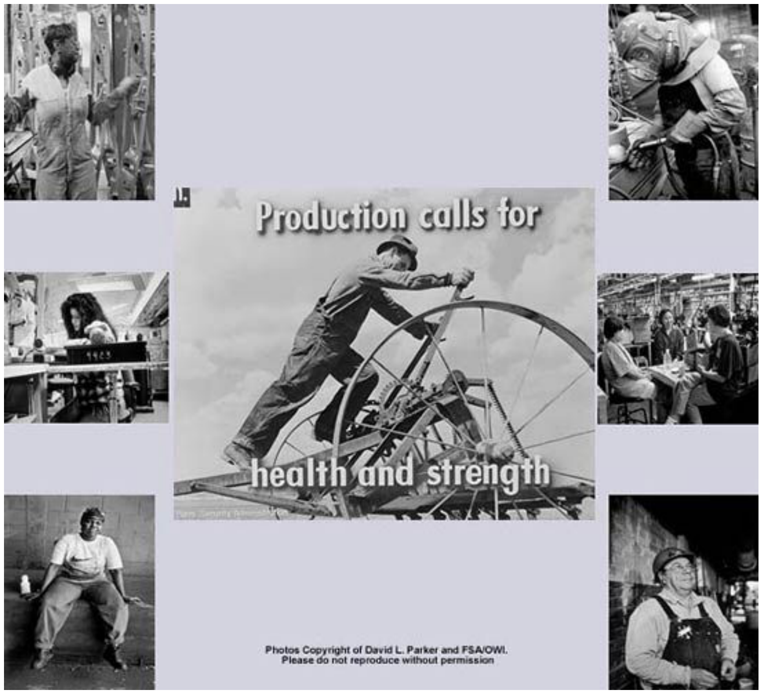
Occupation and Mortality:
The National Health Interview Survey 1986-1994

Monograph



Lora E Fleming MD PhD, Terry Pitman BA, William LeBlanc PhD, Alberto Caban Jr MPH,
Orlando Gómez-Marín PhD MSc, David Lee PhD,
Diane Zheng MS, Dulce Jane MA

Study Website: http://www.UMiamiORG.com

Department of Epidemiology and Public Health
University of Miami School of Medicine
Miami, FL
33136

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ABSTRACT

The National Health Interview Survey (NHIS) is a multipurpose household survey of the US civilian non-institutionalized population conducted annually since 1957. From 1986-1994, over 450,000 US workers, age 18 years and older, participated in a probability sampling of the entire non-institutionalized US population; variables collected included a range of measures of acute and chronic disability. Recently, the NHIS conducted a Mortality Follow-up with cause of death through 1997 available to researchers.

The objective of this Monograph was to review the mortality experience for US workers by occupation using the 1986-1994 NHIS data with follow-up through 1997. After adjustment for sample weights and design effects using SUDAAN, the unadjusted and age adjusted mortality rates (with their standard errors) using the direct method and the 2000 US Standard population were created in tabular format. The top 10 US causes of death identified by the Centers for Disease Control and Prevention (CDC) for the 1986-1994 Study Period were selected. These mortality rates have been presented by occupational subgroups, as well as by gender, race, and ethnicity subgroups within each occupation. Additional information has been made available to allow for extrapolation to the entire US worker population during the 1986-1994 time period. The Study Website (**http://www.UMiamiORG.com**) contains a repository of interactive tables which are available in both Excel and PDF formats; additional study and NHIS documentation are also available at this Website.

Understanding the occupational risk factors and improving the health of US workforce remains a public health priority. Occupational surveillance using the NHIS dataset allows for the careful monitoring of these occupational risk factors in order to identify prevention strategies and to minimize occupational mortality.

KEY WORDS

Mortality, Top 10 Causes of Death, Occupation, Industry, National Health Interview Survey (NHIS), Surveillance

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INTRODUCTION

It is recognized that a variety of occupational and environmental risk factors interact to determine the overall health and well being of the US workforce. Occupational health surveillance is poised to analyze these interactions by systematically collecting, analyzing, and interpreting health data essential to the planning, implementation and evaluation of public health strategies to maximize workforce health. These robust surveillance systems collect and maintain health outcome information for all members of a temporally and geographically defined population at risk. The NIOSH NHIS Research Group at the University of Miami is funded by the National Institute for Occupational Safety and Health (NIOSH) to study the National Health Interview Survey (NHIS) dataset collected and conducted by the National Center for Health Statistics (NCHS) at the Centers for Disease Control (CDC).

The National Health Interview Survey (NHIS) is a continuous multipurpose and multistage probability area survey of the US civilian non-institutionalized population living at addressed dwellings (Kaminski 1980, Botman 1995, NCHS 2001). Each week a probability sample of households is interviewed by trained personnel to obtain information about the characteristics of each member of the household (Liao 1998). Data from the 1986-1994 NHIS Surveys included a range of measures of acute and chronic disability collected for all participants. Recently, the NHIS conducted a Mortality Follow-up with cause of death through 1997 for approximately 97% of the NHIS survey population from 1986-1994. The NHIS database allows for longitudinal analysis of mortality data as a retrospective cohort study, as well as for cross-sectional and trend analysis of the aggregate morbidity data. Thus, the NHIS database represents a unique opportunity to explore new research hypotheses, and to use the data as a surveillance tool to evaluate time trends, occupational disease, and mortality in the US for the past 2 decades in both genders and in a variety of race-ethnic subpopulations.

This Mortality Monograph establishes and applies a methodology to assess mortality rates by the top 10 causes of death for the US population during the 1986-1994 time period for US workers by occupation using the 1986-1994 NHIS data with follow-up through 1997. After adjustment for sample weights and design effects, the mortality rates were created in tabular format. These age adjusted mortality rates have been presented by occupation, as well as by gender, race, and ethnicity. Additional information has been made available to allow for extrapolation to the entire US worker population during the 1986-1994 time period.

