the log-likelihood of the model that contains the adjustment variables but not the specific variables of inter-

TABLE 1. AGE-ADJUSTED ANNUAL MORTALITY RATES FOR MAJOR OCCUPATIONAL GROUPS, BY SEX AND RACE, AGES 25–64 YEARS: U.S. NATIONAL LONGITUDINAL MORTALITY STUDY, 1979–1989 FOLLOW-UP

	Whites				Blacks			
Major Occupation	Number of Observations	Number of Deaths	Mortality Rate[a]	95% Confidence Interval	Number of Observations	Number of Deaths	Mortality Rate[a]	95% Confidence Interval
Males								
Professional and technical	34,767	858	331	309–354	1,467	47	450	331–599
Managers and administrators	34,843	1,121	369	348–391	1,102	46	501	366–668
Sales workers	12,005	445	468	425–513	329	12	594	307–1,038
Clerical and kindred	10,859	480	534	487–583	1,289	65	668	513–849
Craftsmen and kindred	45,031	1,630	452	430–474	3,090	168	667	569–775
Operatives excluding transportation	19,468	728	500	464–537	2,585	137	686	575–810
Transportation equipment operators	11,275	461	520	473–570	1,779	121	806	667–961
Laborers excluding farmers	9,420	393	584	527–644	2,060	133	770	643–911
Farmers and farm managers	6,088	205	344	298–394	45	5		
Farm laborers and foremen	2,239	87	527	421–648	332	26	816	533–1,196
Service workers excluding private household workers	12,566	570	580	533–630	2,474	168	829	707–963
Private household workers	35	1			17	1		
Total	198,596	6,979			16,569	929		
Females								
Professional and technical	27,706	338	179	160–199	2,609	52	255	189–333
Managers and administrators	13,412	234	210	183–238	730	18	318	189–503
Sales workers	9,051	163	175	172–235	364	7	245	99–505
Clerical and kindred	49,204	859	215	201–230	4,647	83	291	231–360
Craftsmen and kindred	2,920	43	183	133–247	267	5		
Operatives excluding transportation	15,024	299	220	195–246	2,662	69	331	256–417
Transportation equipment operators	1,165	19	224	135–350	139	2		
Laborers excluding farmers	1,684	30	235	158–335	283	7	305	123–629
Farmers and farm managers	852	23	271	172–406	5	1		
Farm laborers and foremen	1,598	18	121	72–191	98	3		
Service workers excluding private household workers	22,111	469	260	237–284	4,865	167	366	312–425
Private household workers	2,078	67	356	275–451	1,219	78	491	387–611
Total	146,805	2,562			17,888	492		

[a]Age-adjusted, using indirect method with sex- and race-specific rates across all occupations used as standard. Mortality rates not shown for groups with five or fewer deaths. Rates are per 100,000.

est. The likelihood ratio chi-square statistic is represented by this difference and is distributed as a chi-square distribution with degrees of freedom equal to the difference in number of variables between the two models. We also determined the proportion of total occupational effect due to the approximate BRG groupings by determining the ratio of the log-likelihood function based on only the approximate BRG grouping compared with the log-likelihood based on the full set of occupations.

