

Risk of Multiple Myeloma by Occupation and Industry Among Men and Women: A 24-State Death Certificate Study

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This cancer surveillance investigation uses death certificates from 24 states for the period 1984–1989 to identify multiple myeloma and occupation associations and to stimulate hypotheses. A case-control study of multiple myeloma was created from 3,159,417 certificates in which 12,148 male and female cases were frequency matched by age, race, and gender with five controls per case. We screened 231 industries and 509 occupations. Women demonstrated significant excess risk among managers and administrators, post-secondary teachers, elementary teachers, social workers, other sales workers, waitresses, and hospital maids. Men showed significant risks among computer system scientists, veterinarians, elementary teachers, authors, engineering technicians, general office supervisors, insurance adjusters, barbers, electronic repairers, supervisors of extracting industries, production supervisors, photoengravers, and grader/dozer operators. Men and women elementary school teachers demonstrated the most consistent, statistically significant increased risk of multiple myeloma.

Multiple myeloma is a malignant plasma cell proliferation rare in people under age 35. Rates are higher among men than women, with the highest worldwide incidence rates occurring among black African descendants. Although its etiology is largely unknown, epidemiologic efforts suggest several occupational associations, including agricultural, metal, rubber, benzene, wood, leather, textile, and petroleum occupations.¹ It is difficult, however, to assemble populations of men and women that are sufficiently large to evaluate occupation and rare disease associations. We used death certificates for black and white residents from 24 states for the years 1984–1989 to generate clues to occupational associations with multiple myeloma.

Methods

The National Cancer Institute (NCI), National Institute for Occupational Safety and Health, and the National Center for Health Statistics developed the death certificate data base used in this study. Participating states (Colorado, Georgia, Idaho, Indiana, Kansas, Kentucky, Maine, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, Ohio, Oklahoma, Rhode Island, South Carolina, Tennessee, Utah, Washington, West Virginia, Wisconsin, Vermont) began coding occupation and industry titles on death certificates in 1984. Not all states contributed in 1984. Occupation and industry codes correspond to 1980 US Census Bureau classification

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of 231 industries (IC) and 509 occupations (OC).²

From 3,159,417 total deaths, 12,148 multiple myeloma deaths (International Classification of Diseases, Ninth Revision (ICD)) among white (87.9%) and black (11.5%) men and women were selected. Five controls, dying of diseases other than cancer, were frequency matched to the cases by age (5-year age groups), gender, and race. A subgroup of controls, consisting entirely of individuals dying from cardiovascular disease, was also used for specific analyses.

Associations between IC/OC code(s) and multiple myeloma were derived from case-control design³ using standard logistic regression methods.⁴ Proportional mortality ratios (PMRs) were derived using methods developed by Monson⁵ and software developed at NCI⁶ to identify eligible controls with an unrelated disease and no proportional mortality excess related to their occupation. Race-specific and gender-specific analyses of black female, black male, white female, and white male mortality odds ratios (ORs) were adjusted for age, autopsy status, and urban/rural residence, except where noted. For region-specific analyses, cases and controls were selected only from that region, with ORs adjusted for individual state contributions.

Three-digit OC or IC classification codes were evaluated. Typically, decedents with specific OC or IC codes were compared to "all others" codes. Occasionally, if socioeconomic status (SES) was thought to confound a result, the unexposed were a restricted group of occupations. Military, retired with no occupation reported, homemaker, student, volunteer, and never worked or disabled OC codes were added to the original 503 occupation codes of the 1980 census list. In all, 509 OC codes and 231 IC codes were screened. Where appropriate, separate three-digit codes such as secretaries (OC 313) and stenographers (OC 314) were analyzed together. ORs are presented if there were five or more deaths among cases and the estimate was ≥ 2.0 , or statistically significant, except where noted in table footnotes.

Results

Cases and controls displayed similar distributions in rural/urban residence, autopsy status, and geographic region (Table 1). Whites represented nearly five times as many total multiple myeloma deaths as blacks. Accordingly, more multiple myeloma/occupation associations were examined for whites.

