# Diversity in the Association between Occupation and Lung Cancer among Black and White Men

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## Abstract

**A population-based case comparison study of incident lung cancer and occupational risk factors was conducted in the tricounty Detroit metropolitan area. Nearly 6000 lung cancer cases and a comparison group of 3600 colon cancer cases were interviewed. This report includes 3792 white and black male lung cancer cases and 1966 black and white colon cancer referents. Cigarette smoking, age at diagnosis, and lifetime work history were assessed to determine the relationship between length of employment in specific occupations and industries and lung cancer. Diverse patterns of association between work history and lung cancer were observed for black and white men. Significant associations were seen between lung cancer and increasing length of employment in the following occupations: for white men, concrete and terrazzo finishers, grinding machine operators, heat treating machine operators, miscellaneous machine operators, truck drivers, driver sales, and laborers; for black men, farm workers, automobile mechanics, painting machine operators, furnace operators, and garbage collectors; for both black and white men, farmers, slicing and cutting machine operators, and garbage collectors. Distinct patterns for black and white men also were observed for length of employment by industry. This study clearly demonstrates the need to include black men in studies of occupational cancer etiology and to evaluate black and white men separately. It also indicates the necessity for cigarette smoking history to accurately assess workplace cancer risks. We propose guidelines for incorporating the use of biomarkers into further studies of occupational cancer epidemiology.**

## Introduction

Over the past 50 years, new hypotheses regarding the occupational etiology of lung cancer have been sparse. A substantial segment of published studies describing the relationship between occupational risk factors and lung cancer is based upon data obtained solely from death certificates. In an effort to obtain new insights into lung cancer and its association with the workplace, we initiated the Occupational Cancer Incidence Surveillance Study in 1984 to interview a population-based series of lung cancer cases and a comparison group of colon and rectum cancer cases. This study of nearly 6000 lung cancer cases is intended to go beyond most previous studies by obtaining lifetime work histories and tobacco use histories and by utilizing lung cancer incidence rather than mortality as the disease outcome. In early analyses we reported occupational risks among black and white men and women in terms of usual occupation and industry (1). The Occupational Cancer Incidence Surveillance Study identified significant elevated risks for certain occupations and industries as well as differentiated workplace risks between blacks and whites. The objective of the current report is to identify occupations and industries in which black and white males experience increasing risk of lung cancer in association with increasing years of employment in specific occupations and industries. One major objective of the Occupational Cancer Incidence Surveillance Study is to understand occupational lung cancer etiology among blacks. A further objective is to provide leads for investigations of specific exposures in the workplace and for the incorporation of biomarkers into investigations of occupational cancer etiology.

## Materials and Methods

Cases and controls included in this report are from the OCISS[2] which has been described in detail elsewhere (1). Briefly, OCISS is a population-based case comparison study of occupational risk factors for selected cancers diagnosed among residents of the metropolitan Detroit area. Study subjects were identified through the Metropolitan Detroit Cancer Surveillance System, a participant in the Surveillance Epidemiology, and End Results (SEER) program (2). Incident lung cancer cases diagnosed among black and white males between the ages of 40 and 84 years, during 1984 through 1987, are included in this report. All cancer cases included in the analysis were histologically confirmed. This analysis of black and white men includes 3792 lung cancer cases and a comparison group of 1966 colon and rectum cancer cases, which encompasses all cases diagnosed during the study time period.

Data were collected by telephone interview with the subject or his surrogate. Interview data included lifetime work history, lifetime smoking history, medical history, demographic information, and residential history. Occupation and industry data were coded using the 1980 United States Census Bureau classification codes. In addition, we selected occupations and industries with little

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[2] The abbreviation used is: OCISS, Occupational Cancer Incidence Surveillance Study.

or no exposure to carcinogens and defined them as an unexposed group, rather than simply comparing each individual occupation and industry to all other occupations and industries; the latter approach would have resulted in misclassification by combining exposed and unexposed into a single group (1).

Age at diagnosis, pack-years of cigarette smoking, and race were used in the model as confounding explanatory variables. Logistic regressions were used to estimate the coefficients of explanatory variables. The maximum likelihood estimates of the regression parameters were computed using the iteratively reweighted least squares algorithm (3). The estimated covariance matrix of the maximum likelihood estimates is obtained by inverting the expected value of the hessian matrix for the last iteration (4). The likelihood ratio $\chi^2$ test statistic was used to test the joint significance of the explanatory variables included in the model. For each explanatory variable, the Wald statistic was used to test its association with the outcome variable (lung cancer). The logistic regression has the form

$$\text{logit}(p) = \log \frac{p}{1-p} = \alpha + \underline{\beta}'\underline{x},$$

