Occupational Bladder Cancer Mortality Among Racial and Ethnic Minorities in 21 States

By: Mark R. Schulz, MSPH and Dana Loomis, PhD

Schulz, M. R. & Loomis, D. (2000). Occupational bladder cancer mortality among racial/ethnic minorities in 21 states. *American Journal of Industrial Medicine, 38 (1)*, 90-98.

Abstract:
Background: Occupational bladder cancer mortality among minority racial/ethnic groups is not well described compared to occupational bladder cancer mortality among non-minority males in the United States.
Methods: Race/ethnicity- and sex-specific bladder cancer mortality (1985-1992) of workers employed in 21 states was examined using a proportionate mortality study design. Mortality of specific racial/ethnic/ occupational groups was compared separately with workers in the specific occupation and with members of the specific racial/ethnic group.
Results: This study identified elevated bladder cancer mortality among African American males and females and Latino males in several occupational groups with exposure to suspected bladder carcinogens as well as among Asian males in sales (PMR = 2.13) and Asian females in the personal services industry (PMR = 5.25; CI: 1.64-16.75).
Conclusion: Surveillance of occupational cancer risks among racial/ethnic minorities using regularly available death certificate data is facilitated when states code both usual occupation/industry and race/ethnicity.
KEY WORDS: mortality; PMR; bladder cancer; African Americans; Asian Americans; Latinos; polycyclic aromatic hydrocarbons; autoworkers; occupation; industry; death certificate

Article:

INTRODUCTION

Bladder cancer incidence is only exceeded by the incidence of prostate, breast, lung and bronchus, and colon and rectal cancer in the general population of the United States [Wingo et al., 1999]. There is extensive evidence linking bladder cancer with workplace exposures [Silverman et al., 1996]. However, little is known about the relative risk of bladder cancer mortality for U.S. minority—racial— ethnic groups compared to non-minorities within specific industries or occupations, or about the relative risk of bladder cancer mortality by occupation and industry within racial—ethnic and gender groups other than white males.

Although in the general population bladder cancer incidence is highest among white males [Wingo et al., 1999], we suspected that historical job discrimination based on race and ethnicity may have resulted in elevated bladder cancer incidence and mortality among racial minorities in some occupations. The best documented case of injustice in the workplace leading to elevated bladder cancer risk in a minority racial and ethnic group is the Augusta Chemical Company cohort, a group of 1,385 hourly workers employed between 1942 and 1972 [Schulte et al., 1985]. African American workers had jobs involving greater exposure to the known bladder carcinogen, betanaphthylamine, than the jobs of white workers. As a result, African American workers in the cohort experienced a risk ratio for bladder cancer of 5.0 while the risk ratio for white workers was 2.6. The discrepancy was even more pronounced among workers who were employed more than 10 years: African Americans experienced a risk ratio of 1 11. 1 compared to a risk ratio of 8.0 for whites.

In a multi-site case-control study, Schairer et al. [1988] found different occupations showed increased risk of bladder cancer mortality among blacks than among whites. In contrast, Silverman et al. [1989] found patterns of bladder cancer mortality risk by occupation to be similar for white men and nonwhite men. Little information is available for other groups. The small numbers of African Americans, Latinos, Asian Americans, and Native

Americans usually employed in a particular occupation in a single community or by a particular employer is one of the reasons cited for the lack of attention to these populations in occupational epidemiologic studies [Zahm et al., 1994].

This study investigates sex-specific bladder cancer mortality in occupational groups of four understudied racial and ethnic groups: African Americans, Latinos, Asian Americans, and Native Americans. Their mortality is compared to that of all workers of the same sex in the specific occupational group and to mortality in all workers of the same sex within the specific racial and ethnic group. A large geographically diverse set of bladder cancer deaths was used to overcome the obstacle of small numbers.

MATERIALS AND METHODS

Study Population

The study population was selected from 1985-1992 mortality data [NCHS, 1987, 1988, 1989, 1990, 1992, 1993a, 1993b, 1994] supplied by the National Center for Health Statistics (NCHS) for the 21 states (Colorado, Georgia, Idaho, Indiana, Kansas, Kentucky, Maine, Nebraska, Nevada, New Jersey, New Mexico, North Carolina, Ohio, Rhode Island, South Carolina, Tennessee, Utah, Vermont, Washington, West Virginia, and Wisconsin) that coded occupational information and racial and ethnic origin information in any of those years. A state's mortality data were included for each year that it coded both racial and ethnic origin and occupational data from the death certificate. Nebraska coded both only in 1985, while the remaining 20 states each contributed 4-8 years of mortality data.

Only individuals age 19 or older at the time of death were included in this study. Individuals whose industry or occupation was coded as retired, homemaker, student, volunteer, unemployed, never worked, or disabled, and those who did not work after 1974, were excluded from the dataset. After the exclusions, the numbers of bladder cancer deaths remaining varied by minority racial/ethnic/gender group from 719 Black males to three Native American females (Table I).