Occupation

Of the 301 occurrences of five or more exposed cases, 23 statistically significant (lower limit of 95% confidence interval (CI) ≥ 1.05) elevated ORs occurred, when only 7.5 would have been expected by chance alone. Women who were managers and administrators, post-secondary teachers, elementary teachers, social workers, other sales workers, waitresses, or hospital maids showed significantly in-

creased risks. Men who were computer system scientists, veterinarians, elementary teachers, authors, engineering technicians, general officer supervisors, insurance adjusters, barbers, electronic repairers, supervisors of extracting industries, production supervisors, photoengravers, or grader/dozer operators also showed significantly increased risks. Women who were homemakers or had never been employed showed significantly reduced ORs, whereas men who were painters, construction laborers, or laborers or had never been employed showed significant decreased association. OCs with ORs ≥ 2.0 but not statistically significant are also shown in Table 2.

Across race/gender groups, teachers demonstrated the strongest association with ORs, ranging from 26.8 for black female secondary school teachers to 1.3 for black male elementary

TABLE 1
Population Parameter Distribution for Multiple Myeloma Cases and Controls

Parameter	Cases n (%)	Controls n (%)
Age group		
<45	187 (01)	935 (01)
45-64	3,020 (25)	15,100 (25)
≥ 65	8,941 (74)	44,705 (74)
Race/gender		
Black female	997 (8)	4,985 (8)
White female	5,056 (42)	25,280 (42)
Black male	946 (8)	4,730 (8)
White male	5,149 (42)	25,745 (42)
Rural/urban		
Metropolitan	7,720 (64)	37,817 (62)
Nonmetropolitan	4,426 (36)	22,885 (38)
Other	2 (0)	38 (0)
Autopsy		
Yes	465 (04)	5,580 (09)
No	9,363 (77)	45,900 (76)
Unkown	2,320 (19)	9,260 (15)
Region*		
Northeast	1,242 (10)	6,107 (10)
Southeast	4,217 (35)	22,149 (36)
Central	5,416 (45)	26,771 (44)
West	1,273 (10)	5,713 (09)

* Northeast = Maine, New Hampshire, New Jersey, Rhode Island, Vermont; Southeast = Georgia, Kentucky, North Carolina, South Carolina, Tennessee, West Virginia; Central = Indiana, Kansas, Missouri, Nebraska, Ohio, Oklahoma, Wisconsin; West = Colorado, Nevada, New Mexico, Utah, Washington, Idaho.

TABLE 2
Mortality Odds Ratios, 95% Confidence Interval, and Cases Exposed for Multiple Myeloma, According to Occupation Code

Occupation	Cases Exposed*	Mortality Odds Ratio	95% Confidence Interval
Manager and professional specialty occupation [003-199]†			
Black females	93	1.5	1.2-2.0
White females	655	1.3	1.1-1.3
Black males	81	1.6	1.2-2.1
White males	1,109	1.4	1.3-1.5
Management and administration (0.19)‡			
White females	120	1.3	1.1-1.6
Black males	20	1.8	1.1-3.1
White males	416	1.4	1.2-1.5
Chemical engineer			
White males	10	2.0	0.9-4.1
Computer system analyst and scientist (064)			
White males	5	7.9	1.8-33.8
Veterinarian (086)			
White males	6	3.2	1.1-9.0
Post-secondary teacher (154)			
Black females	5	26.8	3.1-233.3
Elementary teacher (156)			
Black females	38	1.6	1.1-2.4
White females	224	1.5	1.3-1.8
White males	64	1.8	1.4-2.5
Social worker (174)			
Black females	7	2.8	1.1-7.4
Author (183)			
White males	6	3.4	1.2-9.9
Technical, sales, and administration support occupation [203-389]			
Black females	58	1.3	1.0-1.8
White females	838	1.2	1.1-1.3
Black males	58	1.2	0.9-1.7
White males	758	1.0	1.0-1.1
Engineer technician (216)			
White males	12	2.7	1.3-5.4
Other sales worker (274)			
Black females	8	2.6	1.1-6.3
General office supervisor (303)			
White males	11	2.2	2.1-4.4
Payroll clerk (338)			
White females	8	2.0	0.9-4.5
Postal clerk (354)			
White females	8	2.1	0.9-4.8

school teachers. Elementary school teachers' risks were consistently increased.