BACKGROUND

The European countries, particularly England since 1837 in their Registrar General's Decennial Supplements for England and Wales, have had a long and illustrious history of performing nationwide occupational studies (Boffetta 1999, Drever 1995). As noted in the 1995 Registrar General's Report (Drever 1995), these data have provided a valuable means of generating hypotheses about work-related risks to health as well as insight in the effectiveness of preventive measures. The United States has had relatively few studies of equal scope and caliber to evaluate the causes of morbidity and mortality, and their trends, in US workers (Kaminski 1980, Milham 1976, Milham 1983, NIOSH 1993, Guralnick 1962, Guralnick 1963a, Guralnick 1963b, NIOSH 1997, Drever 1995, Gallagher 1989). As described below, the majority of these studies have focused on special subsets of data, not truly representative national data, and they have focused on mortality rather than morbidity.

US National Occupational Mortality Studies

Similar to the English studies, Guralnick (1962, 1963a, 1963b) used all US death certificates to look at age-race standardized mortality ratios (SMRs) for white and black men aged 20-64 by industry and by occupation. She evaluated trends by age, and compared them to the US Census data. Dr. Guralnick also acknowledged several study limitations, including what would now be called the healthy worker effect, and lack of information on important confounders such as socio-economic class. No female or other race-ethnic worker subpopulations were examined. Another major limitation was the use of death certificate-derived occupation/industry status; this has been shown to be highly inaccurate when compared to lifetime occupational histories, with misclassification estimated between 30-50% in US studies (Monson 1990, Checkoway 2004, Guralnick 1962, Guralnick 1963a, Guralnick 1963b, Kircher 1985, Schumacher 1986, Swanson 1984, Schade 1988).

Milham (1976, 1983) used data from Washington State to evaluate causes of mortality by occupation and industry using proportionate mortality ratios (PMRs) based on a large number of death certificates from 1950-1979. Limitations of these studies included no available confounders, the lack of rates (i.e. only proportions experienced), the lack of other race-ethnic worker subpopulations, lack of information on socio-economic class, and the use of death certificate information to classify occupation/industry status.

The National Traumatic Occupational Fatalities (NTOF) surveillance system estimates the risk of work-related fatal injuries for 50 industries and 50 occupations having the highest risks. NTOF supplies cause-specific risk estimates; it does not provide estimates for causes of death other than injury (Fosbroke 1997, Loomis 1998, Stout 1996). Similar analyses have been made using insurance databases (Toscano 1996). The National Institute of Occupational Safety and Health (NIOSH) (NIOSH 1993) used the death certificates with injury cause of death to evaluate fatal occupational injury rates from 1980-89 among male and female race-ethnic US worker populations. In addition to cause specific information, occupational injury rates (blacks>whites; males>females) and years of productive life lost were evaluated. Limitations to this study included no available confounders (such as socio-economic class), and the use of death certificate occupation/industry status.

Wagener et al (1997) attempted to use data from many available national databases (i.e., NHIS, NHANES, National Occupational Mortality Surveillance System, and NTOF, as well as the National Maternal and Infant Health Survey, National Hospital Ambulatory Medical Care Survey, the Census of Fatal Occupational Injuries, the Annual Survey of Occupational Injuries, and the Current Population Survey) to examine the health of women according to workforce and job conditions. In addition to presenting an overview of numbers and frequencies by age, race, ethnicity and educational level of various occupations, industries and presumed occupational exposures, for morbidity and mortality analyses, the risks were calculated as the observed over expected proportions, not rates or trends over time.

Reviere et al (1995) used the National Mortality Follow-up Survey of 1986 to identify Sentinel Health Events Occupational (SHE(O)s) to look at causes of death beyond injury for the US worker. The National Cancer Institute (NCI), NIOSH and others have developed a database known as the National Occupational Mortality Surveillance System based on the death certificate listed occupation to study cancer and other causes of mortality in a variety of occupations (Ma 1998, Alterman 1997). NIOSH (1993, 1997) also evaluated mortality by occupation, industry, state and cause of death as proportionate mortality ratios from 24 reporting States from 1984-1988 among male and female black and white US worker populations. In addition to trends, years of productive life lost were estimated. The results may be evaluated by researchers and used as leads for further studies and to confirm previously identified associations. Researchers may identify new occupations and industries not previously recognized as experiencing an excess risk for a known occupational disease. Finally, these databases may be used to prioritize health promotion and intervention activities to the appropriate workers for both occupational and non occupational diseases (Kaminski 1980, Drever 1995). Limitations to these studies included no available confounders, the lack of rates and the use of only selected states' data, the lack of other race-ethnic worker subpopulations, and the use of death certificate occupation/industry.

Other Large Mortality and Morbidity Occupational Studies

In the US, as in other industrialized countries (Drever 1995),there have been a large number of studies of the mortality and morbidity rates of particular industries or groups of workers. Traditionally, occupational epidemiologic studies of mortality and morbidity have focused on cohorts of workers at particular industrial worksites, due to the relative ease of access to data (Honda 1995, Dell 1995, Tsai 1996, Chiazze 1997, Gold 1998). Research has also been performed on the causes of mortality and morbidity for white male workers in large occupational groups, such as chemical workers, construction workers, etc (Suruda 1996, Robinson 1995, Koskala 1997, Matanoski 1998, Steenland 1995, Blair 1993, Kross 1996, Savitz 1998). In addition, work has been done on morbidity and mortality trends for US workers in specific geographic areas (Fleming 1999, Hwang 1995, Milham 1976). Although performed in other countries (Kagamimori 1998, Engholm 1995, Schouten 1995), very little research has been performed on the US workforce as a whole, due to the lack of large and appropriately selected samples. Therefore, when studying the health status of the US worker, particular industry/worker group, and/or geographic constraints have applied.