where $\alpha$ is the intercept parameter, $\underline{\beta}$ is the vector of parameters, $\underline{x}$ is covariate matrix, and $p$ is the probability of having lung cancer. The analysis was stratified by race. Years of employment in each reported occupation or industry was divided into 3 (0; 1–9; 10+) or 4 (0; 1–9; 10–19; 20+) categories, depending upon the number of subjects in each job classification. Pack-years of cigarette smoking was divided into 5 categories (0; 1–29; 30–59; 60–89; 90+). Age was coded into 9 categories (40–44; 45–49; 50–54; 55–59; 60–64; 65–69; 70–74; 75–79; 80+). Age and pack-years were treated as continuous variables. Years of employment was treated as a categorical variable. Tests for trend were performed using a $\chi^2$ statistic to determine whether there was a linear association between years of employment and lung cancer (5). Odds ratios and their respective confidence intervals were calculated for each occupation and industry category that included at least 15 cases. Each duration-specific odds ratio was calculated by using $\psi = e^{\beta}$ to compare cases and controls for specific duration of occupation or industry with those who were employed solely in unexposed occupations and industries during their lifetimes. $\beta$ is the estimated coefficient that represents the change in the logit for a change of employment status from never exposed to any exposed occupations or industries to some specific duration of exposed occupation or industry. Therefore, only a single comparison was made for each odds ratio; its 95% confidence interval is $(e^{\beta-1.96*s.e.(\beta)}, e^{\beta+1.96*s.e.(\beta)})$.

## Results

Table 1 compares the distribution of cases and controls by race, age at diagnosis, cigarette smoking status, pack-years of smoking, and interview outcome.

The risk of lung cancer by occupation or industry and length of employment among black and white males is shown in Tables 2 and 3. The results presented are restricted to occupations or industries showing either a significant trend in increasing odds ratios with increasing length of employment or a significant increase in risk for a particular length of employment category. If the odds ratio for an occupation was significant for one of the race/sex groups and not for the other, the nonsignificant results are presented as a comparison to the significant results.

*Table 1* Occupational Cancer Incidence Surveillance Study: characteristics of lung cancer cases and colon/rectum controls

| | Cancer site | | | |
|---|---|---|---|---|
| | Lung | | Colon/rectum | |
| | *n* | % | *n* | % |
| Race and gender | | | | |
| White males | 2866 | 75.6 | 1596 | 81.2 |
| Black males | 926 | 24.4 | 370 | 18.8 |
| Total | 3792 | 100.0 | 1966 | 100.0 |
| Age at diagnosis (years) | | | | |
| 40–44 | 57 | 1.5 | 32 | 1.6 |
| 45–49 | 126 | 3.3 | 62 | 3.2 |
| 50–54 | 289 | 7.6 | 120 | 6.1 |
| 55–59 | 555 | 14.6 | 216 | 11.0 |
| 60–64 | 751 | 19.8 | 320 | 16.3 |
| 65–69 | 775 | 20.4 | 382 | 19.4 |
| 70–74 | 669 | 17.6 | 330 | 16.8 |
| 75–79 | 376 | 9.9 | 304 | 15.5 |
| 80–84 | 194 | 5.1 | 200 | 10.2 |
| Total | 3792 | 100.0 | 1966 | 100.0 |
| Cigarette smoking status | | | | |
| Ever | 3618 | 95.4 | 1325 | 67.4 |
| Never | 174 | 4.6 | 637 | 32.4 |
| Unknown | | | 4 | 0.2 |
| Total | 3792 | 100.0 | 1966 | 100.0 |
| Pack-years of cigarette smoking | | | | |
| Nonsmoker | 174 | 4.6 | 637 | 32.5 |
| <30 | 448 | 11.8 | 456 | 23.2 |
| 30–59 | 1278 | 33.7 | 439 | 22.3 |
| 60–89 | 804 | 21.2 | 199 | 10.1 |
| ≥90 | 816 | 21.5 | 156 | 7.9 |
| Unknown | 272 | 7.2 | 79 | 4.0 |
| Total | 3792 | 100.0 | 1966 | 100.0 |
| Interview outcome | | | | |
| Subject interview | 1663 | 43.9 | 1386 | 70.5 |
| Surrogate interview for subject too ill to be interviewed | 630 | 16.6 | 336 | 17.1 |
| Surrogate interview for deceased subject | 1499 | 39.5 | 244 | 12.4 |
| Total | 3792 | 100.0 | 1966 | 100.0 |

The patterns of occupation among the lung cancer cases with elevated odds ratios among black men are distinct from those observed among white men. For each occupation in which both black and white men had significant positive trends in length of employment, black men had higher odds ratios in nearly all length of employment categories (farmers, furnace operators, slicing and cutting machine operators, and assemblers). Of the 12 occupations for which white male lung cancer was significantly associated with increasing length of employment, 8 (concrete and terrazzo finishers, grinding machine operators, heat treating machine operators, miscellaneous machine operators, drivers of heavy trucks, drivers of light trucks, driver sales, and laborers) did not show similar trends among the black male lung cancer cases. Similarly, of the eight occupations for which black male lung cancer was significantly associated with in-