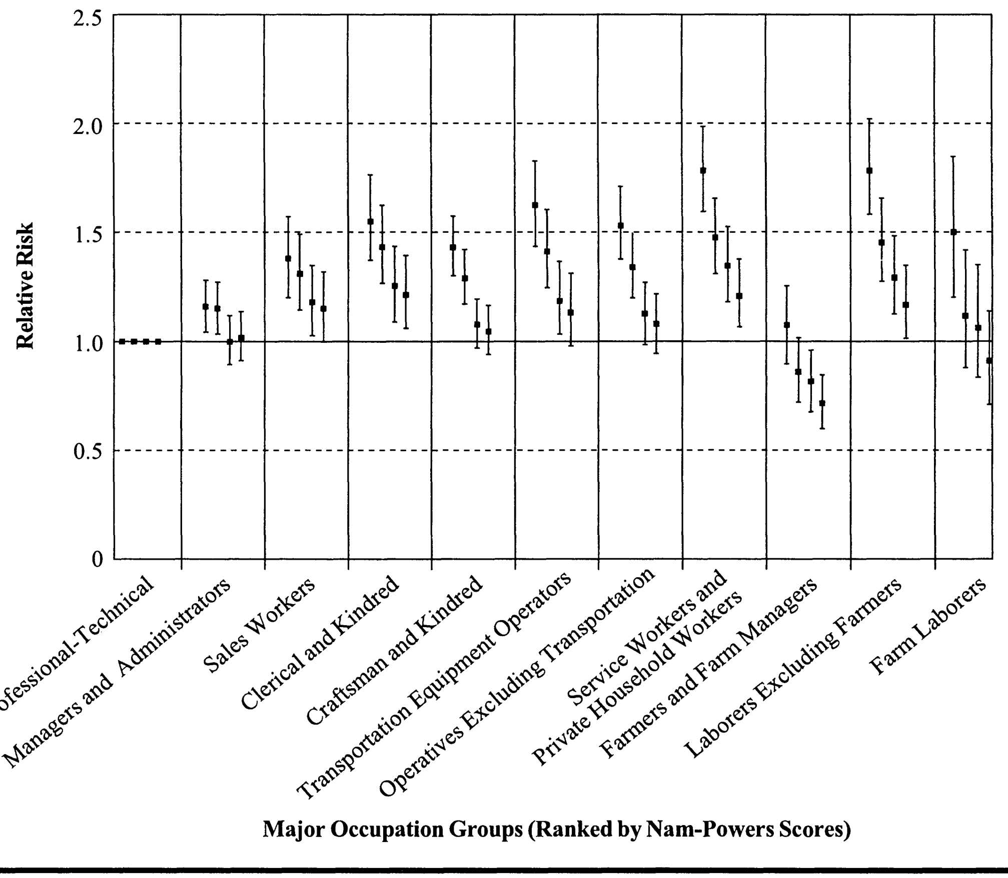
Finally, although the CPS is designed as a complex stratified sample, all analytical results obtained for this research are based on simple random sample methods. Hypothesis tests may show less significance and confidence intervals may be wider due to larger variances if analyses take into account the complex design. Previous results for determining point estimates and standard errors for rates from the NLMS and similar databases have shown little difference between results based on simple random sample methods and those based on complex sample methods (Anderson et al. 1997; Feldman et al. 1989).

RESULTS

Table 1 shows, for each sex- and race-specific group, the number of persons, number of deaths, and age-adjusted annual death rates based on person-years for each of the 11 major occupation categories. Ninety-five percent confidence intervals have been computed for each rate. For both black males and white males, increasing mortality is generally seen across occupations in moving from the professional-technical end of the occupational spectrum to the less-skilled service and labor-intensive occupations. For women in occupations with adequate person-years, the gradient across occupations is similar in magnitude to the gradient for males. Of note for specific groups, for white males, farmers and farm managers have a much lower mortality rate than would be expected for a labor-intensive occupation.

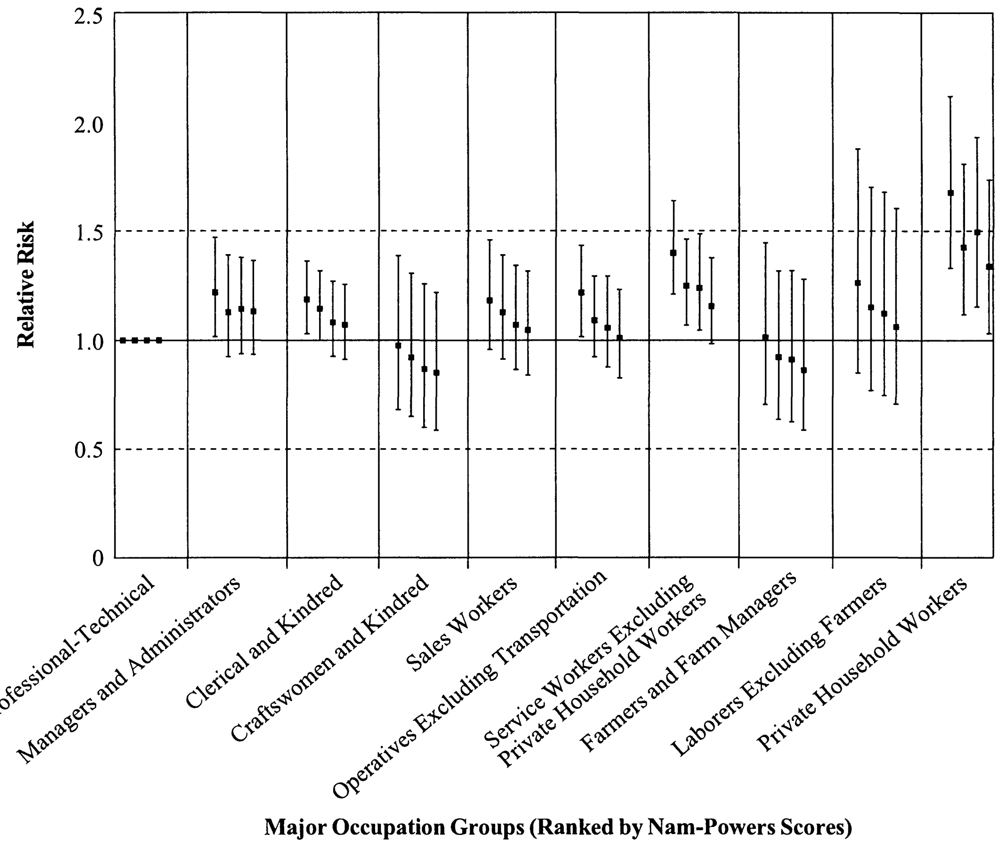
The estimated relative risk of mortality for major occupational groups relative to the professional-technical group determined by Cox proportional-hazards models is shown for males in Figure 1 and for females in Figure 2. The groups of