TABLE I. Bladder Cancer Mortality in Five Racial/Ethnic Groups, Referent Includes all Ethnic Groups in each Sex Group

Race/ethnicity	Sex	Observed	PMR[a]	95% CI[b]	
Asian	Female	7	1.69	0.75	3.82
Asian	Male	24	0.94	0.63	1.41
African American	Female	329	0.99	0.88	1.11
African American	Male	719	0.68	0.63	0.74
Latino	Female	24	1.07	0.70	1.63
Latino	Male	116	0.76	0.63	0.91
Native American	Female	3	0.44	0.13	1.52
Native American	Male	9	0.29	0.15	0.56
non-minority	Female	2,316	1.00	0.95	1.06
non-minority	Male	10,204	1.04	1.02	1.07

[a]Proportionate mortality ratio.
[b]95% confidence interval.

Bladder cancer deaths in the study population were identified from the Mortality Detail File based on the data provided for cause of death. The cause of death data were coded according to the International Classification of Diseases, 9th Revision (ICD-9). Only bladder cancer deaths with malignant bladder neoplasm (ICD-9 code 188) listed as the underlying cause of death were included in the study.

Racial, Ethnic and Occupational Groups

Membership in four minority groups in the United States—African Americans, Latinos, Asians, and Native Americans—was defined using race, ethnic origin (Latino was replaced by Hispanic origin in 1989 and subsequent years), and place of birth variables in the Mortality Detail File. The four minority groups were defined as follows: African Americans (Race = "Black" or Origin = "Other African" and Place of birth = US);

Latinos (Origin = "Mexican," "Puerto Rican," "Cuban," "Central or South American" or "Other unknown Spanish" (1985—88) or Hispanic Origin indicated (1989 onward)); Asians (Race = "Chinese," "Japanese," "Hawaiian," "Filipino" or "Other Asian or Pacific Islander"); Native American (Race = "American Indian" [includes Aleuts and Eskimos] or Origin= "American Indian"). All eligible persons not classified as one of these four minority groups were assigned to a "non-minority" referent group.

Occupational information in the Mortality Detail File was coded to the 1980 Census System for the Classification of Industries and Occupations. Three digit codes (the most detailed coding level) for individual occupation and industry categories were aggregated according to schemes similar to those used in previous studies based on these data [Loomis, 1991; Loomis and Savitz, 1991].

Data Analysis

This study involved two types of comparisons between occupational groups. First, proportional bladder cancer mortality of each minority—racial/ethnic—sex group in a specific occupational group was compared to proportional bladder cancer mortality for all workers in the same racial/ ethnic—sex group. Second, proportional bladder cancer mortality of each racial/ethnic—sex group in a specific occupational group was compared to proportional bladder cancer mortality for all workers in the same occupational group and sex. Classically, proportionate mortality ratios (PMRs) are used to analyze the structure of mortality within a population. PMRs can be thought of as a comparison of observed and expected numbers of deaths measured by an observed/ expected ratio. The observed number of deaths in a study group of interest, O, is equal to P1D1, or the product of the crude proportion of deaths from a specific cause in that study group, P1, times the total number of deaths, D1, in that study group. The number of deaths expected, E, is then equal to P2D1, where P2 is the proportion of cause-specific deaths in the referent group.

We adjusted our PMRs for age using 10-year age strata. Since the interest of this study is to compare bladder cancer mortality among multiple occupation groups within each race/ethnic—sex group and to compare sex-specific bladder cancer mortality among several race/ethnic groups within occupational group, mutually comparable measures of association are preferred. Mutually comparable measures of association are achieved through the use of a common set of weights for all groups, as in direct standardization, in each type of comparison described above. Therefore, the weights we used for age adjustment were, respectively, the total number of deaths among all workers of a given racial/ ethnic age group or the total number of deaths among all racial/ethnic groups in a specific occupation—age group. This method of weighting is essentially that described by Miettinen [1972] and is equivalent to direct standardization. Standard errors of the directly adjusted ratios are estimated using the classical formulation of Chiang [1963].

RESULTS

Mortality by Race, Ethnicity, and Sex

Bladder cancer mortality for each racial and ethnic— sex group without regard to occupation or industry is shown in Table I. PMRs greater than unity were observed for Asian females (PMR = 1.69), Latino females (PMR = 1.07), and non-minority males (PMR = 1.04). Bladder cancer mortality among non-minority females was very close to expected (PMR = 1.00). The vast majority of the bladder cancer deaths occurred among the non-minority males and females, resulting in very stable PMR estimates that are only trivially different from 1.0 for these two groups. Bladder cancer mortality was less than expected among African American males (PMR=0.68; 95% confidence interval (CI): 0.63-0.74), Latino males (PMR=0.76; CI: 0.63-0.91), and Native American males (PMR = 0.29; CI: 0. 15 -0.56).