*Table 2* Risk of lung cancer by number of years employed in specific occupations[a]

| Occupation groups | White males | | | | | Black males | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of years employed | Lung cancer cases | Colon/rectum cancer controls | OR | CI | Lung cancer cases | Colon/rectum cancer controls | OR | CI |
| Farmers | 0 | 88 | 81 | 1.0[b] | | 12 | 10 | 1.0[b] | |
| | 1-9 | 57 | 32 | 1.3 | 0.7, 2.4 | 19 | 12 | 1.9 | 0.5, 6.9 |
| | 10-19 | 45 | 19 | 1.8 | 0.9, 3.6 | 25 | 11 | 2.2 | 0.6, 8.0 |
| | 20+ | 24 | 11 | 2.1 | 0.9, 5.1 | 15 | 3 | 10.4 | 1.4, 77.1[c] |
| Farm workers | 0 | 88 | 81 | 1.0 | | 12 | 10 | 1.0[b] | |
| | 1-9 | 53 | 22 | 2.0 | 1.0, 3.7[c] | 26 | 9 | 3.0 | 0.8, 10.9 |
| | 10+ | 24 | 15 | 1.1 | 0.5, 2.3 | 25 | 10 | 4.2 | 1.1, 16.8[c] |
| Industrial maintenance workers | 0 | 88 | 81 | 1.0 | | 12 | 10 | | |
| | 1-9 | 9 | 11 | 0.9 | 0.3, 2.5 | 3 | 0[d] | | |
| | 10-19 | 20 | 4 | 4.1 | 1.3, 13.4[c] | 5 | 1 | | |
| | 20+ | 44 | 23 | 1.5 | 0.8, 2.9 | 2 | 2 | | |
| Concrete and terrazzo finishers | 0 | 88 | 81 | 1.0[b] | | 12 | 10 | | |
| | 1-9 | 4 | 2 | 2.4 | 0.2, 23.6 | 3 | 1 | | |
| | 10+ | 8 | 1 | 8.5 | 1.0, 72.8[c] | 7 | 0[d] | | |
| Automobile mechanics | 0 | 88 | 81 | 1.0 | | 12 | 10 | 1.0[b] | |
| | 1-9 | 38 | 22 | 1.3 | 0.7, 2.6 | 13 | 5 | 2.6 | 0.6, 11.6 |
| | 10-19 | 33 | 12 | 2.2 | 1.0, 5.0 | 6 | 4 | 1.3 | 0.2, 7.6 |
| | 20+ | 43 | 18 | 1.5 | 0.7, 3.0 | 18 | 4 | 6.9 | 1.4, 35.0[c] |
| Production supervisors | 0 | 88 | 81 | 1.0 | | 12 | 10 | 1.0 | |
| | 1-9 | 58 | 22 | 1.9 | 1.0, 3.7[c] | 12 | 1 | 15.2 | 1.5, 159.6[c] |
| | 10-19 | 47 | 30 | 1.3 | 0.7, 2.4 | 8 | 3 | 2.1 | 0.4, 12.5 |
| | 20+ | 82 | 48 | 1.4 | 0.8, 2.3 | 6 | 4 | 2.2 | 0.4, 13.7 |
| Inspectors | 0 | 88 | 81 | 1.0 | | 12 | 10 | 1.0 | |
| | 1-9 | 53 | 34 | 1.1 | 0.6, 2.1 | 10 | 6 | 2.0 | 0.4, 9.5 |
| | 10-19 | 26 | 17 | 1.2 | 0.6, 2.5 | 11 | 5 | 2.1 | 0.4, 10.1 |
| | 20+ | 49 | 17 | 2.1 | 1.0, 4.2[c] | 13 | 3 | 5.6 | 1.0, 32.3[c] |