Industry

Among all industries, of the 327 occurrences with five or more exposed cases (Table 3), 29 demonstrated statistically significant increased associations with multiple myeloma deaths, when only 8.2 would have been expected by chance alone. Women involved in blast furnace industries, hardware retailing, grocery businesses, jewelry industries, and insurance showed significant associations. Other industries showing significant associations among women included persons working in physicians' offices, health services, elementary and secondary schools, and religious organizations.

Men, in contrast, demonstrated significant associations in industries involved in the production of dairy products, plastic footwear, iron and steel, ordnance, electronic computer equipment, unspecified electrical equipment, water transportation, wire-radio-telephone communications equipment, and urban transportation vehicles (buses). Men, but not women, employed in colleges and universities also had elevated ORs.

Both men and women showed significant associations with businesses involved in real estate, finance and securities industries, church organizations, and educational institutions such as elementary/secondary schools.

Statistically significant decreased associations occurred among black males in agriculture, white females in eating and drinking retail trades, and white males in dwelling building repair and general government industries.

Other ICs with ORs ≥ 2.0 that were not statistically significant are also included in Table 3.

Elementary School Teachers Analysis

Region-specific analyses indicated that multiple myeloma was elevated among elementary school teachers in all geographic regions (Table 4).

TABLE 2—Continued
Mortality Odds Ratios, 95% Confidence Interval, and Cases Exposed for Multiple Myeloma, According to Occupation Code

Occupation	Cases Exposed*	Mortality Odds Ratio	95% Confidence Interval
Traffic, shipping clerk (364)			
White females	7	2.1	0.9–5.2
Insurance adjuster (375)			
White males	10	3.3	1.5–7.3
Service occupations [403–469]			
Black females	329	1.1	1.0–1.3
White females	377	0.9	0.8–1.0
Black males	124	1.0	0.8–1.2
White males	285	0.9	0.8–1.1
Waiter (435)			
Black females	5	4.9	1.4–17.0
Miscellaneous food preparation (444)			
Black females	7	2.5	1.0–6.3
Hospital, maid (449)			
Black females	32	1.8	1.2–2.7
Barber (457)			
White males	26	1.7	1.1–2.7
Child care worker (468)			
Black females	7	2.6	1.0–6.6
Farming, forestry, & fishing occupation [473–499]			
Black females	20	0.7	0.5–1.2
White females	17	1.1	0.6–1.8
Black males	89	0.7	0.5–0.9
White males	589	1.0	0.9–1.1
Supervisor, farm worker (477)			
White males	5	2.5	0.8–7.3
Precision production, craft, and repair occupation [503–699]			
Black females	15	1.3	0.7–2.3
White females	88	1.2	0.9–1.5
Black males	138	1.1	0.9–1.4
White males	1,114	0.9	0.9–1.0
Farm equipment mechanic (517)			
White males	5	2.1	0.7–6.0
Electronic repair (523)			
White males	12	2.1	1.1–4.1
Carpet installer (566)			
White males	5	2.4	0.8–6.9
Painter (579)			
White males	23	0.5	0.4–0.8
Plumber (585)			
Black males	5	2.2	0.8–6.3

White elementary school teachers showed statistically significant increased associations when circulatory diseases were used as the control group or when the unexposed were limited to managers and professionals (OC = 001–199). ORs for multiple myeloma among elementary school teachers were reduced from the previous analysis, but remained elevated above 1.0. When the unexposed were restricted to secondary school teachers (OC = 113–154), ORs were elevated only among white females.