For the occupational subgroup analyses that follow we focus on the minority racial and ethnic groups. We have highlighted two groups of comparisons: (1) Those comparisons in which the exposed group included three or more deaths and both the PMR and its lower 95% confidence bound exceeded unity, and (2) Those in which the exposed group included five or more deaths and the PMR was greater than or equal to 1.5. By reporting only these comparisons, we are focusing on the more precise results.

Mortality by Occupation

Using all workers in the same racial/ethnic—sex group as the referent, Table II shows minority groups with elevated bladder cancer PMRs by occupation and sex. African American female precision production workers (PMR = 1. 8 1) were the only female group with an elevated PMR. Latino male fabricators, assemblers, and hand workers (PMR = 2.82; CI: 1.0 1 —7.90) and African American males (PMR = 1.62) in the same occupation had elevated PMRs. African American male professional specialists (PMR = 1.41) also had an elevated PMR. Asian salesmen (PMR=2.13) were the only occupation group for whom bladder cancer mortality was elevated relative to bladder cancer mortality among Asian males in all occupations.

TABLE II. Bladder Cancer Mortality in Specific Occupations[a], Referent Includes all Occupations within the same Ethnic—Sex Group

Race/ethnicity	Sex	Occupation	Observed	PMR[b]	95% CI[c]	
Asian	Male	Sales	5	2.13	0.81	5.59
African American	Female	Precision production workers	11	1.81	0.99	3.31
African American	Male	Fabricators assemblers and hand workers	14	1.62	0.90	2.92
African American	Male	Professional specialists	44	1.41	1.03	1.93
Latino	Male	Construction trades	14	1.56	0.88	2.77
Latino	Male	Fabricators assemblers and hand workers	4	2.82	1.01	7.90
Latino	Male	Machine operators and tenders	13	1.74	0.97	3.13
Latino	Male	Mechanics and repaires	6	1.63	0.72	3.70

[a]Occupations in which ((L.95 $\geq$ 1.0 and obs $>$ 2) or (pmr $\geq$ 1.5 and obs $\geq$ 5)).
[b]Proportionate mortality ratio.
[c]95% confidence interval.

TABLE III. Bladder Cancer Mortality in Selected Occupations[a], Referent includes all Ethnic Groups in the Specific Occupation for each Sex

Race/ethnicity	Sex	Occupation	Observed	PMR[b]	95% CI[c]	
Asian	Male	Sales	5	1.85	0.77	4.45
African American	Female	Precision production workers	11	1.67	0.88	3.14
African American	Female	Technicians and related support workers	9	1.79	0.84	3.81

[a]Occupations in which ((L.95 $\geq$ 1.0 and obs $>$ 2) or (pmr $\geq$ 1.5 and obs $\geq$ 5)).
[b]Proportionate mortality ratio.
[c]95% confidence interval.

When all workers in the same occupation were used as the referent group in sex-specific comparisons (Table III), Asian salesmen (PMR = 1. 85) and African American female precision production workers (PMR = 1.67) again had elevated bladder cancer mortality.

TABLE IV. Bladder Cancer Mortality in Specific Industries[a], Referent Includes all Industries in each Ethnic—Sex Group

Race/ethnicity	Sex	Industry	Observed	PMR[b]	95% CI[c]	
African American	Female	Business and repair services	12	1.62	0.87	3.04
African American	Female	Wholesale trade	3	4.78	1.45	15.79
African American	Male	Motor vehicle and motor vehicle equipment mfg.	17	1.22	1.18	1.26
Latino	Male	Metal industries	14	2.16	1.23	3.80
Latino	Male	Other manufacturing	5	3.17	1.29	7.79
Latino	Male	Rubber and misc. plastics mfg.	3	6.68	2.11	21.08

[a]Industry in which ((L.95 $\geq$ 1.0 and obs $>$ 2) or (pmr $\geq$ 1.5 and obs $\geq$ 5)).
[b]Proportionate mortality ratio.
[c]95% confidence interval.

Mortality by Industry

Among men and women, several groups experienced elevated bladder cancer mortality relative to all industries combined in the same racial and ethnic group and relative to all workers in the same industry group (Tables IV and V). PMRs for Latino males in metal industries (PMRs = 2.16 and 1.68), rubber and miscellaneous plastic manufacturing (PMRs = 6.68 and 4.08), and other manufacturing (PMRs = 3.17 and 2.13) were all elevated relative both to all Latino men and to all men in the same industry. African American females in wholesale trade (PMRs = 4.78 and 5.01) also experienced elevated bladder cancer mortality. African American males in motor vehicle and motor vehicle equipment manufacturing (PMR=1.22; CI: 1.18-1.26) experienced elevated bladder cancer mortality relative to all African American male workers.