| Grinding machine operators | 0 | 88 | 81 | 1.0[b] | | 12 | 10 | 1.0 | |
| | 1-9 | 67 | 42 | 1.1 | 0.6, 2.0 | 30 | 15 | 2.7 | 0.8, 9.3 |
| | 10-19 | 29 | 18 | 1.5 | 0.7, 3.2 | 7 | 7 | 1.1 | 0.2, 4.6 |
| | 20+ | 63 | 22 | 2.3 | 1.2, 4.4[c] | 6 | 8 | 0.6 | 0.1, 3.2 |
| Heat treating machine operators | 0 | 88 | 81 | 1.0[b] | | 12 | 10 | 1.0 | |
| | 1-9 | 7 | 5 | 1.3 | 0.3, 4.7 | 5 | 3 | 1.8 | 0.2, 14.5 |
| | 10+ | 13 | 2 | 9.2 | 1.1, 76.4[c] | 6 | 4 | 2.1 | 0.3, 12.2 |
| Painting machine operators | 0 | 88 | 81 | 1.0 | | 12 | 10 | 1.0[b] | |
| | 1-9 | 23 | 16 | 1.1 | 0.5, 2.4 | 17 | 9 | 1.5 | 0.4, 5.6 |
| | 10-19 | 6 | 6 | 0.6 | 0.2, 2.2 | 7 | 1 | 9.9 | 0.9, 109.2 |
| | 20+ | 17 | 5 | 3.9 | 1.2, 13.0[c] | 10 | 1 | 8.7 | 0.9, 89.3 |
| Furnace operators | 0 | 88 | 81 | 1.0[b] | | 12 | 10 | 1.0[b] | |
| | 1-9 | 23 | 15 | 1.4 | 0.6, 2.9 | 23 | 8 | 5.5 | 1.2, 25.7[c] |
| | 10-19 | 19 | 3 | 4.2 | 1.1, 15.7[c] | 7 | 3 | 2.0 | 0.3, 13.5 |
| | 20+ | 13 | 6 | 1.8 | 0.6, 5.2 | 19 | 6 | 5.9 | 1.1, 31.4[c] |
| Slicing and cutting machine operators | 0 | 88 | 81 | 1.0[b] | | 12 | 10 | 1.0[b] | |
| | 1-9 | 22 | 10 | 1.7 | 0.7, 4.1 | 11 | 5 | 5.2 | 0.9, 29.7 |
| | 10+ | 23 | 9 | 2.0 | 0.8, 5.2 | 4 | 1 | 9.8 | 0.6, 152.6 |
| Miscellaneous machine operators | 0 | 88 | 81 | 1.0[b] | | 12 | 10 | 1.0 | |
| | 1-9 | 66 | 36 | 1.2 | 0.7, 2.1 | 20 | 10 | 2.2 | 0.6, 8.0 |
| | 10-19 | 30 | 7 | 3.0 | 1.2, 7.6[c] | 11 | 6 | 2.2 | 0.5, 10.2 |
| | 20+ | 41 | 17 | 1.9 | 1.0, 3.9[c] | 12 | 5 | 2.0 | 0.5, 9.2 |
| Welders | 0 | 88 | 81 | 1.0 | | 12 | 10 | 1.0 | |
| | 1-9 | 39 | 26 | 1.1 | 0.6, 2.1 | 33 | 9 | 4.9 | 1.2, 20.0[c] |
| | 10-19 | 26 | 11 | 1.2 | 0.5, 2.8 | 19 | 9 | 2.3 | 0.5, 9.6 |
| | 20+ | 54 | 27 | 1.5 | 0.8, 2.8 | 18 | 10 | 2.8 | 0.7, 11.5 |
| Assemblers | 0 | 88 | 81 | 1.0[b] | | 12 | 10 | 1.0[b] | |
| | 1-9 | 243 | 104 | 1.7 | 1.1, 2.7[c] | 82 | 38 | 2.9 | 0.9, 9.2 |
| | 10-19 | 72 | 43 | 1.2 | 0.7, 2.1 | 47 | 11 | 4.3 | 1.2, 15.8[c] |
| | 20+ | 80 | 30 | 2.3 | 1.2, 4.2[c] | 64 | 18 | 5.3 | 1.5, 18.5[c] |