Discussion

Death certificate use in cancer surveillance studies has a long history.^{7–10} Although cause of death and occupation/industry reporting errors occur,^{11–13} death certificate studies provide sufficiently large populations to evaluate rare occupations and/or cancers and inexpensively identify changes in associations over time.¹⁴ Multiple myeloma case ascertainment is reliable, with 96% detection and 98% confirmation rates, respectively,¹⁵ although agreement appears to be poorer for women and nonwhites.¹⁶

We caution that nonparticipating states with large, urban, and black population centers—such as New York, Pennsylvania, Illinois, Michigan, Texas, and California—led to less stable estimates of association among African Americans and other minorities.¹⁷ Also, death certificate occupation and industry reporting varies widely among population subgroups when compared to lifetime work histories.¹⁸ In addition, occupational histories were unavailable for this study, which may have led to nondifferential misclassification and biased risk estimates toward the null.¹⁹

Because many comparisons were made and chance associations may have occurred, our findings should be viewed with a healthy dose of skepticism. The purpose of this analysis was to generate clues to possible multiple myeloma-associated industries and/or occupations, which can be further evaluated in analytic investigations. By restricting OR reporting to occupations and industries with five or

TABLE 2—Continued
Mortality Odds Ratios, 95% Confidence Interval, and Cases Exposed for Multiple Myeloma, According to Occupation Code

Occupation	Cases Exposed*	Mortality Odds Ratio	95% Confidence Interval
Supervisor, extractive (613) White males	8	2.7	1.1–6.3
Production supervisor (633) White males	139	1.3	1.1–1.5
Patternmaker (676) White males	5	2.3	0.8–6.7
Operator, fabricator, & repair occupation [703–889]			
Black females	78	1.1	0.8–1.4
White females	405	1.0	0.9–1.2
Black males	371	0.9	0.8–1.1
White males	1,018	0.9	0.8–0.9
Photoengraver (735) White males	6	4.0	1.4–11.7
Miscellaneous machine operator (777) Black females	7	2.5	1.0–6.4
Product inspector (769) Black females	5	3.7	1.0–13.9
Bus driver (808) Black males	8	2.4	1.0–5.6
Supervisor, moving equipment (843) White males	5	2.5	0.9–7.6
Grader, dozer operator (855) White males	12	2.7	1.2–6.1
Construction laborer (869) White males	61	0.7	0.5–0.9
Stevedore (876) Black males	9	2.3	1.0–5.1
Stock handler (877) White females	14	1.5	0.8–2.7
Laborer (889) Black males	96	0.7	0.6–0.9
Homemaker (914) Black females	364	0.8	0.7–0.9
White females	2,562	0.9	
Never employed (917) White females	20	0.4	0.3–0.7
White males	23	0.4	0.2–0.6

* Cases exposed = number of cases with that usual occupation.

‡ [] = 1980 census 3-digit industry code.

† () = 1980 census 3-digit occupation code.

All estimates of grouped job categories are reported regardless of statistical significance or number of deaths.

more deaths and ORs ≥ 2.0 , or which were statistically significant, we adopted a conservative approach that should help focus on the associations that are more likely to represent new leads or confirm previous reports. It is also important to remember that because these analyses were limited to decedent cases and controls, comparability may present special limitations.^{20–22} While we lacked important lifestyle information such as alcohol and tobacco use, these factors may not be strongly associated with multiple myeloma and should not confound risk estimates.^{23–25}

Teachers were the most consistently elevated group, particularly elementary teachers. This association, which persisted across gender, race, and geographic region, has been reported elsewhere,^{14,26,27} but not for women separately. It does not appear to be strictly a socioeconomic phenomenon, because excesses still occurred when manager and professional codes (OC = 001–199) were specifically selected as unexposed occupations. Comparisons with post-secondary teachers, however, eliminated the excess for all but white females.

Additional caution regarding excesses among teachers is necessary, however. Since the population at risk is unknown, appropriate control selection becomes very important. Good health is a selection factor related to initial and continued employment.^{28,29} Stewart and Hunting³⁰ demonstrated that both the PMR and OR may overestimate cause-specific mortality in working populations with strong healthy worker effects; teachers are generally healthier than other workers.³¹ When teachers were compared with managers and other professionals (OC = 001–199) in an effort to control for SES, ORs were reduced, but excesses remained. A comparison of elementary teachers (OC = 156) with post-secondary teachers (OC 113–154) found deficits for all race/gender groups, except white women (OR = 1.4). This suggested that the association is more likely to be related to teaching than to simply having a white-collar job.