TABLE V. Bladder Cancer Mortality in Selected Industries[a], Referent Includes all Ethnic Groups in the Specific Industry for each Sex

Race/ethnicity	Sex	Industry	Observed	PMR[b]	95% CI[c]	
Asian	Female	Personal services	3	5.25	1.64	16.75
African American	Female	Wholesale trade	3	5.01	1.43	17.51
Latino	Male	Metal industries	14	1.68	0.98	2.88
Latino	Male	Other manufacturing	5	2.13	0.88	5.15
Latino	Male	Rubber and misc plastics mfg.	3	4.08	1.29	12.86

[a]Industries in which ((L95 $\geq$ 1.0 and obs $>$ 2) or (pmr $\geq$ 1.5 and obs $\geq$ 5)).
[b]Proportionate mortality ratio.
[c]95% confidence interval.

Mortality by Occupation within Industry

Narrower and presumably more homogeneous occupational groups were examined by looking at occupations within industries (Table VI). Relative to all workers in the same racial/ethnic— sex group, PMRs were elevated among three occupations of African American males in the retail trade industry: executives, administrators, and managers (PMR = 2.05), professional specialists (PMR = 6.66; CI: 2.47-17.94), and services (PMR = 1.50). Two occupational groups among African American males in motor vehicle and motor vehicle equipment manufacturing: precision production workers (PMR = 3.23) and service workers (PMR = 3.19) experienced elevated bladder cancer mortality. African American male machine operators and tenders in the transportation, communication, and utilities industry also experienced elevated bladder cancer mortality (PMR = 5.69; CI: 2.72-11.89). Among African American females in the transportation, communication, and utilities industry, motor vehicle operators (PMR = 7.44; CI: 2.28 — 24.29) experienced elevated bladder cancer mortality. Among Latino males, machine operators and tenders in the metal industries (PMR = 2.07) and service workers in the professional and related service industry (PMR = 1.65) experienced elevated bladder cancer mortality. In contrast, among African American males, precision production workers in the metal industries (PMR = 2.26) and technicians and related support workers in the professional and related service industry (PMR=3.87; CI: 1.03–14.53) experienced elevated bladder cancer mortality.

When the referent group was all workers in the specific industry–occupation for each sex, there were considerably fewer groups with elevated bladder cancer mortality (Table VII). Among African American males, professional specialists in the retail trade industry (PMR = 3.02; CI: 1.08 – 8.45) and machine operators and tenders in the transportation, communication, and utilities industry (PMR=3.41; CI: 1.37–8.48) experienced elevated bladder cancer mortality. In addition, African American female laborers in the metal industries (PMR=4.24; CI: 1.07–16.80) experienced elevated bladder cancer mortality.

DISCUSSION

This study identified elevated bladder cancer mortality among several occupational groupings of African American males and females and Latino males as well as for Asian males in retail sales and Asian females in the personal services industry. Bladder cancer mortality was elevated for these groups either when compared to all workers of the same sex and racial/ethnic group or when they were compared to all workers in the same

occupational group and sex. Oftentimes the bladder cancer mortality of these groups was elevated relative to both referent groups. This internal consistency across referent groups indicates the importance of the associations between the occupational groups and bladder cancer. To our knowledge, this is the first study to identify occupational groups of Latinos and Asians in the United States with elevated bladder cancer mortality. Three occupational groups within the metal industry– African American female laborers, African American male precision production workers, and Latino male machine operators and tenders—had elevated bladder cancer mortality when compared to all workers of the same racial/ ethnic group and sex (Table VI). Benzo(a)pyrene and more generally polycyclic aromatic hydrocarbon (PAH) exposure levels above those experienced by the general public might be expected in the metal industry. Primary aluminum smelters and steel mills with their coke ovens would both be included in the metal industry [U.S. Bureau of the Census,

TABLE VI. Bladder Cancer Mortality in Selected Industries/Occupations[a], Referent Includes all Industries/Occupations in the Specific Ethnic—Sex Group