Furthermore, there has been relatively little research on different age, race-ethnic and female subpopulations, as well as socio-economic class, of the US workforce as a whole. Recent Health disparity studies have shown that older age, race-ethnic, lower socio-economic class, and even some female subpopulations are at increased risk for disability and mortality compared to their white male counterparts (Pollan 1999, Zwerling 1996 & 1998, King 1997, Bollini 1995, Murray 2003, Boffetta 1997, Barbeau 2004, Steenland 2003b, Steenland 2003a, Zwerling 1997, O'Campo 2004, Janzen 2003, Khlat 2000, Frumkin 1999, Wagener 1991).

Although laudable, all of these attempts have been biased by selective reporting or by the use of occupation at time of death as the definition of occupational exposure, or have focused purely on traumatic injury, or are not generalizable to the entire US workforce due to sampling issues. As noted by Kaminski and Spirtas (1980), as a nationally representative dataset, the NHIS data can be used as a surveillance system for occupational disease morbidity and mortality for all US workers, and recommended that its use for this purpose be explored further.

METHODS

The NHIS dataset is anonymous and publicly available through the National Center for Health Statistics (NCHS); although there are no human subject considerations in the use of this dataset per the NCHS, an official waiver was obtained from the University of Miami School of Medicine Human Subjects Committee. During the 1986-1994 study period, annual NHIS survey response rates experienced ranged from 95-98% (Massey 1989). In the majority of cases (63%), the participants themselves answered all the questions, and for the remaining participants, the responses were obtained from their relatives or other proxies. For simplicity, in the present study either self-reported or proxy-reported data are referred to as "reported."

Information on employment during the two weeks prior to the interview was collected for all persons 18 years or older in order to determine the person's employment status; as utilized by other investigators, all subjects age 18 years and older who had worked or experienced having jobs, both paid and unpaid, during the two weeks prior to the NHIS survey were considered currently employed (Kaminski 1980, Zwerling 1997, Brackbill 1988). Standardized Occupational Codes (really US Census codes) were provided in the NHIS database (NCHS 1998a, NCHS 1992) as well as various NHIS recodes with less detailed grouped occupational codes. For the purpose of this study, only the 206 occupations employing at least 100,000 workers annually in the US during the 1986-94 study period were selected for detailed analyses (including their US Census standardized occupational codes).

A Personal Identifier Code has been created by NCHS, allowing linkage with the individual NHIS survey years. The linkage was performed completely by computer, and used an algorithm with a match class and score. On average, the linkage was 97% complete; only those under 18 years and those with insufficient information to permit linkage to the NDI were considered ineligible and excluded from the analysis. With the NHIS Mortality Follow-up through December 31, 1997, a total of 12,124 deaths were found by this successful linkage with 440,245 working adults among the 451,897 who participated in the NHIS 1986-94 surveys (NCHS 1998b, NCHS 2001). This Mortality Follow-up permits the use of the NHIS Survey data since 1986 for survival, mortality, and life expectancy analyses. For example, Liao et al (1998) used a part of the NHIS Mortality Follow-up survey (1986-90) to examine mortality rates in Hispanics compared to Non Hispanic Whites in the US; the University of Miami Investigators have used the 1986-1994 Study Database to examine causes of mortality among all pesticide applicators and farmers compared to other US workers (Fleming 2003).

Provided in Table 2 are the number of workers who participated in the NHIS survey pooled over the 1986-94 period ("sample size"), the number of NHIS worker participants with mortality follow-up through 1997 ("mortality follow-up sample size"), the estimated number of workers these participants represented in the US worker population during this time period ("estimated US worker population"), and the number of deaths are presented by gender, race and ethnicity subpopulations. Of note, tables for the 13, 41, and 206 occupational groups are available at the Study Website (**www.UMiamiORG.com**).

For the present analyses, the Investigators used the CDC Top 10 Causes of Death for the US population age 18 years and older from 1986-1994 (Table 1). The rankings of these causes of death were generated using the CDC program WISQARS TM (Web-based Injury Statistics Query and Reporting System) which is an interactive database system that provides customized reports of injury-related data. These data can be generated at the Website of the CDC National Center for Injury Prevention and Control: http://webapp.cdc.gov/sasweb/ncipc/leadcaus9.html. The ICD 9 Codes for these Top 10 Causes of Death can be found in Table 1 . For each of the Top 10 Causes of Death, analyses were performed by occupation and other factors available (i.e. gender, race, and ethnicity).

Statistical Methods

Because of the multi-stage sampling design, all analyses were performed with adjustment for sample weights and design effects using the SUDAAN statistical package (RTI 2001). The sample weights used were those required for the analysis of data from combined survey years and were calculated as specified by Botman and Jack (1995).

Age-adjusted mortality rates

Age-adjusted rates and the corresponding standard errors presented in the present monograph are expressed in terms of deaths per 100,000 person years, and were computed using the " direct method" using the year 2000 US population, ages 18 and older, as the standard population. The latter was obtained from the master list of age-adjustment weights, broken into 15 categories, from the CDC's Healthy People 2010 Statistical Notes #20 (http://www.cdc.gov/nchs/products/pubs/pubd/hp2k/statnt/20-11.htm).