Excesses were observed among several occupations that used electrical

appliances. Combined gender associations with computer system scientists were reported previously by Demers et al.³² Barbers operate small, hand-held, electric appliances that may contribute electromagnetic field (EMF) exposures. Wire, radio, and telephone communications workers are also exposed to EMF. Clerks,¹⁴ repairers, and grocery employees operate instruments that generate EMF. Previous studies designed to investigate EMF associations have focused on leukemia,³³⁻³⁸ with little attention given to multiple myeloma^{39,40} or gender. Eriksson and Karlsson⁴¹ saw no association.

Several studies have associated various chemical agents with multiple myeloma,^{26,42-47} including plastics,^{26,32,44,48,49} but only Pottern et al⁴⁸ report results for women.

White men who were painters demonstrated a significantly decreased association in this study but not in others.^{26,32,50} In addition, white men demonstrated significant risk among repair occupations that may use solvents, including electrical repairing, pattern making, and photoengraving.

Others have reported pesticide associations, but none reported their findings for women separately.^{27,48,51-56} We found an association among white male veterinarians (OR = 3.2, 1.13-9.0), an occupation where pesticide exposure may occur. Despite increased likelihood of exposure to pesticides, we did not see a significantly increased risk among men or women employed in agriculture, except for men who were farm supervisors.

Bus driver, stevedore, moving equipment supervisor, and grader/dozer operator excesses suggest that exhaust exposures may be associated with multiple myeloma, an exposure previously reported by Flodin and colleagues for men and women combined⁵⁷ and by Heineman et al²⁶ for men alone. Metal industry associations may indicate hazards from metal exposure. Volatile gases from metal production demonstrated an increased risk for women employed in these industries. Hansen⁵⁸ showed similar results for men.

These data also suggest that occupational exposures may explain a por-

TABLE 3
Mortality Odds Ratios, 95% Confidence Interval, and Cases Exposed for Multiple Myeloma, According to Industry Code

Industry Category [Group] (Industry specific)	Cases Exposed*	Mortality Odds Ratio	95% Confidence Interval
Agriculture, forestry, and fisheries [010-031]†			
Black females	20	0.7	0.4-1.1
White females	21	1.0	0.6-1.6
Black males	83	0.7	0.6-1.0
White males	567	1.0	0.9-1.1
Agriculture products, crops (010)‡			
Black males	74	0.7	0.5-0.9
Mining [040-050]			
White females	6	2.6	0.9-7.0
Black males	9	1.2	0.6-2.6
White males	132	1.0	0.9-1.2
Construction [060]			
White females	18	1.1	0.7-1.9
Black males	108	0.8	0.7-1.0
White males	505	0.9	0.8-1.0
Manufacturing (nondurable [100-222])			
Black females	40	1.2	0.8-1.7
White females	348	1.1	0.7-1.9
Black males	102	1.3	1.1-1.7
White males	532	1.1	1.0-1.2
Dairy products (101)			
White males	32	1.7	1.1-2.6
Bakery products (111)			
Black males	6	2.7	1.0-7.4
Rubber and miscellaneous plastic products, tire/inner tube			
Black males	8	2.2	1.0-5.2
White females	6	2.3	0.9-6.1
Other rubber products, and plas- tic footwear (211)			
White males	30	2.1	1.4-3.2
Manufacturing (durable) [230-392]			
Black females	29	1.6	1.1-2.3
White females	213	1.1	1.0-1.3
Black males	237	1.1	1.1-1.7
White males	1,424	1.0	0.9-1.1
Blast furnaces, steelworks, rolling and finishing mills (270)			
White females	12	2.1	1.1-4.1
Iron and steel foundries (271)			
White males	25	1.7	1.1-2.7