Race/ethnicity	Sex	Industry	Occupation	Observed	PMR[b]	95% CI[c]	
Asian	Male	Retail trade	Sales	4	2.88	1.00	8.26
African American	Female	Business and repair services	Professional specialists	4	2.94	1.09	7.91
African American	Female	Metal industries	Laborers	3	6.68	2.17	20.63
African American	Female	Personal services	Precision production workers	5	2.01	0.83	4.88
African American	Female	Transportation communication and utilities	Motor vehicle operators	3	7.44	2.28	24.29
African American	Male	Motor vehicle and motor vehicle equip. mfg.	Precision production workers	5	3.23	1.14	9.20
African American	Male	Motor vehicle and motor vehicle equip. mfg.	Services	3	3.19	1.06	9.59
African American	Male	Lumber wood products furniture mfg.	Freight stock and materials handlers	3	3.37	1.05	10.83
African American	Male	Metal industries	Precision production workers	6	2.26	0.96	5.32
African American	Male	Professional and related services	Technicians and related support workers	5	3.87	1.03	14.53
African American	Male	Public administration	Executives administrators managers	7	1.63	0.60	4.44
African American	Male	Retail trade	Executives administrators managers	6	2.05	0.85	4.91
African American	Male	Retail trade	Professional specialists	4	6.66	2.47	17.94
African American	Male	Retail trade	Services	21	1.50	0.95	2.37
African American	Male	Textile and apparel mfg.	Machine operators and tenders	13	1.50	0.84	2.69
African American	Male	Transportation communication and utilities	Machine operators and tenders	7	5.69	2.72	11.89
Latino	Male	Metal industries	Machine operators and tenders	6	2.07	0.90	4.78
Latino	Male	Professional and related services	Services	5	1.65	0.67	4.08

[a]Industries/occupation groups in which ((L95 $\geq$ 1.0 and obs $>$ 2) or (pmr $\geq$ 1.5 and obs $\geq$ 5)).
[b]Proportionate mortality ratio.
[c]95% confidence interval.

TABLE VII. Bladder Cancer Mortality in Selected Industries/Occupations Groups[a], Referent Includes all Ethnic Group in the Specific Industry/Occupation for each Sex

Race/ethnicity	Sex	Industry	Occupation	Observed	PMR[b]	95% CI[c]	
African American	Female	Metal industries	Laborers	3	4.24	1.07	16.80
African American	Female	Personal services	Precision production workers	5	1.60	0.58	4.46
African American	Male	Motor vehicle and motor vehicle equipment mfg.	Precision production workers	5	1.86	0.64	5.43
African American	Male	Professional and related services	Technicians and related support workers	5	2.39	0.58	9.77
African American	Male	Retail trade	Professional specialists	4	3.02	1.08	8.45
African American	Male	Transportation, communication, and utilities	Machine operators and tenders	7	3.41	1.37	8.48
Latino	Male	Metal industries	Machine operators and tenders	6	1.65	0.72	3.79
Latino	Male	Professional and related services	Services	5	1.58	0.64	3.90

[a]Industry/occupation groups in which ((L95 $\geq$ 1.0 and obs $>$ 2) or (pmr $\geq$ 1.5 and obs $\geq$ 5)).
[b]Proportionate mortality ratio.
[c]95% confidence interval.

1982]. PAH exposures in both of these industries have been associated with increased risk of bladder cancer [Bonassi et al., 1989; Spinelli et al., 1991; Clavel et al., 1994; Tremblay et al., 1995].

In addition, African American female motor vehicle operators in the transportation, communications, and utilities industry experienced elevated bladder cancer mortality when compared to all African American females. Both diesel and gasoline engine exhaust have been shown to be substantial sources of PAH emissions [IARC, 1989].

Our age-adjusted bladder cancer proportionate mortality results for African American males and Native Americans of both sexes relative to all ethnic groups (Table I) are in rank order agreement with the age-adjusted United States (1977-1983) mortality rates for the same groups [Horm et al., 1996]. However, as might be expected, some incongruent results were found for other groups. Horm et al. [1996] report an age-adjusted mortality rate of 2.6 per 100,000 for Black females vs. 1.9 per 100,000 for White females. In contrast, we found bladder cancer mortality among African American women to be comparable to that among all women combined (PMR = 0.99; 95% CI: 0.88– 1.11) (Table I). PMRs usually will not equal ratios of mortality rates even when they are calculated for the same group of deaths because the denominators are different. For proportionate mortality, the denominator is all deaths in the group of interest, while for a mortality rate, the denominator is all those at risk of dying in the group of interest.

Three case-control studies have examined occupational bladder cancer risk among minority–racial/ethnic groups in the United States. Silverman et al. [1989] identified occupations at increased risk of bladder cancer among 126 nonwhite male cases (88 Black men) and 383 nonwhite male controls (287 Black men) comparing individuals who ever worked in an occupation to those who never worked in the occupation. Nonwhite autoworkers and clerical workers were at increased risk with increasing duration of exposure while the dry cleaner, ironer, presser group were at elevated risk (RR=2.8; 95% CI: 1.1-7.4), but the risk did not increase with increased duration of exposure. Similar to Silverman et al. [1989], in this study African American males in the motor vehicle and motor vehicle equipment manufacturing industry experienced elevated bladder cancer mortality when compared to all African American males (PMR = 1.22; CI: 1. 18 –1.26) (Table IV). We examined occupational subgroups of African American males within the motor vehicle and motor vehicle equipment manufacturing industry, and we found notably elevated bladder cancer mortality among precision production workers (PMR=3.23; CI: 1.14-9.20) and service workers (PMR=3.16; CI: 1.06-9.59) (Table VI). In contrast to Silverman et al. [1989], our study did not find male African American administrative support and clerical workers or dry cleaning machine operators to be at elevated risk of bladder cancer mortality when compared to all male African American workers.