FIGURE 1. RELATIVE RISKS OF MORTALITY AMONG MALES AGED 25–64 WITHIN MAJOR OCCUPATIONS, ADJUSTED FOR AGE, RACE, INCOME, AND EDUCATION: NATIONAL LONGITUDINAL MORTALITY STUDY



Notes: The first point is adjusted for age and race; the second for age, race, and household-adjusted income; the third for age, race, and education; and the fourth for age, race, household-adjusted income, and education.

FIGURE 2. RELATIVE RISKS OF MORTALITY AMONG FEMALES AGED 25–64 WITHIN MAJOR OCCUPATIONS, ADJUSTED FOR AGE, RACE, INCOME, AND EDUCATION: NATIONAL LONGITUDINAL MORTALITY STUDY



Notes: The first point is adjusted for age and race; the second for age, race, and household-adjusted income; the third for age, race, and education; and the fourth for age, race, household-adjusted income, and education.

four plotted points show the estimated relative risk with adjustment for (1) age and race, (2) age, race, and household-adjusted income, (3) age, race, and education, and (4) age, race, household-adjusted income, and education. Major occupational categories are shown in descending order according to the average of the Nam-Powers scores of the occupations composing the major occupation category. For neither males nor females does this ordering result in a monotonically increasing pattern of risk, as would be expected if mortality risk were highly inversely correlated with the Nam-Powers scores.

For men, the farmers and farm managers group is the only major occupation in which the age- and race-adjusted relative risk is not significantly higher than that of the professional-technical group. For each major occupation category, relative to the professional-technical group, adjustment for educational status has a greater impact than adjustment for household-adjusted income on reducing risk. After adjustments for both household-adjusted income and education, only the farmers and farm managers and the farm laborers groups have an adjusted relative risk less than that of the professional-technical group. Three major occupations—clerical and kindred, service and private household workers, and laborers excluding farmers—have an adjusted relative risk that is significantly greater than that for the professional-technical group. Finally, the risk pattern for farmers and farm managers is conspicuously inconsistent with the overall pattern of risks viewed across the major occupations ordered by their Nam-Powers scores.

The patterns for females are somewhat different (see Figure 2). There are four major occupational groups for which the unadjusted relative risk is not significantly different than that for the professional-technical group: craftswomen, farmers and farm managers, sales workers, and laborers. The impact of household-adjusted income and education is not as pronounced for females as for males. Neither of these variables leads to a consistently greater reduction in risk compared with the other across occupational groups. After adjustment for both household-adjusted income and education, only the relative risk for private household workers is significantly