*Table 2* Continued

| Occupation groups | White males | | | | | Black males | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of years employed | Lung cancer cases | Colon/rectum cancer controls | OR | CI | Lung cancer cases | Colon/rectum cancer controls | OR | CI |
| Drivers of heavy trucks | 0 | 88 | 81 | 1.0[b] | | 12 | 10 | 1.0 | |
| | 1-9 | 78 | 39 | 1.4 | 0.8, 2.4 | 27 | 12 | 2.7 | 0.8, 9.2 |
| | 10-19 | 38 | 13 | 1.6 | 0.8, 3.5 | 16 | 11 | 1.9 | 0.5, 7.2 |
| | 20+ | 121 | 31 | 2.5 | 1.4, 4.4[c] | 16 | 8 | 2.1 | 0.5, 9.2 |
| Drivers of light trucks | 0 | 88 | 81 | 1.0[b] | | 12 | 10 | 1.0 | |
| | 1-9 | 46 | 23 | 1.7 | 0.9, 3.3 | 11 | 9 | 1.7 | 0.4, 7.7 |
| | 10+ | 36 | 12 | 2.1 | 0.9, 4.6 | 8 | 6 | 1.4 | 0.3, 7.7 |
| Industrial equipment operators | 0 | 88 | 81 | 1.0 | | 12 | 10 | 1.0 | |
| | 1-9 | 23 | 20 | 0.8 | 0.4, 1.8 | 20 | 5 | 6.1 | 1.4, 27.7[c] |
| | 10-19 | 17 | 10 | 1.2 | 0.5, 3.1 | 17 | 5 | 3.4 | 0.8, 15.1 |
| | 20+ | 17 | 13 | 0.9 | 0.4, 2.0 | 22 | 8 | 3.0 | 0.8, 11.6 |
| Driver sales | 0 | 88 | 81 | 1.0[b] | | 12 | 10 | 1.0 | |
| | 1-9 | 44 | 17 | 2.2 | 1.1, 4.4[c] | 10 | 6 | 2.7 | 0.6, 12.8 |
| | 10+ | 59 | 18 | 2.5 | 1.3, 5.0[c] | 5 | 1 | 6.4 | 0.5, 77.8 |
| Construction laborers | 0 | 88 | 81 | 1.0 | | 12 | 10 | 1.0 | |
| | 1-9 | 74 | 31 | 1.6 | 0.9, 2.9 | 59 | 20 | 4.4 | 1.2, 16.0[c] |
| | 10-19 | 24 | 6 | 2.7 | 1.0, 7.4 | 12 | 8 | 3.6 | 0.7, 19.3 |
| | 20+ | 14 | 10 | 1.0 | 0.4, 2.6 | 27 | 12 | 3.6 | 0.8, 15.2 |
| Garage and service station workers | 0 | 88 | 81 | 1.0 | | 12 | 10 | 1.0 | |
| | 1-9 | 47 | 17 | 2.2 | 1.1, 4.4[c] | 8 | 5 | 1.7 | 0.3, 8.7 |
| | 10+ | 7 | 4 | 2.3 | 0.5, 10.8 | 9 | 1 | 6.8 | 0.7, 70.8 |
| Garbage collectors | 0 | 88 | 81 | 1.0 | | 12 | 10 | 1.0[b] | |
| | 1-9 | 4 | 1 | 2.6 | 0.2, 27.7 | 5 | 2 | 2.5 | 0.3, 19.1 |
| | 10+ | 2 | 2 | 0.7 | 0.1, 6.1 | 8 | 1 | 12.5 | 1.0, 156.1[c] |
| Laborers | 0 | 88 | 81 | 1.0[b] | | 12 | 10 | 1.0 | |
| | 1-9 | 97 | 50 | 1.5 | 0.9, 2.5 | 72 | 27 | 4.0 | 1.2, 13.4[c] |
| | 10-19 | 27 | 11 | 1.9 | 0.8, 4.6 | 23 | 15 | 2.4 | 0.6, 9.2 |
| | 20+ | 22 | 11 | 2.0 | 0.8, 4.8 | 20 | 6 | 4.5 | 0.9, 24.0 |
| Armed services personnel | 0 | 88 | 81 | 1.0 | | 12 | 10 | 1.0 | |
| | 1-9 | 1497 | 746 | 1.3 | 0.9, 2.0 | 366 | 149 | 3.0 | 1.0, 9.2[c] |
| | 10-19 | 24 | 12 | 1.4 | 0.6, 3.2 | 3 | 2 | 1.4 | 0.1, 15.9 |
| | 20+ | 14 | 6 | 1.8 | 0.6, 5.4 | 8 | 2 | 14.5 | 1.1, 186.2[c] |

[a] OR, odds ratio; CI, confidence interval.
[b] $\chi^2$ test for trend significant at $P \leq 0.05$.
[c] Confidence interval significant at $P \leq 0.05$.
[d] ORs cannot be calculated due to zero subjects in the control group.

creasing length of employment, 4 (farm workers, automobile mechanics, painting machine operators, and garbage collectors) did not show significant elevation among white men.

Table 3 presents data describing patterns of length of employment by industry among white and black males. Contrasting the lung cancer cases to the comparison group, significant overall positive trends were observed among white males for increasing length of employment in railroads, coal mining, blast furnaces and steel mills, iron and steel foundries, aluminum manufacturing, unspecified manufacturing, grocery stores, taxi services, and trucking services. Among black males, an overall association between lung cancer and increasing numbers of years of employment was significant for farming, meat production, blast furnaces and steel mills, iron and steel foundries, protective services, automotive repair, hospitals, grocery stores, armed services, and odd jobs. There were three industries for which both white and black men had increasingly elevated odds ratios with increasing numbers of years of employment: (*a*) blast furnaces; (*b*) iron and steel foundries; and (*c*) grocery stores. In all three industries, the odds ratios observed among black men were higher than those observed among white men.

## Discussion

The results of this analysis demonstrate a pattern of increasing risk of lung cancer with increasing length of employment for several occupations and industries. These data clearly demonstrate different patterns of association between employment history and lung cancer for black and white men. The variability observed between black and white men may be due to variation in exposure levels, differences in host susceptibility, or di-

*Table 3* Risk of lung cancer by number of years employed in specific industries[a]