Schairer et al. [1988] found that African Americans ever employed in occupations that involve exposure to dye, rubber, leather, ink or paint were at no increased risk of bladder cancer incidence while Whites ever employed in the same occupations were at increased risk. Their population-based case-control study included a total of 122 African American cases (men and women combined) and they adjusted for smoking, gender, age, family history of bladder cancer, and history of bladder infection. We did not combine occupational groups in a comparable way in our study, but we identified one occupational group probably exposed to dyes and inks with elevated bladder cancer mortality. African American male machine operators and tenders in the textile and apparel manufacturing industry (PMR = 1.50) had elevated bladder cancer mortality relative to all African American male workers (Table VI).

Burns and Swanson [1991] conducted a registry-based case-control study of bladder cancer, occupation, and smoking in the Detroit, Michigan (US) metro area. The study included 161 incident cases of bladder cancer among African American males and 85 among African American females. In their analysis by usual industry and occupation, they found a significant excess of bladder cancer among just one occupational group of African Americans—male mechanics (OR= 7.5). They adjusted for age at diagnosis and smoking. The referent group was African Americans in a large group of occupations and industries postulated to have the least exposure to

carcinogens. Our study found elevated bladder cancer mortality among Latino male mechanics and repairers relative to all Latino males, but not among African American male mechanics.

We chose to conduct a PMR analysis rather than a case-control mortality study in part because the major potential advantage of the mortality case-control design was difficult to achieve because the selection of control causes of death unrelated to occupation is required. Since reliable occupational mortality rates for the populations and time periods of interest are not available from the literature, causes unrelated to occupation could only be speculatively identified [Pearce and Checkoway, 1988].

deaths. We had more than four times as many African American bladder cancer cases as the largest previous study [Burns and Swanson, 1991] that examined occupational bladder cancer in African Americans. With the large number of bladder cancer deaths in our multi-state study population, we were able to identify occupations with elevated bladder cancer mortality among Asians and Latinos.

Calculation of PMRs for two different referent groups allowed us to check the elevated-mortality occupations we identified for internal consistency. Direct age adjustment of the PMRs using the method of Miettinen [1972] allowed us to compare mortality between racial/ethnic groups among all workers of a single sex in an occupation as well as mortality between occupations among all workers of a single sex and racial/ethnic group.

The NCHS mortality data on which this study is based bring limitations as well as strengths. The key limitation is the lack of information on incident cases of bladder cancer. Using mortality as the end point in studying occupational bladder cancer is likely to increase the chances of falsely negative results [Ward et al., 1991; Axtell et al., 1998]. The 5-year relative survival rate (observed survival adjusted for expected mortality) for bladder cancer was 82% in the Surveillance, Epidemiology, and End Results program areas for those diagnosed in 1989 [Ries et al., 1997]. This relatively good 5-year survival rate for bladder cancer means that many incident cases do not progress to death, and even when death occurs bladder cancer may not be coded as the underlying cause of death. This limitation is complicated by the fact that 5-year relative survival rates for bladder cancer vary by race, sex, and place. The 5-year relative survival rate for malignant cases among Hispanic females diagnosed in New Mexico between 1975 and 1984 was only 37.3%; the comparable rate among Japanese males diagnosed in San Francisco or Hawaii was 85.6% [Horm et al., 1996].

Another limitation is the inability to adjust for the smoking history of the decedents, because that information is not recorded on death certificates. Relative risks between 2.0 and 4.0 have been reported for smokers vs. nonsmokers [Silverman et al., 1996]. Thus, we can assume smoking status is associated with bladder cancer in our study population, but smoking status could only bias our results away from the null if smoking status were also strongly and positively associated with occupation or race/nationality. In 1992-93, modest differences in smoking prevalences by race and gender were documented with the highest prevalences among black males and the lowest among Latino and Asian women [Shopland et al., 1996]. Similarly modest differences in smoking prevalence by occupation and industry have been documented [Brackbill et al., 1988]. However, several studies have demonstrated that relative risks between bladder cancer and occupation in excess of 1.2 are unlikely to be artifacts due to uncontrolled confounding by smoking status [Asp, 1982; Blair et al., 1985; Siemiatycki et al., 1988].

Misclassification of the decedents' usual industry or occupation on the death certificate may also bias the results of our analysis [Schade and Swanson, 1988; Olsen et al., 1990; Burnett et al., 1994]. The death certificate data on industry and occupation have been found to be less accurate for women and minorities than they are for white males [Mallin et al., 1989; Burnett and Dosemeci, 1994]. The misclassification is likely to be nondifferential and bias our PMR estimates toward the null [Dosemeci et al., 1990].