TABLE 2. TESTS OF COX PROPORTIONAL-HAZARDS MODELS FOR SPECIFIC OCCUPATIONS

					Occupations		Males		Females	
	Age	Race	Income	Education	BRG Group	Specific	Likelihood Ratio χ^2	*df*	Likelihood Ratio χ^2	*df*
Model 1	*A*						8,784	1	3,319	1
Model 2	*A*	*R*					8,992	3	3,410	3
Model 3	*A*	*R*	*I*				9,677	16	3,576	16
Model 4	*A*	*R*		*E*			9,384	8	3,457	8
Model 5	*A*	*R*	*I*	*E*			9,856	21	3,601	21
Model 6	*A*	*R*			*B*		9,199	6	3,446	6
Model 7	*A*	*R*	*I*	*E*	*B*		9,861	24	3,607	24
Model 8	*A*	*R*			*B*	*S*	9,542	71	3,509	34
Model 9	*A*	*R*	*I*		*B*	*S*	10,034	84	3,624	47
Model 10	*A*	*R*		*E*	*B*	*S*	9,681	76	3,529	39
Model 11	*A*	*R*	*I*	*E*	*B*	*S*	10,116	89	3,657	52
Tests										
Test 1. Occupational groups (unadjusted): Model 6 – Model 2							207**	3	36**	3
Test 2. Specific occupations (unadjusted): Model 8 – Model 6							343**	65	63**	28
Test 3. BRG equivalent occupations adjusted for income and education: Model 7 – Model 5							5	3	6	3
Test 4. Specific occupations given BRG equivalent groups adjusted for income and education: Model 11 – Model 7							255**	65	50*	28
Ratios										
Ratio 1. Percentage of occupational differences due to BRG equivalent groups: $\frac{\text{Model 6} - \text{Model 2}}{\text{Model 8} - \text{Model 2}}$							$\frac{207}{550} = 37.6\%$		$\frac{36}{99} = 36.4\%$	
Ratio 2. Percentage of occupational differences due to BRG equivalent group after adjustments for income and education: $\frac{\text{Model 7} - \text{Model 5}}{\text{Model 11} - \text{Model 5}}$							$\frac{5}{260} = 1.9\%$		$\frac{6}{56} = 10.7\%$	

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

greater than that for the professional-technical group, and this difference is barely significant.

To investigate the impact of general and specific occupational groupings as well as the impact of household-adjusted income and education, we estimated various proportional-hazards models. Table 2 shows the likelihood ratio statistic for models with age (*A*), race (*R*), household-adjusted income (*I*), education (*E*), approximate BRG occupational categories (*B*), and specific occupations (*S*) in various combinations as independent variables. Tests 1 and 2 in Table 2 show that after adjustment for age and race, the approximate BRG occupational groups and the specific occupations within approximate BRG occupational groups have a highly significant association with mortality (p values < .0001) for both sexes. After adjustment for household-adjusted income and education (Tests 3 and 4, respectively), however, the mortality differences for social status as determined by the approximate BRG occupational groupings are no longer significant for either sex (Test 3). That is, differences in mortality associated with the four social status occupational groups are almost completely explained by household-adjusted income and education. As revealed by Test 4, differences for specific occupations within social status are highly significant for both sexes (p values < .005). Therefore, among specific occupations, important mortality differences remain that are not accounted for by household-adjusted income, education, or the approximate BRG occupational groupings representing social status. As shown by Ratio 1 in Table 2, the percentage of the total occupational effect due to the approximate BRG occupational groups is 37.6% for males and 36.4% for females. After adjustments for household-adjusted income and education in Ratio 2, the approximate BRG groups account for very little of the total occupational effect for either sex. In separate analyses not included here, we repeated all analyses shown in Table 2 using social status categories based on quartiles of Nam-Powers scores for the given occupations. We found little difference between the results for the approximate BRG groups shown in Table 2 and groups based on Nam-Powers scores. In particular, the percentage of occupational difference due to the Nam-Powers groups after adjustment for income and education (the corresponding measurement to Ratio 2 in Table 2) was 5% for males and 0% for females.

Figures 3 and 4 plot two estimates of relative risks determined from the Cox model: one adjusted for age and race only and the other adjusted for age, race, household-adjusted income, and education. We order the specific occupations presented within the approximate BRG groups according to the age- and race-adjusted relative risk for ease of visual assessment of the effects of social status and the impact of adjustments for household-adjusted income and education. The chosen reference occupations for relative risk for all occupations is teachers for males and elementary school teachers for females. These occupations have low risks and large frequencies. Having a large frequency is important for the stability of parameter estimates. With allowances made for multiple-comparison testing with a Bonferroni significance-level adjustment (Neter et al. 1985), for males, the occupations of office workers, construction crafts, construction laborers, and food service workers have statistically significant high risks compared with teachers, after adjustments for household-adjusted income and education. For females, general office managers, other teachers, and office machine operators have significantly low risks compared with elementary school teachers; waitresses and protective service and private household workers have noticeably high relative risks.

Figures 3 and 4 also show that within approximate BRG groups, risk relative to the reference occupation varies considerably. For example, after adjustment, males have relative risk values between 0.7 and 1.7 within each approximate BRG group. As expected, adjustments for household-adjusted income and education have an increasingly greater effect in moving from the professional-technical occupations (BRG 1) to the most labor-intensive group (BRG 4). For each approximate BRG group, important mortality differences are observed within groups, whereas the differences among approximate BRG groups are small. This finding suggests that, rather than social classes, it is the specific occupational effects, exposures to environment, and common behaviors of specific occupations that lead to differential risks.