TABLE 2—Continued

Industry Category [Group] (Industry specific)	Cases Exposed*	Mortality Odds Ratio	95% Confidence Interval
Ordinance (292) White males	14	2.3	1.2-4.3
Electronic computer equipment (322) White males	6	3.7	1.3-10.8
Other electrical machinery, equip- ment and supplies (342) White males	51	1.6	1.2-2.2
Aircraft and parts (352) Black males	5	3.1	1.0-9.6
Ship/boat building and repair (360) Black males	5	2.1	0.7-5.9
Miscellaneous manufacturing industry (391) White females	20	1.8	1.1-2.9
Not specified industry (392) Black females	10	2.2	1.0-4.6
Transportation, communications, and other public utilities [400-472] Black females	7	0.9	1.4-2.1
White females	95	1.2	0.9-1.5
Black males	122	1.2	1.0-1.5
White males	488	0.9	0.8-1.0
Bus/urban transit (401) Black males	9	2.5	1.1-5.6
Water transport (420) Black males	12	2.4	1.2-4.8
Communications radio/TV broad- cast (440) White females	5	2.8	0.9-8.3
Wire/radio/phone (441) White males	38	1.6	1.1-2.3
Water supply (470) Black males	6	2.3	0.9-6.1
Wholesale trade Durable goods [500-532] White females	19	1.9	1.1-3.2
Black males	3	0.5	0.2-1.6
White males	78	1.2	1.0-1.6
Electronic goods (512) White females	5	2.8	0.9-8.3
Nondurable goods [540-571] White females	21	1.4	0.9-2.3

tion of the mortality difference between US blacks and whites found in other studies examining factors such as race⁵⁹⁻⁶¹ and SES.⁶³ Among 22 occupations in which black and white men have five or more cases (includes occupations not statistically significant and/or with ORs < 2.0), 15 occupations showed black men with higher ORs than white men, six showed white men with higher ORs than blacks, and one occupation showed an equivalent association. Similarly, among 39 industries in which black and white men appeared in sufficient numbers for comparison (includes industries not statistically significant or with ORs < 2.0), 27 showed black men with higher ORs than white men, 11 show white men with higher ORs than black men, and one industry produced equal estimates for both groups. It is unlikely (χ^2 goodness of fit: $P < 0.005$) that chance alone would account for this racial distribution among occupations or industries. Differences in exposure levels within specific occupations may contribute to higher rates for multiple myeloma deaths among blacks than whites in the United States.^{1,64} Health care access and quality might also contribute to US racial mortality differences.

Among industries with white male and female cases available in the same industry, 27% showed male ORs higher than female, whereas 45% showed female associations higher than male. Larger associations for women than men for occupational exposures have been reported elsewhere.⁶⁵ It may be that blacks and women must accept "riskier" tasks, within the same job, than white men. Blacks and women could also be more susceptible to occupational exposures.

Understanding the occupational/industrial associations and gender differences observed here involves a broader understanding of biological and sociological factors. A larger proportion of the unexposed among women consisted of persons with limited industrial exposures (eg, housewives). If women classified as unexposed truly lack exposure, it may be easier to detect associations among women than men in this data base.

TABLE 2—Continued

Industry Category [Group] (Industry specific)	Cases Exposed*	Mortality Odds Ratio	95% Confidence Interval
Black males	9	1.3	0.6-2.7
White males	99	1.1	0.9-1.4
Electrical goods (512)			
White females	5	2.8	0.9-8.3
Retail trade [580-691]			
Black females	47	1.2	1.0-1.2
White females	429	1.1	1.0-1.2
Black males	51	1.0	0.7-1.4
White males	428	0.9	0.9-1.1
Hardware stores (581)			
White females	9	2.7	1.2-5.9
Department stores (591)			
Black females	9	2.0	0.9-4.3
Groceries (601)			
White females	64	1.7	1.3-2.2
Bakeries (610)			
White females	9	2.3	1.0-4.0
Miscellaneous vehicle dealers (622)			
White males	5	2.8	0.9-8.3
Eating and drinking (641)			
White females	85	0.7	0.6-0.9
Jewelry (660)			
White females	12	2.7	1.2-5.9
Finance, insurance, and real estate [700-712]			
Black females	5	0.6	0.3-1.7
White females	132	1.5	1.2-1.8
Black males	11	0.7	0.7-1.4
White males	176	1.2	1.0-1.4
Security, commodity, brokerage and investment (710)			
White males	18	2.1	1.2-3.7
Insurance (711)			
White females	50	1.7	1.2-2.3
Real estate (712)			
White females	32	1.6	1.1-2.3
Business and repair services [721-760]			
Black females	11	1.1	0.6-2.2
White females	45	0.9	0.6-1.2
Black males	33	1.0	0.7-1.5
White males	159	0.9	0.7-1.0
Dwelling/building service (722)			
White males	6	0.4	0.2-0.9