Using the Sudaan's "Proc Descript," the investigator can perform calculation of age-standardized rates by the direct method with adjustments for sample weights and design effects. However, without suitable modification to the data set, this procedure does not allow the inclusion of person-years and does not take into account the changing age-structure of a cohort followed over time. Therefore, before using Sudaan's "Proc Descript," the data set was rewritten so that there would be one record per year of follow-up for each individual, either until the year of death or until the end of the follow-up period, i.e., December 31, 1997. In addition, the survey respondent's age on each additional record was advanced one year. These modifications generated a new data set that takes into account not only the number of years-at-risk for each survey participant, but also the age dynamics of the cohort.

Data Tables and Use

Mortality data are presented in tabular format for each of the 3 levels of major US occupational groupings (i.e. 13, 41, and 206). First, there is an initial table showing the age adjusted mortality rates (and their corresponding standard errors) per 100,000 for the study time period for overall mortality and the Top 10 Causes of Mortality for all workers of a particular occupational group (Table 3). Subsequent Tables present data on the age adjusted overall and cause specific mortality rates (and their corresponding standard errors) per 100,000 for the study time period for the different gender and race/ethnicity subpopulations with corresponding sample sizes.

Mortality rates were calculated when there was at least 1 death in the occupational subpopulation of interest. It should be noted that mortality analyses with less than 5 deaths/occupational subpopulation can result in very unstable point estimates and corresponding standard errors. Furthermore, because of the sample weighting of the NHIS, in some instances a very small standard error of approximately 0.0 will result. Therefore, analyses of small numbers of deaths should be interpreted with caution.

These unique data tables have been made available in two contemporary file formats: Portable Document Format (PDF) and Excel Spread Sheets (Excel) at the Study Website (URL: **http://www.UMiamiORG.com**). The PDF format allows researchers to quickly view and print the current table layouts, while the Excel format can be utilized to download the files to a remote computer and manipulate the data table locally.

To save an Excel file to a local computer system, the Study Website user can right click with their mouse over a link, at which time a dialog box will appear. Select the "Save target as" option to save the file from the Study website to the local system. A file viewer for PDF files is readily and freely available at the following website **http://www.adobe.com/products/acrobat/readstep2.html**.

Researchers can utilize these additional data tables to further explore mortality experienced among this population-based sample and extrapolate to the general US workforce. As discussed above, the Standard Errors (SEs) presented in the Tables for the age adjusted overall and cause specific mortality rates are presented. These SEs can be used to generate estimates of national level numbers as well as to generate confidence intervals. For example, for a particular disability measure, the reader can take (1.96 x SE) ± Mortality Rate to generate the estimated range of that particular mortality rate among US workers.

RESULTS

The results presented below summarize the age adjusted overall and cause specific mortality rates (± their corresponding standard errors [SE]) per 100,000 persons enrolled during the study period 1986-1994 with follow-up through 1997 by describing the highest and lowest of the particular cause specific mortality rate for each of the occupational groupings (i.e. 13, 41, and 206). More detailed tables which include standard errors for the 13, 41 and 206 occupations are available at the Study Websites and Appendices as described above; in addition to occupation, all tables report the data by gender, race and ethnicity as well as total populations.

Overall Mortality

13 Occupations : In Table 4, the age adjusted mortality rate for overall mortality by the different occupations is presented by gender, race and ethnicity, as well as the estimated US population numbers. Among the 13 occupations, Protective service workers experienced the highest overall mortality rates (1058±150), while Technicians/related support workers experienced the lowest (454±72). Among the gender-race-ethnicity subgroups, black Protective service workers experienced the highest overall mortality rate (2139±678), while Hispanic Private household workers experienced the lowest (160±72).

41 Occupations : In Table 4 , the age adjusted mortality rate for overall mortality by the different occupations is presented by gender, race and ethnicity, as well as the estimated US population numbers. Among the 41 occupations, Computer equipment operators experienced the highest overall mortality rate (1429±869), while other transportation, except motor vehicles workers experienced the lowest (337±103). Among the gender-race-ethnicity subgroups, Construction laborers in the 'other races' category experienced the highest overall mortality rate (4152±2237), while eight subgroups of workers experienced no deaths.

206 Occupations : In Table 4 , the age adjusted mortality rate for overall mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 206 occupations, Sales workers, parts (3111±200) experienced the highest overall mortality, while Personnel and labor relations managers experienced the lowest (90±32). Among the gender-race-ethnicity subgroups, black Industry workers experienced the highest overall mortality (6918±803), while two hundred three worker subgroups experienced no deaths.

Cardiovascular Disease

In Table 5 , the age adjusted mortality rate for cardiovascular mortality by the different occupations is presented by gender, race and ethnicity, as well as the estimated US population numbers. Among the 13 occupations, Transportation/material moving workers experienced the highest rate of cardiovascular mortality (372±93), while technicians/related support workers experienced the lowest (167±52). Among the gender-race-ethnicity subgroups, black Executive, administrative, managerial workers experienced the highest cardiovascular mortality (714±446), while Technicians/related support workers in the 'other races' category experienced no deaths.

41 Occupations : In Table 5 , the age adjusted mortality rate for cardiovascular disease by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 41 occupations, Computer equipment operators experienced the highest rate of cardiovascular mortality (1251±868), while Fabricators, assemblers, inspectors, samplers experienced the lowest (69±15). Among the gender-race-ethnicity subgroups, Hispanic

Other professional specialty occupations experienced the highest rate of cardiovascular mortality (1313±864), while thirty subgroups of workers experienced no deaths.

206 Occupations : In Table 5 , the age adjusted mortality rate for cardiovascular mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 206 occupations, Heating air conditioning, and refrigeration mechanics experienced the highest cardiovascular mortality rate (2155±38), while bank tellers and dental assistants experienced no deaths. Among the gender-race-ethnicity subgroups, Hispanic Medicine and health workers (4801±1615) experienced the highest cardiovascular mortality, while workers in four hundred ninety-five different subgroups of workers experienced no deaths.