| Industry groups | White males | | | | | Black males | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of years employed | Lung cancer cases | Colon/rectum cancer controls | OR | CI | Lung cancer cases | Colon/rectum cancer controls | OR | CI |
| Railroads | 0 | 73 | 70 | 1.0[b] | | 15 | 14 | 1.0 | |
| | 1–9 | 27 | 14 | 1.2 | 0.5, 2.7 | 22 | 13 | 2.6 | 0.8, 7.9 |
| | 10+ | 40 | 15 | 2.4 | 1.1, 5.1 | 9 | 6 | 2.7 | 0.6, 12.1 |
| Farming | 0 | 73 | 70 | 1.0 | | 15 | 14 | 1.0[b] | |
| | 1–9 | 90 | 47 | 1.5 | 0.9, 2.7 | 38 | 17 | 3.1 | 1.0, 9.1[c] |
| | 10–19 | 60 | 26 | 1.5 | 0.8, 2.9 | 48 | 22 | 3.3 | 1.1, 9.8[c] |
| | 20+ | 28 | 14 | 2.1 | 0.9, 4.8 | 18 | 3 | 17.3 | 2.6, 115.7[c] |
| Construction | 0 | 73 | 70 | 1.0 | | 15 | 14 | 1.0 | |
| | 1–9 | 173 | 75 | 1.5 | 0.9, 2.5 | 82 | 33 | 3.7 | 1.3, 10.5[c] |
| | 10–19 | 88 | 38 | 1.4 | 0.8, 2.5 | 39 | 16 | 3.5 | 1.1, 11.2[c] |
| | 20+ | 239 | 112 | 1.5 | 0.9, 2.3 | 63 | 29 | 3.1 | 1.0, 9.1[c] |
| Coal mining | 0 | 73 | 70 | 1.0[b] | | 15 | 14 | 1.0 | |
| | 1–9 | 46 | 15 | 1.9 | 0.9, 3.9 | 15 | 6 | 4.1 | 0.9, 18.8 |
| | 10+ | 37 | 14 | 1.9 | 0.9, 4.2 | 9 | 6 | 3.1 | 0.5, 18.0 |
| Automobile manufacturing | 0 | 73 | 70 | 1.0 | | 15 | 14 | 1.0 | |
| | 1–9 | 359 | 191 | 1.4 | 0.9, 2.1 | 143 | 49 | 4.3 | 1.6, 12.1[b] |
| | 10+ | 999 | 552 | 1.3 | 0.8, 1.9 | 419 | 160 | 3.8 | 1.4, 10.1[b] |
| Meat production | 0 | 73 | 70 | 1.0 | | 15 | 14 | 1.0[b] | |
| | 1–9 | 7 | 4 | 2.1 | 0.5, 8.3 | 12 | 4 | 5.5 | 1.0, 30.8[c] |
| | 10+ | 14 | 6 | 1.3 | 0.4, 3.9 | 10 | 2 | 8.1 | 1.0, 63.5[c] |
| Blast furnaces and steel mills | 0 | 73 | 70 | 1.0[b] | | 15 | 14 | 1.0[b] | |
| | 1–9 | 45 | 33 | 0.8 | 0.4, 1.5 | 25 | 16 | 2.3 | 0.7, 7.4 |
| | 10–19 | 22 | 7 | 2.2 | 0.8, 6.1 | 14 | 4 | 3.0 | 0.7, 13.0 |
| | 20+ | 84 | 25 | 2.3 | 1.2, 4.3[c] | 20 | 5 | 8.5 | 1.8, 39.8 |
| Iron and steel foundries | 0 | 73 | 70 | 1.0[b] | | 15 | 14 | 1.0[b] | |
| | 1–9 | 18 | 10 | 0.9 | 0.3, 2.3 | 23 | 9 | 3.9 | 1.0, 14.3[c] |
| | 10–19 | 10 | 2 | 6.5 | 0.7, 59.9 | 15 | 4 | 7.4 | 1.4, 37.9[c] |
| | 20+ | 10 | 3 | 3.9 | 0.7, 20.1 | | | | |
| Aluminum manufacturing | 0 | 73 | 70 | 1.0[b] | | 15 | 14 | 1.0 | |
| | 1–9 | 18 | 10 | 0.9 | 0.3, 2.3 | 13 | 6 | 5.3 | 1.1, 26.4[c] |
| | 10+ | 20 | 5 | 4.7 | 1.2, 18.1[c] | 5 | 3 | 1.6 | 0.2, 11.9 |
| Not specified manufacturing | 0 | 73 | 70 | 1.0[b] | | 15 | 14 | | |
| | 1–9 | 29 | 15 | 1.6 | 0.7, 3.6 | 5 | 1 | | |
| | 10–19 | 9 | 2 | 3.8 | 0.7, 21.3 | 2 | 0[d] | | |
| | 20+ | 10 | 4 | 2.7 | 0.6, 12.1 | 1 | 0 | | |
| Other transportation manufacturing | 0 | 73 | 70 | 1.0 | | 15 | 14 | 1.0 | |
| | 1–9 | 21 | 13 | 1.4 | 0.6, 3.2 | 8 | 1 | 10.5 | 1.1, 102.6[c] |
| | 10+ | 20 | 4 | 3.7 | 1.0, 14.3[c] | 3 | 2 | 1.9 | 0.3, 14.8 |
| Grocery stores | 0 | 73 | 70 | 1.0[b] | | 15 | 14 | 1.0[b] | |
| | 1–9 | 21 | 8 | 2.4 | 0.9, 6.6 | 5 | 1 | 13.7 | 0.8, 227.9 |
| | 10–19 | 13 | 6 | 1.7 | 0.5, 5.9 | 4 | 3 | 2.9 | 0.4, 22.9 |
| | 20+ | 20 | 8 | 2.8 | 1.0, 7.7[c] | 5 | 3 | 11.6 | 1.1, 120.5[c] |
| Protective services | 0 | 73 | 70 | | | 15 | 14 | 1.0[b] | |
| | 1–9 | 11 | 4 | | | 16 | 3 | 7.4 | 1.4, 40.0[c] |
| | 10+ | 4 | 0[d] | | | 2 | 1 | 6.6 | 0.4, 125.8 |
| Automotive services | 0 | 73 | 70 | 1.0 | | 15 | 14 | 1.0 | |
| | 1–9 | 10 | 8 | 1.0 | 0.3, 3.1 | 17 | 3 | 8.8 | 1.5, 50.8[c] |
| | 10+ | 5 | 2 | 1.7 | 0.3, 10.5 | 9 | 3 | 3.0 | 0.5, 17.3 |
| Taxi service | 0 | 73 | 70 | 1.0[b] | | 15 | 14 | 1.0 | |
| | 1–9 | 20 | 5 | 2.7 | 0.8, 9.2 | 8 | 6 | 1.2 | 0.3, 5.4 |
| | 10+ | 15 | 2 | 4.1 | 0.8, 20.4 | 5 | 2 | 2.2 | 0.3, 14.7 |