This study generated a large number of PMRs and hence a large number of statistical comparisons. Multiple comparisons have been cited as a potential source of spurious associations, but the application of this statistical idea to epidemiologic studies has been strongly questioned [Rothman, 1990; Savitz and Olshan, 1995]. There

are sound reasons, nevertheless, for concern about the large numbers of comparisons generated by this study. Our study is based on surveillance data which provide many observations but only a limited amount of information for each one. Hence, concern should be framed in terms of the inherent limitations of the data, rather than the number of comparisons they permit.

A related limitation of this study is that precision was poor for some comparisons. The numbers of deaths from specific cancers were small for some combinations of race or ethnicity with occupation or industry, despite the large overall size of the study. For many comparisons, the confidence intervals were wide, even when unity was not included. This limitation reflects the nature of the original data, which have a fixed sample size and therefore do not afford the opportunity to augment study power by adding subjects. We used all of the data available at the time of this study.

CONCLUSION

This study identified elevated bladder cancer mortality among several occupational groupings of African American males and females and for the first time occupational groups of Latinos and Asians. Extending this study design to cover longer time periods holds promise for providing more information regarding occupational bladder cancer risks among the less studied racial/ethnic groups in the United States such as Latinos, Asians, and Native Americans. Surveillance of occupational cancer risks among racial/ ethnic groups in the US could be improved if more states, particularly states with diverse populations such as California, Florida, New York, and Texas would code both usual occupation and industry, and race/ethnicity on their death certificates and report the information to NCHS.

REFERENCES

Asp A. 1982. Confounding by variable smoking habits in different occupational groups. Scand J Work Environ Health 10:325±326.

Axtell CD, Ward EM, McCabe GP, Schulte PA, Stern FB, Glickman LT. 1998. Underlying and multiple cause mortality in a cohort of workers exposed to aromatic amines. Am J Ind Med 34:506±511.

Blair A, Hoar S, Walrath J. 1985. Comparison of crude and smoking-adjusted standardized mortality ratios. J Occup Med 27:881±884.

Bonassi S, Merlo F, Pearce N, Puntoni R. 1989. Bladder cancer and occupational exposure to polycyclic aromatic hydrocarbons. Int J Cancer 44:648-651.

Brackbill R, Frazier T, Shilling S. 1988. Smoking characteristics of US workers, 1978-1980. Am J Ind Med 13:5±41.

Burnett CA, Dosemeci M. 1994. Using occupational mortality data for surveillance of work-related diseases in women. J Occup Med 36(11):1199±1203.

Burnett CA, Silverman DT, Lalich NR. 1994. A comparison of analyses of occupational bladder cancer: death certificate vs. population-based case-control interview data. Am J Ind Med 25(5):677-688.

Burns PB, Swanson GM. 1991. Risk of urinary bladder cancer among blacks and whites: the role of cigarette use and occupation. Cancer Causes Control 2:371±379.

Chiang CL. 1963. Standard error of the age-adjusted death rate. Vital Statistics -Special Reports 47:275-285.

Clavel J, Mandereau L, Limasset JC, Hemon D, Cordier S. 1994. Occupational exposure to polycyclic aromatic hydrocarbons and the risk of bladder cancer: a French case-control study. Int J Epidemiol 23(6):1145-1153.

Dosemeci M, Wacholder S, Lubin J. 1990. Does nondifferential misclassification of exposure always bias a true effect toward the null value? Am J Epidemiol 132:746-748.

Horm JW, DeVesa SS, Burhansstipanov L. 1996. Cancer incidence, survival and mortality among social and ethnic minority groups in the United States. In: Schottenfeld D, Fraumeni JF, Jr, editors. Cancer epidemiology and prevention. 2nd ed. New York: Oxford University Press. p 192-235.

IARC. 1989. IARC monographs on the evaluation of the carcinogenic risk to humans. Diesel and gasoline engine exhausts and some nitroarenes Vol. 46. Lyon, France: IARC.

Loomis DP. 1991. Occupation, industry and motor vehicle crash fatalities in 20 states, 1986-1987. Am J Public Health 81: 733-735.