Malignant Neoplasms

In Table 6 , the age adjusted mortality rate for cancer mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 13 occupations, Protective service workers experienced the highest cancer mortality rate (438±96), while technicians/related support experienced the lowest (139±25). Among the gender-race-ethnicity subgroups, black Protective service workers experienced the highest cancer mortality (1675±677), while private Household workers in the ‘other races’ category experienced no deaths.

41 Occupations : In Table 6 , the age adjusted mortality rate for cancer mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 41 occupations, Forestry and fishing occupations experienced the highest rates of cancer mortality (755±237), while Computer equipment operators experienced the lowest (82±27). Among the gender-race-ethnicity subgroups, black Officials and administrators public administration experienced the highest cancer mortality (3961±113), while twenty-three subgroups of workers experienced no deaths.

206 Occupations : In Table 6 , the age adjusted mortality rate for cancer mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 206 occupations, Sales workers experienced the highest rate of cancer mortality (2814±163), while operations/systems researchers and analysts experienced the lowest (17±17). Among the gender-race-ethnicity subgroups, Hispanic Garage and service station related occupations experienced the highest cancer mortality (5527±748), while four hundred eighteen subgroups of workers experienced no deaths.

Cerebrovascular Disease

In Table 7 , the age adjusted mortality rate for cerebrovascular mortality by the different occupations is presented by gender, race, and ethnicity. Among the 13 occupations, Precision production, craft, repair workers experienced the highest rate of cerebrovascular mortality (78±28), while Technicians/related support experienced the lowest (4±2). Among the gender-race-ethnicity subgroups, black Handlers, equipment cleaners, helpers, laborers experienced the highest cerebrovascular mortality (169±97), while thirteen subgroups of workers experienced no deaths.

41 Occupations : In Table 7 , the age adjusted mortality rate for cerebrovascular mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 41 occupations, Precision production occupations experienced the highest rates of cerebrovascular mortality (147±61), while Health technologists and technicians workers experienced the lowest (8±6). Among the gender-race-ethnicity subgroups, Mail and message distributing workers in the ‘other races’ category experienced the highest cerebrovascular mortality (375±266), while ninety-seven subgroups of workers experienced no deaths.

206 Occupations : In Table 7 , the age adjusted mortality rate for cerebrovascular mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 206 occupations, Inspectors, testers, and graders experienced the highest cerebrovascular mortality rates (2473±18), while seventy-four occupational groups experienced no deaths. Among the gender-race-ethnicity subgroups, Musicians and composers in the 'other races' category experienced the highest cerebrovascular mortality (6191±0.0), while nine hundred forty-four subgroups of workers experienced no deaths.

Chronic Respiratory Disease

In Table 8 , the age adjusted mortality rate for chronic respiratory disease mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 13 occupations, Precision production, craft, repair workers experienced the highest chronic respiratory mortality rate (61±25), while Private household workers experienced the lowest (5±4). Among the gender-race-ethnicity subgroups, Hispanic Sales workers experienced the highest chronic respiratory disease mortality (75±57), while twenty-three subgroups of workers experienced no deaths.

41 Occupations : In Table 8 , the age adjusted mortality rate for chronic respiratory disease mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 41 occupations, Construction and extractive trades experienced the highest rate of chronic respiratory disease mortality (223±122), while four occupational groups experienced no deaths. Among the gender-race-ethnicity subgroups, Construction laborers in the 'other races' category experienced the highest chronic respiratory disease mortality (484±522), while one hundred twenty-one subgroups of workers experienced no deaths.

206 Occupations : In Table 8 , the age adjusted mortality rate for chronic respiratory disease mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 206 occupations, Brickmasons and stonemasons experienced the highest rate of chronic respiratory disease mortality (546±24), while ninety-eight occupational groups experienced no deaths. Among the gender-race-ethnicity subgroups, black Industrial workers experienced the highest chronic respiratory disease mortality (5517±0.0), while one thousand seventy subgroups of workers experienced no deaths.

Unintentional Injury

13 Occupations : In Table 9 , the age adjusted mortality rate for unintentional injury mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 13 occupations, transportation/ material moving workers experienced the highest rate of unintentional injury mortality (231±82), while Executive, administrative managerial occupations experienced the lowest (21±3). Among the gender-race-ethnicity subgroups, white Transportation/material moving workers experienced the highest unintentional injury mortality (342±133), while seven subgroups of workers experienced no deaths.

41 Occupations : In Table 9 , the age adjusted mortality rate for unintentional injury mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 41 occupations, Material moving equipment operators experienced the highest rate of unintentional injury mortality (563±13), while Other transportation, except motor vehicles, workers experienced no deaths. Among the gender-race-ethnicity subgroups, male Material moving equipment operators experienced the highest unintentional injury mortality (565±13), while seventy subgroups of workers experienced no deaths.

206 Occupations : In Table 9 , the age adjusted mortality rate for unintentional injury mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 206 occupations, Real estate sales occupations experienced the highest rate of unintentional injury mortality (571±550), while forty-five occupational groups experienced no deaths. Among the gender-race-ethnicity subgroups, black Tool and die makers experienced the highest unintentional injury mortality (2696±2589), while seven hundred sixty-four subgroups of workers experienced no deaths.

Pneumonia and Influenza

In Table 10 , the age adjusted mortality rate for pneumonia and influenza mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 13 occupations, Machine operators, assemblers, inspectors experienced the highest rates of pneumonia and influenza mortality (65±56), while Technicians/related support workers experienced the lowest (1±1). Among the gender-race-ethnicity subgroups, male Machine operators, assemblers, inspectors experienced the highest pneumonia and influenza mortality (96±85), while nineteen subgroups of workers experienced no deaths.