DISCUSSION

Historically, the development of methodological research on differences in mortality within occupational categories has proceeded from the aggregate approach of the early British studies to the longitudinal approach based on individual records used by the U.S. National Longitudinal Mortality Study. As the methodology has progressed, continued interest in research on mortality differences has been motivated by the understanding that conditions in the workplace effect long-term health and survival. In addition to the influences of the social status associated with specific occupations, environmental influences such as carcinogenic exposure, accidental injury, psychological stress, and shared behavioral risk factors affect specific occupational mortality differences.

For major occupational groups, the U.S. National Longitudinal Mortality Study shows that mortality risk generally increases across the occupational spectrum in moving from the professional, highly skilled occupations to the less-skilled, more labor-intensive occupations. Even after adjustments for household-adjusted income and educational attainment, statistically significant elevated risks exist for some of the most highly labor-intensive and less-skilled occupational groups, regardless of sex. In addition, the findings show that, after adjustments for income and education, the mortality risk for farmers and farm-related occupations, usually thought to be labor intensive, is lower than the risk for the professional-technical groups.

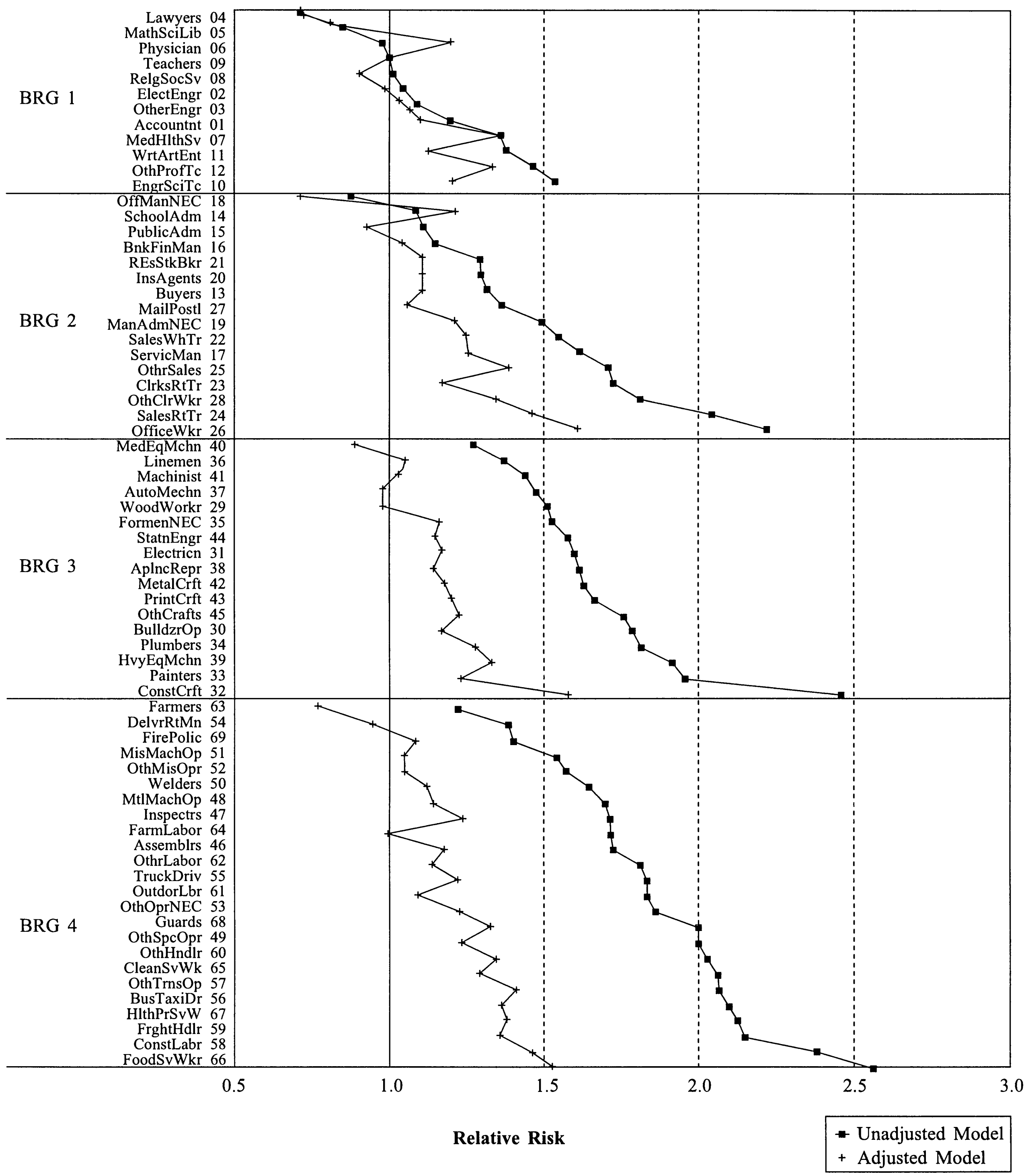
These findings are consistent with the findings of other noted studies. Goldblatt and Fox (1990) compared results from the 1971 Decennial Supplement and the Longitudinal Survey. They identified agricultural occupations, such as farmers, foresters, fisherman, and administrative and professional occupations, as having consistent and markedly low Standard Mortality Ratios (SMR's), and miners, glass and ceramic makers, drivers, and laborers as having consistently high SMR's.