Loomis DP, Savitz DA. 1991. Occupation and leukemia among men in 16 states, 1985-1987. Am J Ind Med 19:509-521.
Mallin K, Rubin M, Joo E. 1989. Occupational cancer mortality in Illinois white and black males, 1979-1984, for seven cancer sites. Am J Ind Med 15:699-717.
Miettinen OS. 1972. Standardization of risk ratios. Am J Epidemiol 96:383-388.
NCHS 1987. Public use data tape documentation: mortality detail, 1985 data. Hyattsville, MD: U.S. Department of Health and Human Services, National Center for Health Statistics.
NCHS 1988. Public use data tape documentation: mortality detail, 1986 data. Hyattsville, MD: U.S. Department of Health and Human Services, National Center for Health Statistics.
NCHS 1989. Public use data tape documentation: mortality detail, 1987 data. Hyattsville, MD: U.S. Department of Health and Human Services, National Center for Health Statistics.
NCHS 1990. Public use data tape documentation: mortality detail, 1988 data. Hyattsville, MD: U.S. Department of Health and Human Services, National Center for Health Statistics.
NCHS 1992. Public use data tape documentation: mortality detail, 1989 data. Hyattsville, MD: U.S. Department of Health and Human Services, National Center for Health Statistics.
NCHS 1993a. Public use data tape documentation: mortality detail, 1990 data. Hyattsville, MD: U.S. Department of Health and Human Services, National Center for Health Statistics.
NCHS 1993b. Public use data tape documentation: mortality detail, 1991 data. Hyattsville, MD: U.S. Department of Health and Human Services, National Center for Health Statistics.
NCHS 1994. Public use data tape documentation: mortality detail, 1992 data. Hyattsville, MD: U.S. Department of Health and Human Services, National Center for Health Statistics.
Olsen GW, Brondum J, Bodner KM. 1990. Occupation and industry on death certificates of long-term chemical workers: concordance with work history records. Am J Ind Med 17:465-481.
Pearce N, Checkoway H. 1988. Case-control studies using other diseases as controls: problems of excluding exposure-related diseases. American Journal of Epidemiology American Journal of Epidemiology 127:851-856.
Ries L, Kosary CL, Hankey BF, Miller BA, Harras A, Edwards BK (eds). 1997. SEER cancer statistics review, 1973-1994. Bethesda, MD: National Cancer Institute. NIH Pub. No. 97-2789.
Rothman KJ. 1990. No adjustments are need for multiple comparisons. Epidemiology 1:43-46.
Savitz DA, Olshan AF. 1995. Multiple comparisons and related issues in epidemiologic research. Am J Epidemiol 142:904-908.
Schade WJ, Swanson GM. 1988. Comparison of death certificate occupation and industry data with lifetime occupational histories obtained by interview: variations in the accuracy of death certificate entries. Am J Ind Med 14:121-136.
Schairer C, Hartge P, Hoover RN, Silverman DT. 1988. Racial differences in bladder cancer risk: a case-control study. Am J Epidemiol 128(5):1027-1037.
Schulte PA, Ringen K, Hemstreet GP, Altekruse EB, Gullen WH, Patton MG, Allsbrook WC Jr, Crosby JH, West SS, Witherington R and others. 1985. Risk assessment of a cohort exposed to aromatic amines. J Occup Med 27(2):115-121.
Shopland DR, Hartman AM, Gibson JT, Mueller MD, Kessler LG, Lynn WR. 1996. Cigarette smoking among U.S. adults by state and region: estimates from the current population survey. J Natl Cancer Inst 88(23):1748-1758.
Siemiatycki J, Wacholder S, Dewar R, Cardis E, Greenwood C, Richardson L. 1988. Degree of confounding bias related to smoking, ethnic group, and socioeconomic status in estimates of the associations between occupation and cancer. J Occup Med 30(8):617-625.
Silverman DT, Levin LI, Hoover RN. 1989. Occupational risks of bladder cancer in the United States: II Nonwhite men. J Natl Cancer Inst 81(19):1480-1483.
Silverman DT, Morrison AS, DeVesa SS. 1996. Bladder cancer. In: Schottenfeld D, Fraumeni JF, Jr, Cancer epidemiology and prevention. 2nd ed. New York: Oxford University Press. p 1156-1174.
Spinelli JJ, Band PR, Svirchev LM, Gallagher RP. 1991. Mortality and cancer incidence in aluminum reduction plant workers. J Occup Med 33(11):1150-1155.

Tremblay C, Armstrong B, Theriault G, Brodeur J. 1995. Estimation of risk of developing bladder cancer among workers exposed to coal tar pitch volatiles in the primary aluminum industry. Am J Ind Med 27(3):335-348.
U.S. Bureau of the Census. 1982. 1980 Census of population: alphabetical index of industries and occupations PHC80-R3. Washing-ton, DC: U.S. Bureau of the Census.
Ward E, Roberts D, Streicher R, Boeniger M, Fajen J. 1991. Response to "An alternative hypothesis for bladder cancer among workers exposed to orthotoluidine and aniline." J Natl Cancer Inst 83:1686- 1687.
Wingo PA, Ries LA, Giovino GA, Miller DS, Rosenberg HM, Shopland DR, Thun MJ, Edwards BK. 1999. Annual report to the nation on the status of cancer, 1973-1996, with a special section on lung cancer and tobacco smoking. J Natl Cancer Inst 91:675-690.
Zahm SH, Pottern LM, Lewis DR, Ward MH, White DW. 1994. Inclusion of women and minorities in occupational cancer epidemiologic research. J Occup Med 36(8):842-847.