41 Occupations : In Table 10 , the age adjusted mortality rate for pneumonia and influenza mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 41 occupations, Machine operators/tenderers (except precision) experienced the highest rates of pneumonia and influenza mortality (79 ±67), while seven occupations experienced no deaths. Among the gender-race-ethnicity subgroups, male Machine operators/tenderers (except precision) experienced the highest pneumonia and influenza mortality (129±112), while one hundred and thirty-one subgroups of workers experienced no deaths.

206 Occupations : In Table 10 , the age adjusted mortality rate for pneumonia and influenza mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 206 occupations, Roofers experienced the highest rates of pneumonia and influenza mortality (1227±0.0), while one hundred and fifteen occupations experienced no deaths. Among the gender-race-ethnicity three subgroups, white, male, and non-Hispanic Roofers experienced the highest pneumonia and influenza mortality (1227±0.0), while eleven hundred twenty-six subgroups of workers experienced no deaths.

Diabetes

In Table 11 , the age adjusted mortality rate for diabetes mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 13 occupations, Administrative support occupations (including clerical) experienced the highest rates of diabetes mortality (35±14), while Handlers, equipment cleaners, helpers, laborers experienced the lowest (4±2). Among the gender-race-ethnicity subgroups, Hispanic Protective service workers experienced the highest diabetes mortality (157±116), while twenty worker subgroups experienced no deaths.

41 Occupations : In Table 11 , the age adjusted mortality rate for diabetes mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 41 occupations, Other Transportation (except motor vehicles) occupations experienced the highest rates of diabetes mortality (279±278), while seven occupations experienced no deaths. Among the gender-race-ethnicity subgroups, Hispanic Police and firefighters experienced the highest diabetes mortality (4436±2717), while one hundred twenty-five subgroups of workers experienced no deaths.

206 Occupations : In Table 11 , the age adjusted mortality rate for diabetes mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 206 occupations, Supervisors, mechanics, and repairers experienced the highest rates of diabetes mortality (4211±1087), while one hundred and four occupations experienced no deaths. Among the gender-race-ethnicity subgroups, Hispanic Sheriffs/bailiffs/other law enforcement officers experienced the highest diabetes mortality (10755±0.0), while one thousand seventy-eight subgroups of workers experienced no deaths.

Suicide

In Table 12 , the age adjusted mortality rate for suicide mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 13 occupations, Handlers, equipment cleaners, helpers, laborers experienced the highest rate of suicide mortality (128±65), while private household workers experienced the lowest (18±18). Among the gender-race-ethnicity subgroups, Private household workers in the 'other races' category experienced the highest suicide mortality (639±685), while nineteen subgroups of workers experienced no deaths.

41 Occupations : In Table 12 , the age adjusted mortality rate for suicide mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 41 occupations, Forestry and fishing occupations experienced the highest rate of suicide mortality (168±110), while Architects and surveyors experienced no deaths. Among the gender-race-ethnicity subgroups, Hispanic Personal service workers experienced the highest suicide mortality (826±763), while one hundred nine subgroups experienced no deaths.

206 Occupations : In Table 12 , the age adjusted mortality rate for suicide mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 206 occupations, Legal assistants experienced the highest rates of suicide mortality (721±468), while eighty-two occupations experienced no deaths. Among the gender-race-ethnicity subgroups, Supervisors, cleaning and building service workers in the 'other races' category experienced the highest suicide mortality (2933±2650), while one thousand fifteen subgroups of workers experienced no deaths.

Liver Disease

In Table 13 , the age adjusted mortality rate for liver disease mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 13 occupations, Handlers, Equipment cleaners, helpers, laborers experienced the highest rate of liver disease mortality (123±42), while Administrative support occupations, including clerical workers experienced the lowest (14±6). Among the gender-race-ethnicity subgroups, Handlers, equipment cleaners, helpers, laborers in the 'other races' category experienced the highest liver disease mortality (244±240), while sixteen subgroups of workers experienced no deaths.

41 Occupations : In Table 13 , the age adjusted mortality rate for liver disease mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 41 occupations, Other protective service occupations experienced the highest rate of liver disease mortality (152±87), while eight occupations experienced no deaths. Among the gender-race-ethnicity subgroups, Construction laborers in the 'other races' category experienced the highest liver disease mortality (4036±2931), while one hundred thirty-six subgroups of workers experienced no deaths.

206 Occupations : In Table 13 , the age adjusted mortality rate for liver disease mortality by the

different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 206 occupations, Molding and casting machine operators experienced the highest rate of liver disease mortality (1036±954), while one hundred sixteen occupations experienced no deaths. Among the gender-race-ethnicity subgroups, Construction laborers in the ‘other races’ category experienced the highest liver disease mortality (4036±2931), while eleven hundred twenty-eight subgroups of workers experienced no deaths.

HIV/AIDS

In Table 14 , the age adjusted mortality rate for HIV/AIDS mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 13 occupations, Handlers, equipment cleaners, helpers, laborers experienced the highest rates of HIV/AIDS mortality (86±25), while Farming, forestry, fishing workers experienced the lowest (24±10). Among the gender-race-ethnicity subgroups, black Handlers, equipment cleaners, helpers, laborers experienced the highest HIV/AIDS mortality (330±138), while thirteen subgroups of workers experienced no deaths.

41 Occupations : In Table 14 , the age adjusted mortality rate for HIV/AIDS mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 41 occupations, Architects and surveyors experienced the highest rates of HIV/AIDS mortality (226±142), while two occupations experienced no deaths. Among the gender-race-ethnicity subgroups, black Construction and extractive trade workers experienced the highest HIV/AIDS mortality (599±355), while eighty-six subgroups of workers experienced no deaths.