versity in acquired susceptibility factors, such as comorbid conditions or dietary habits. Two key risk factors for lung cancer have been incorporated into our analyses: (*a*) cigarette smoking; and (*b*) age at diagnosis. Thus, the differences observed between black and white men remain to be explained by other factors.

As with any case referent study, there are both strengths and limitations that must be considered when

*Table 3* Continued

| Industry groups | White males | | | | | Black males | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of years employed | Lung cancer cases | Colon/ rectum cancer controls | OR | CI | Lung cancer cases | Colon/ rectum cancer controls | OR | CI |
| Trucking service | 0 | 73 | 70 | 1.0[b] | | 15 | 14 | 1.0 | |
| | 1-9 | 59 | 31 | 1.1 | 0.6, 2.2 | 9 | 4 | 2.9 | 0.6, 14.1 |
| | 10-19 | 29 | 12 | 1.2 | 0.5, 2.8 | 5 | 2 | 2.0 | 0.3, 15.0 |
| | 20+ | 89 | 32 | 1.6 | 0.9, 3.0 | 7 | 3 | 4.9 | 0.7, 37.6 |
| Automotive repair | 0 | 73 | 70 | 1.0 | | 15 | 14 | 1.0[b] | |
| | 1-9 | 29 | 19 | 1.1 | 0.5, 2.4 | 11 | 3 | 4.7 | 1.0, 22.6[c] |
| | 10+ | 37 | 15 | 1.6 | 0.8, 3.5 | 18 | 2 | 11.9 | 2.0, 71.1[c] |
| Hospitals | 0 | 73 | 70 | 1.0 | | 15 | 14 | 1.0[b] | |
| | 1-9 | 34 | 11 | 2.7[c] | 1.1, 6.4 | 23 | 4 | 6.0 | 1.5, 24.4 |
| | 10+ | 14 | 8 | 1.1 | 0.4, 3.2 | 22 | 4 | 7.3 | 1.7, 30.4 |
| Armed services | 0 | 73 | 70 | 1.0 | | 15 | 14 | 1.0[b] | |
| | 1-9 | 1493 | 740 | 1.3 | 0.9, 2.0 | 366 | 150 | 3.3 | 1.2, 8.9[c] |
| | 10+ | 38 | 17 | 1.6 | 0.8, 3.5 | 10 | 3 | 8.9 | 1.3, 63.4[c] |
| Odd jobs | 0 | 73 | 70 | 1.0 | | 15 | 14 | 1.0[b] | |
| | 1-9 | 34 | 19 | 1.4 | 0.7, 2.8 | 20 | 11 | 2.4 | 0.7, 8.4 |
| | 10+ | 9 | 7 | 0.7 | 0.2, 2.4 | 13 | 2 | 8.9 | 1.3, 62.8[b] |

[a] OR, odds ratio; CI, confidence interval.
[b] $\chi^2$ test for trend significant at $P \leq 0.05$.
[c] Confidence interval significant at $P \leq 0.05$.
[d] ORs cannot be calculated due to zero subjects in the control group.

interpreting the results. The strengths of this study are considerable. There is a very high response rate, over 90%. The determination of lung cancer for case status and colon and rectum cancer for referent status is precise, utilizing cancer incidence and including only those cases for which histological confirmation was available. As a population-based study, there is no selection bias in recruitment of cases or referents. A detailed history of tobacco use was obtained, enabling us to adjust for smoking history throughout our analyses. Direct information about the occupation and industry was obtained by interview, in contrast to the large number of studies based upon data obtained solely through death certificates (6). The large number of lung cancer cases analyzed provided the opportunity to assess a wide variety of occupations and industries and to evaluate the association between lung cancer and many occupations and industries by length of employment.

There also are limitations. First, no direct information has been obtained regarding specific exposures. Data collected included occupation and industry titles and descriptions of job duties. Specific exposure information would have been preferable, but in order to reduce interview time for the large number of interviews conducted, exposure data were not obtained. In this study, occupation and industry data were coded using information given about the actual duties performed on the job rather than just the occupation or industry title. Assumptions made about putative exposures and the potential for utilizing biomarkers for more exact assessment of occupational carcinogenesis are thus based upon detailed descriptions of job duties. Given our major objective of refining our understanding of the occupational etiology of cancer among blacks and whites, this approach was the most practical.