Moriyama and Guralnick (1956) directly compared occupational mortality in England and Wales with that of the United States using the 1950 censuses of the two countries. They found generally similar mortality patterns across 10-year age groups. However, they observed that among technical-professional occupations, mortality rates in the United States were lower than those in Great Britain and Wales. In the labor-intensive occupations, the United States had higher relative mortality.

In this paper, we show that specific occupational exposures are more important than social status grouping in describing the effects of occupation on mortality. Fox and Adelstein (1978) showed that over 80% of the variability in occupational mortality differences was due to social status, and less than 20% was due to specific occupations. In contrast, our results based on the NLMS show that, for either sex, less than 40% of the log-likelihood generated by Cox models was accounted for by the approximate BRG groups of occupations; thus more than 60% was due to mortality differences from specific occupations. Our results are supported by analyses using Nam-Powers scores in the determination of social status groups.

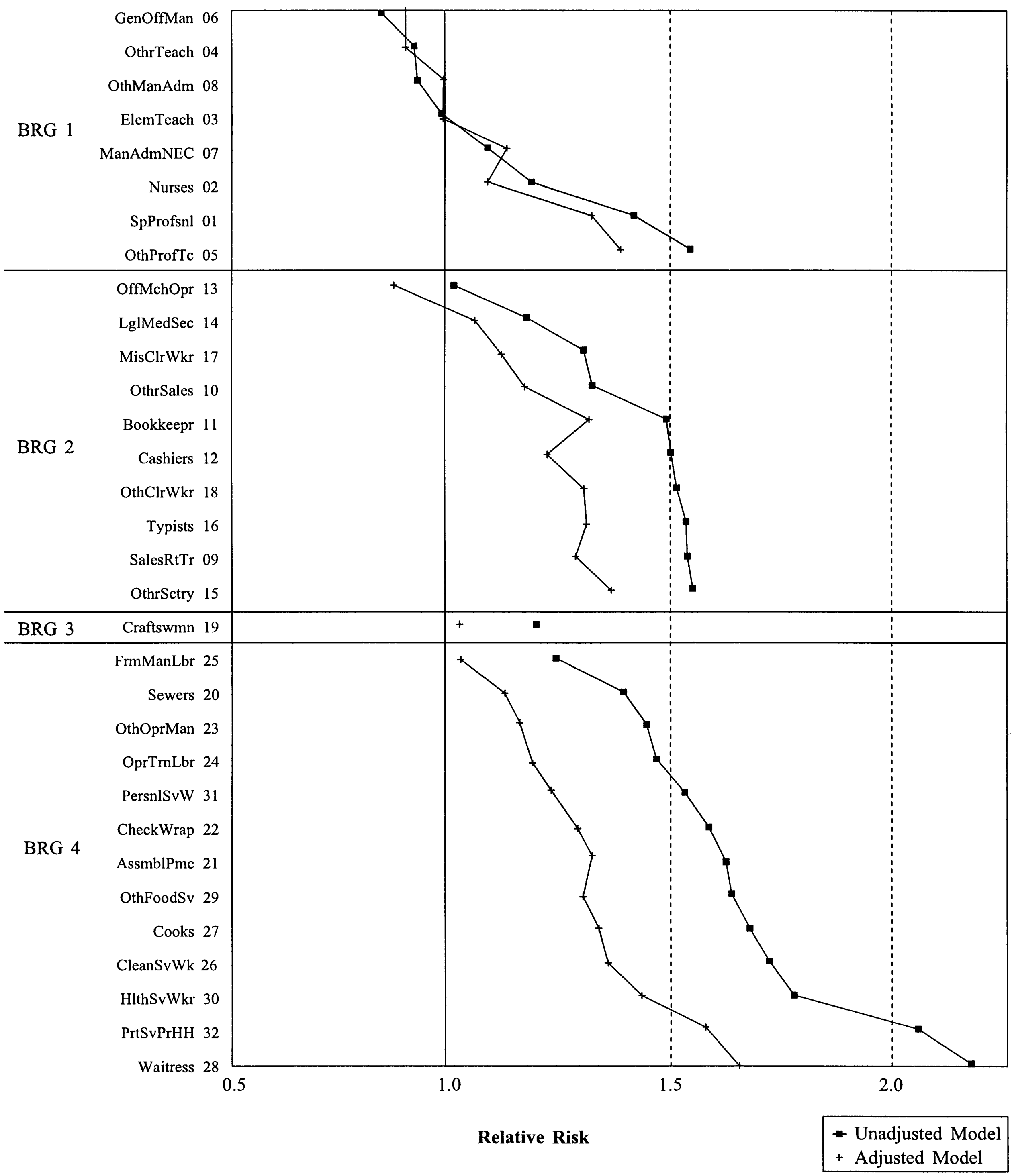
Further, essentially all the contribution to the log-likelihood generated by the approximate BRG groups was explained by adjustments for household-adjusted income and educational attainment. As described by Liberatos et al. (1988:89), the determination of social status based on occupational categories reflects two major components: (1) the relative standing or public opinion of the occupation in society, the prestige component, and (2) the educational requirements and monetary payoff of the occupation, the socioeco-