206 Occupations : In Table 14 , the age adjusted mortality rate for HIV/AIDS mortality by the different occupations is presented by gender, race and ethnicity as well as the estimated US population numbers. Among the 206 occupations, Designers experienced the highest rates of HIV/AIDS mortality (362±192), while seventy-six occupations experienced no deaths. Among the gender-race-ethnicity subgroups, black Advertising and related sales occupations experienced the highest HIV/AIDS mortality (5991±3917), while nine hundred forty-five subgroups of workers experienced no deaths.

CONCLUSIONS

The current Mortality Monograph of all currently employed adults 18 years or older from the 1986-1994 NHIS surveys with mortality follow-up for 97% through 1997 demonstrated increased overall and cause specific mortality rates among certain occupational groups compared to all others. This Monograph confirms some possible associations between particular occupations (and their exposures) and certain cause specific mortality rates already recognized in the literature. This Monograph also demonstrates possible new associations between occupations and cause specific mortality rates, particularly among the gender, race, and ethnic subpopulations with the more detailed occupational coding. In general, these new associations were only able to be detected due to the large representative sample size of the US workforce provided by the NHIS surveys. Furthermore, these possible new associations can be considered "hypothesis generating" and worthy of future investigation and research.

In general, among the occupations, more skilled "white collar" workers were less likely to have increased overall or cause specific mortality. Of note, these same workers were more likely to report less disability, better self rated health and fewer health conditions (Fleming 2004). Within particular occupations, Hispanic, black and "other" workers were more likely to experience increased overall and cause specific mortality. Of note, these same worker subgroups were more likely to report acute and chronic disability measures, poor self rated health and numbers of health conditions. In particular, race-specific comparisons often revealed higher morbidity in workers in the 'other races' category (Fleming 2004).

In a separate analysis, the investigators have modeled acute and chronic disability adjusting for age, gender, race/ethnicity, and education in the entire NHIS worker database, as well as comparing disability among farmers and pesticide applicators with all other US workers (Gomez Marin 2004, Fleming 2004). Among all NHIS workers, for acute disability younger age was a significant risk factor; older age was a significant risk factor in a dose response fashion for reporting chronic disability and poor health status. Of note, using the same NHIS database, Zwerling et al (1996, 1997, 1998) have found a significantly increased experienced injury risk among older and disabled US workers. As with other investigators, Gomez Marin et al (2004) also found that older female uneducated workers were at significantly higher risk of chronic disability and experienced poor health status compared to all other US workers. Less educated older female workers are more likely to have poorly paying jobs with significant physical labor and hours.

Several causes of mortality among those examined in this Monograph have been traditionally associated with occupational exposures: Malignant Neoplasms, Chronic Respiratory Disease, Pneumonia and Influenza, and Unintentional Injury (Nathell 2000, Rosengren 2004, Simpson 1999, Carpenter 1999, Rosenstock 2005). For Malignant Neoplasms, Forestry and fishing occupations had an increased mortality rate as has been explored in the literature with possible associations with exposure to certain herbicides and pesticides (Kirkhorn 2002, Milham 1999); it is interesting that the highest mortality rates were experienced by Hispanic Garage and service station related occupations. For Chronic Respiratory Disease, Construction and extractive trades had an increased rate also reported in the literature (Bernstein 2004, Bergdahl 2004), but the highest rates were seen among the black Industrial workers. For Pneumonia and influenza, Machine operators/tenderers (except precision) had elevated rates which is interesting given exposures to machining fluids with possible bacterial contamination and pulmonary effects (Anon 2002, Kreiss 1997), however the highest rates were seen among Roofers (particularly non Hispanic) who also experience pulmonary effects from occupational exposures and are members of the construction trades (Melius 2003). Finally for Unintentional Injury, as might be expected, Transportation/material moving workers had increased mortality rates (Lam 2004, Janicak 2003), but the highest rates were seen among black Tool and die makers.

The other causes of mortality among the Top 10 Causes of Mortality in the US during the Study Period have had more tenuous associations with occupations and their exposures. For Overall Mortality, it is not surprising the Protective service workers (particularly black) and Construction workers (particularly “other races”) experienced increased mortality rates (Plani 2003, Dong 2004, Steenland 2003a, Steenland 2003b), but black Industry workers experienced the highest rates. With respect to Cardiovascular Disease, as might be expected, Transportation/material moving workers had increased rates (Martins 2003, Stein 2001), however Hispanic Medicine and health workers experienced the highest rates. For Cerebrovascular Disease, Precision production, craft, repair workers had increased mortality rates with the highest rates seen among Musicians and composers of “other races.” Diabetes Mortality rates were highest among Hispanic Sheriffs/bailiffs/other law enforcement officials. For Suicide Mortality, elevated mortality rates were seen among Forestry and fishing occupations possibly associated with the neurotoxicity of occupational pesticide exposures (Gregiore 2002, Parron 1996), however the highest rates were seen among Supervisors, cleaning and building service workers of “other races.” Liver Disease Mortality was highest among Construction workers of “other races.” Finally, HIV/AIDS Mortality was elevated among Designers (Cassano 2000), but highest among black Advertising and related sales occupations.