Our choice of colon and rectum cancer cases as controls could be another source of error in the analysis. Error would result in the analysis if colon and rectum cancers were negatively or positively associated with selected occupations and industries (7, 8). Colon and rectum cancers were considered the most appropriate control group within OCISS because their smoking patterns and occupational distribution are similar to the general population. In addition, a cancer comparison group has the advantage over a population comparison group for reducing recall bias (7, 8).

Analysis of occupations and industries by length of employment goes beyond the analysis of lung cancer and usual occupation and industry. Demonstration of a pattern of increasing risk of lung cancer in association with increasing length of employment in certain occupations and industries strengthens the probability that these are biologically meaningful results. This pattern of association also enables us to highlight specific employment groups that may provide the best opportunities to identify specific exposures that will lead to the potential for utilizing biomarkers of susceptibility, exposure, or effect to delineate more precisely the carcinogens and biological processes involved in the etiological patterns suggested by the trends in lung cancer and length of employment.

A relationship between farming and lung cancer among both white and black males was observed in this analysis. In this study, we analyzed specific occupations and industries and found that farmers and farm workers involved in crop farming, but not in cattle farming or other farms devoted to animal husbandry, accounted for this excess risk and that this association increased significantly with increasing numbers of years of work in this area. OCISS is the first study that we have found in the

literature to report an association between farming and lung cancer. In fact, previous studies have noted a reduced risk of lung cancer among farmers (9–11). Observing the specific association with crop farming and increasing numbers of years of employment as farmers among the lung cancer cases increases our confidence that there is an etiological relationship between farming and lung cancer. Certainly there are exposures that could explain these findings, such as pesticides, herbicides, and other chemicals used on the farm as well as exposure to diesel exhaust from tractors (11–13).

An unexpected finding was the excess of lung cancer among men employed in the armed services. Although small and nonsignificant increases were observed among white males, black males had an odds ratio of 8.9 at 10 or more years when this mode of employment was measured as an industry; when it was measured as an occupation, the odds ratio for black males rose to 14.5 at 20 or more years of employment. The majority of black males was employed in the armed services for 1 to 9 years, which also was found to be significantly increased as both an occupation and an industry. It is difficult to hypothesize exposures in this group, since these men had diverse assignments during their military experience.

This analysis provides further evidence of an association between diesel exhaust and lung cancer. Occupations and industries in this study with known exposure to diesel exhaust include coal mining, farmers, drivers of heavy and light trucks, driver sales, and garbage collectors (14–17). Garage and service station workers, industrial equipment operators, and men employed in construction, trucking services, automotive repair, and some assignments in the armed services are also likely to have some exposure to diesel exhaust (14, 16–18).

Asbestos has been shown to be associated with lung cancer in previous studies (19–21). In this study, further evidence is provided that asbestos is an etiological factor for lung cancer. Concrete and terrazzo finishers, construction laborers, automobile mechanics, garage and service station workers, and men employed in automotive services, automotive repair, and construction and some of the armed services personnel each having varying levels of exposure to asbestos (22–27). Increasing numbers of years of employment among lung cancer cases in automotive repair and as concrete and terrazzo finishers and automobile mechanics make these categories of employment particularly intriguing candidates for further studies of specific biomarkers for exposure.

In a large study such as this, a major concern is to identify workplace hazards for further investigation that are most likely to result in precise specification of carcinogenic agents. We propose that studies of specific exposures and studies incorporating biomarkers of susceptibility, exposure, or effect (28–30) should be based upon the occupations and industries we have delineated that: (*a*) demonstrate a dose response pattern of association; and (*b*) produce different odds ratios among black and white men. Therefore, we suggest that our understanding of the occupational etiology of lung cancer can best be advanced by developing more detailed studies of specific industries: farming, coal mining, railroads, iron and steel foundries, automotive repair, hospitals, and armed services; and specific occupations such as farmers, farm workers, concrete and terrazzo finishers, automobile mechanics, furnace operators, slicing and cutting machine operators, and assemblers.

The results of this study are especially compelling with regard to the distinct patterns of employment associated with lung cancer among black men and white men. The vast majority of occupational cancer etiology studies published includes white males only, justifying this approach by indicating that black men are often a small proportion of those found in specific occupational groups and by stating that there is no reason that occupational risk would differ between black and white men. The latter statement is especially troubling in the context of the results of this study. We clearly provide evidence that black and white men must both be included in studies of occupational cancer etiology and that their risk patterns must be evaluated separately. These results provide evidence that occupational exposures take a greater toll on black men than on white men, after adjusting the data for cigarette use and for age at diagnosis. Further research is mandatory to determine whether blacks have been given "dirtier" jobs historically and thus have greater exposures to carcinogens or whether there is some other factor related to susceptibility that has yet to be evaluated.

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# Diversity in the association between occupation and lung cancer among black and white men.

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