FIGURE 3. ADJUSTED AND UNADJUSTED RELATIVE RISKS OF MORTALITY AMONG MALES AGED 25–64 WITHIN SPECIFIC OCCUPATIONS: NATIONAL LONGITUDINAL MORTALITY STUDY



Notes: The unadjusted model includes age and race; the adjusted model includes age, race, household-adjusted income, and education.

FIGURE 4. ADJUSTED AND UNADJUSTED RELATIVE RISKS OF MORTALITY AMONG FEMALES AGED 25–64 WITHIN SPECIFIC OCCUPATIONS: NATIONAL LONGITUDINAL MORTALITY STUDY



Notes: The unadjusted model includes age and race; the adjusted model includes age, race, household-adjusted income, and education.

nomic component. Theoretically, if occupationally derived social status contains mostly the socioeconomic component, then it is reasonable to expect that adjustment for income and education will eliminate any independent effect of approximate BRG social status. This implies that in the United States, as represented by the NLMS data, there is little of the prestige component in occupationally derived social status. Perhaps in other countries occupational status is more greatly influenced by the prestige component.

The ability to make meaningful inferences about mortality for a reasonably large number of specific occupations requires a large database such as the NLMS. Confirmation of results from other large studies is an important means of validating results. Results from the National Cancer Institute's study of 250,000 white male veterans (Dorn 1959; Kahn 1966; Rogot 1974; Rogot and Murray 1980; Walrath et al. 1985) and the 1950 Occupational Study (Guralnick 1963; Kaplan et al. 1961) reveal consistencies with our findings from the NLMS. The specific occupations of cooks, taxi and bus drivers, longshoremen, transportation operatives, and guards were prominent, with high mortality differences in each of the three studies. These studies also found that natural scientists, teachers, college professors, clergymen, social workers, inspectors, and a variety of specialized engineers consistently have low mortality differences. The consistency across the three studies in demonstrating that these specific occupations are at either end of the risk spectrum lends validity to the results and supports the idea that certain specific occupations are of high or low risk.

Further, results from the NLMS show that cashiers, office workers, retail sales workers, and other clerical workers have high risks. Moore and Hayward (1990), using the National Longitudinal Survey of Mature Men, observed similar findings. They collected information for both current or last occupation and longest occupation for a cohort of 3,080 males of exact age 55. Their results indicate that the high risk observed in the clerical and kindred major occupational category might occur because the occupations in this group accommodate transfers of persons who leave more strenuous occupations to take clerical jobs, possibly because of weakened health. They also found that mortality rates for farmers are low when they examined current occupation but higher when they looked at the longest occupation held; these findings suggest that selection based on health might be partially responsible for the low mortality rates for farmers determined through current assessment, as in the NLMS.