Limitations

These analyses suffered from some of the data limitations seen in similar previous epidemiologic studies. The most important limitation in interpreting the Mortality Rates was the relatively small number of deaths experienced to date by this NHIS Occupational Cohort, particularly those in the 206 Occupational Subgroups further divided by gender, race and ethnicity; therefore, as noted above, any increased rates must be viewed as hypothesis generating only. Other limitations included: the self report and cross sectional nature of the initial data which might lead to underestimation of the true health situation since really sick people leave the work force (part of the healthy worker effect); lack of individual exposure measures, and occupational misclassification in general due to the use of “current job” as a surrogate for “longest held job,” as well as misclassification of occupation related exposures. With regards to the latter issue, two occupational health related supplements were administered to NHIS participants, one in 1986 and the second in 1988. We used previously published Kappa values from these two supplements to estimate the extent to which “current job” reflected “longest held job” within each occupational category (Gomez Marin 2005). The use of the US worker population as the major comparison population is appropriate for controlling for the healthy worker effect and other biases (Cooper 1993, Checkoway 2004, Monson 1990, Burnett 1989). Previous work using the NHIS database has shown that certain occupational groups, such as farmers, smoke and drink less than many other worker groups (15-29% prevalence) which may explain some but not all of the study findings (Brackbill 1988, Nelson 1994, Sterling 1990, Lee 2004). Confounding data such as tobacco use and obesity are available for subpopulations of the NHIS database but were not used in this study; however, tobacco use data are available for use by researchers at the Study Website (www.UMiamiORG.com) (Caban in press, Lee 2004). The NHIS data (including occupation) were based largely on self-report (by the individual or proxy) without objective confirmation. The limitations and lack of these data are an important limitation on any conclusions that can be drawn from these analyses.

Although research in this area is often contradictory, validation studies conducted by the NCHS and others suggest that proxy reports lead to slightly lower prevalence estimates of a range of information compared with reports obtained directly from respondents (Edwards 1994, Edwards 1996, Thornberry 1987). To address this potential bias, we repeated our mortality analyses, including only the 63% of NHIS participants who were interviewed directly in the 1986-1994 NHIS surveys. For example, findings indicated that the non-proxy self experienced responses of the disability measures were uniformly only slightly greater than those from the proxy responses (Fleming 2004).

Ultimately, the NHIS data strongly suggest that selected occupations by gender and race-ethnicity subpopulation should be an important target populations for occupational prevention and intervention (Partenen 2002). Researchers in occupational health are urged to seek out this important and publicly available resource. The NHIS database and mortality follow-up represent a probability sample of the entire US population, with the ability to compare both morbidity and mortality among US workers. Furthermore, as noted by NIOSH (1997) and the English Registrar's Decennial Reports (Drever 1995), databases such as the NHIS surveys and mortality follow-up can be used not only to target studies of work-related conditions and to add to the body of evidence generated from epidemiologic studies, but also to provide surveillance data for establishing priorities, and for tracking progress towards the elimination of preventable diseases and mortality.

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Appendix

Table 1 . 1986-1994 CDC Top 10 Causes of Death, ICD 9 Codes, and Deaths among Survey Respondents (Download Table 1 in Excel Format)

Table 2 . Occupational Groups, Number of Deaths, Sample Sizes, and Population Estimates by 13, 41 and 206 Occupations (Download Table 2 in Excel Format)

Table 3 . Age Adjusted Overall and Cause Specific Mortality Rate/100,000 Person Years (± SE) among 13, 41 and 206 Occupations (Download Table 3 in Excel Format)

Table4 . Crude and Age Adjusted All Cause Mortality Rate/100,000 Person Years and SE among 13, 41 and 206 Occupations by Socio-Demographic Subgroups (Download Table 4 in Excel Format)

Table 5 . Crude and Age Adjusted Cardiovascular Disease Mortality Rate/100,000 Person Years (± SE) among 13, 41 and 206 Occupations by Socio-Demographic Subgroups (Download Table 5 in Excel Format)

Table 6 . Crude and Age Adjusted Malignant Neoplasms Mortality Rate/100,000 Person Years(± SE) among 13, 41 and 206 Occupations by Socio-Demographic Subgroups (Download Table 6 in Excel Format)

Table 7 . Crude and Age Adjusted Cerebrovascular Mortality Rate/100,000 Person Years (± SE) among 13, 41 and 206 Occupations by Socio-Demographic Subgroups (Download Table 7 in Excel Format)

Table 8 . Crude and Age Adjusted Chronic Respiratory Disease Mortality Rate/100,000 Person Years (± SE) among 13, 41 and 206 Occupations by Socio-Demographic Subgroups (Download Table 8 in Excel Format)

Table 9 . Crude and Age Adjusted Unintentional Injury Mortality Rate/100,000 Person Years (± SE) among 13, 41 and 206 Occupations by Socio-Demographic Subgroups (Download Table 9 in Excel Format)

Table 10 . Crude and Age Adjusted Pneumonia and Influenza Mortality Rate/100,000 Person Years (± SE) among 13, 41 and 206 Occupations by Socio-Demographic Subgroups (Download Table 10 in Excel Format)

Table 11 . Crude and Age Adjusted Diabetes Mortality Rate/100,000 Person Years (± SE) among 13, 41 and 206 Occupations by Socio-Demographic Subgroups (Download Table 11 in Excel Format)

Table 12 . Crude and Age Adjusted Suicide Mortality Rate/100,000 Person Years (± SE) among 13, 41 and 206 Occupations by Socio-Demographic Subgroups (Download Table 12 in Excel Format)

Table 13 . Crude and Age Adjusted Liver Disease Mortality Rate/100,000 Person Years (± SE) among 13, 41 and 206 Occupations by Socio-Demographic Subgroups (Download Table 13 in Excel Format)

Table 14 . Crude and Age Adjusted HIV/AIDS Mortality Rate/100,000 Person Years (± SE) among 13, 41 and 206 Occupations by Socio-Demographic Subgroups (Download Table 14 in Excel Format)