LIMITATIONS OF THE DATA

The prospective design of the NLMS solves the problem of numerator-denominator bias. Other issues remain, however. Occupational data used for analysis are assessed at one time point and do not reflect job changes over time. Moore and Hayward (1990) showed that mortality risks based on the use of current or last occupation differ substantially from those determined from the longest held occupation. Mare (1990) showed that comparing first occupation to the current or last occupation produces different results. Because the NLMS data contain information on only the current occupation, we were unable to asses the impact of health status on the selection of an occupation or the impact of duration in an occupation. For certain occupations, results from the NLMS based on current occupation are similar to the findings of Moore and Hayward (1990) based on longest occupation. Similarities are seen for certain high-risk occupations such as sales workers, nonfarm laborers, and service workers and for certain low-risk occupations such as professionals.

In addition, the NLMS data do not contain an assessment of the direct exposure to potentially harmful conditions associated with specific occupations. Thus we can only speculate on what factors might be responsible for increased mortality. Each occupation has risks associated with its working environment, physical requirements, operational dangers, psychological components, and shared behavioral factors. These factors may manifest differences in risks associated with specific occupations through specific causes of mortality. For example, Borgia et al. (1994) focused on Italian taxi cab drivers, an occupation the NLMS has also identified as high risk, to determine if exposure to gasoline engine exhaust leads to increased incidence of lung cancer. Jakobsson et al. (1997), in a study of subgroups of professional drivers in Sweden, concluded that driving in an urban environment leads to a higher risk of lung cancer than driving in nonurban areas. For the identified high-risk occupation of cooks, Foppa and Minder (1992) inferred that the high incidence of mortality in cooks resulting from oral, pharyngeal, and laryngeal cancers might be due to volatile carcinogenic compounds formed during the cooking process. The shared behavior of cigarette smoking may be only a partial explanation for increased mortality in some occupation groups. Results from the National Cancer Institute's Veterans Study showed that associations of greater mortality with certain occupations were still evident after adjustment for smoking information collected from a detailed questionnaire. We intend to examine the relationships between specific causes of mortality and specific occupations in subsequent research.

Results for persons under age 25 or persons over age 65 in the current study were not presented in this paper: Many persons over age 65 have retired, and occupations of persons under age 25 are less established. Although the size of the NLMS study cohort seems adequate, not enough mortality has occurred to permit a detailed study of specific occupations for some important demographic groups. To compensate for the sample sizes, which are smaller than desirable, we generally presented results that were adjusted for race rather than present race-specific results.

We used regression techniques to adjust the occupations for differences in education and household-adjusted income and assumed that the relationships of education and income to mortality are the same for each occupation. This process yields a theoretical adjustment because there are circumstances in which there is little real overlap between the income and education of some occupational groups, such as physicians and unskilled laborers. Nevertheless, our use of a statistical procedure to standardize allows us to compare mortality among different occupations as if they had common income and educational levels.

CONCLUSION

We analyzed mortality for a large national cohort by detailed occupation groups (69 groups for men and 32 groups for women), by broader categories (11 groups) reflecting generalized occupations, and by a four-level classification approximating a social status grouping. Although each of these classification systems is associated with mortality differences, our basic question was whether there were mortality differences among these occupational groups beyond those derived from the income and education levels associated with the occupational groups.

The four-level social status grouping, approximate BRG, did not describe mortality effects beyond income and education. It therefore appears to be a valid social status grouping that mirrors only information captured in the income and education variables. Results for the 11-category grouping, major occupation, indicate that there are some occupational groups, like private household workers and service workers, that have elevated mortality above that expected from their lower education and income levels. Specific occupations within some social status groups are associated with markedly increased risks that cannot be explained by the education and income levels as measured for this study. The results for specific occupations need confirmation from other data. The findings from the NLMS support results from earlier data suggesting that over the last 40 years, occupations such as taxi drivers, cooks, longshoremen, and transportation operatives have experienced elevated mortality. Further research on the specific occupations identified by the NLMS is required to clarify the work-related factors associated with elevated risks for some occupations and the markedly lower risks for others. Rather than rely on measures that rank occupations according to prestige or socioeconomic status, new studies aiming to identify occupational differences in mortality should include measures that rank occupations according to specific job conditions, such as occupational stress (Karasek et al. 1988), job demand and control (Baker and Karasek 1995), decision latitude (Karasek 1981), types of relationships between coworkers, degree of physical hazards, and substantive complexity (Moore and Hayward 1990).

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