TABLE 3—Continued

Industry Category [Group] (Industry specific)	Cases Exposed*	Mortality Odds Ratio	95% Confidence Interval
Computer/data processing (740)			
White males	7	3.5	1.3-9.2
Personal services [761-791]			
Black females	11	1.1	0.6-2.2
White females	45	0.9	0.6-1.2
Black males	33	1.0	0.7-1.5
White males	159	0.9	0.7-1.0
Barber shop (780)			
White males	25	1.7	1.1-2.6
Entertainment and recreation [800-802]			
White females	14	0.9	0.5-1.7
White males	43	1.2	0.8-1.6
Theater/film (800)			
White males	21	1.8	1.1-2.9
Professional and related services [812-892]			
Black females	181	1.6	1.3-1.9
White females	760	1.2	1.0-1.1
Black males	139	1.4	1.1-1.7
White males	668	1.1	1.0-1.2
Physicians' office (812)			
White females	22	1.8	1.1-2.8
Dentists' office (820)			
White females	8	2.1	0.9-4.8
Health services (840)			
Black females	10	5.0	2.1-12.2
Elementary and secondary school (842)			
Black females	71	1.6	1.2-2.1
White females	342	1.5	1.3-1.7
Black males	36	1.6	1.1-2.3
White males	140	1.5	1.2-1.8
College and university (850)			
White males	57	1.5	1.1-2.0
Other social services (871)			
Black females	5	2.2	0.8-6.5
Religious organization (880)			
White females	25	1.6	1.1-2.6
White males	56	1.4	1.1-1.9
Public administration [900-932]			
Black females	26	1.6	1.0-2.6
White females	109	1.0	0.8-1.2
Black males	46	1.2	1.1-1.8
White males	255	1.0	0.8-1.1
Other general government (901)			
White males	69	0.7	0.6-0.9

TABLE 3—Continued

Industry Category [Group] (Industry specific)	Cases Exposed*	Mortality Odds Ratio	95% Confidence Interval
Administrative human resources programs (922)			
Black females	8	2.3	1.0-5.2
Industry not reported (990)			
Black females	16		
White females	62		
Black males	40		
White males	117		

* Cases exposed = number of cases in that industry.

† [] = 1980 census 3-digit industry codes.

‡ () = 1980 census 3-digit occupation code.

All estimates of grouped job categories are reported regardless of statistical significance or number of deaths.

TABLE 4

Multiple Myeloma Cases Exposed, Mortality Odds Ratios, and 95% Confidence Interval for Elementary Teachers (Occupational Code = 156) by Race/Gender Group and Geographic Region

Group	Northeast*			Southeast			Central			West		
	Cases† Exposed	Mortality Odds Ratio	95% Confidence Interval	Cases Exposed	Mortality Odds Ratio	95% Confidence Interval	Cases Exposed	Mortality Odds Ratio	95% Confidence Interval	Cases Exposed	Mortality Odds Ratio	95% Confidence Interval
Black females	1	1.8	0.1-23.0	28	1.6	1.0-2.4	9	1.9	0.9-4.1	0	‡	‡
White females	27	1.9	1.2-2.0	67	1.6	1.2-2.1	102	1.5	1.2-1.9	28	1.2	0.80-1.9
Black males	0	‡	‡	7	1.2	0.5-2.8	3	2.0	0.5-8.2	0	‡	‡
White males	7	1.9	0.8-4.8	19	1.7	1.0-2.9	27	1.7	1.1-2.7	11	2.4	1.10-5.1

* Northeast = Maine, New Hampshire, New Jersey, Rhode Island, Vermont; Southeast = Georgia, Kentucky, North Carolina, South Carolina, Tennessee, West Virginia; Central = Indiana, Kansas, Missouri, Nebraska, Ohio, Oklahoma, Wisconsin; West = Colorado, Nevada, New Mexico, Utah, Washington, Idaho.

† Cases exposed = number of cases with that usual occupation.

‡ Mortality odds ratio not calculated.

Miettinen and Wang³ introduced mortality odds ratio analysis as an alternative to proportional mortality ratio analysis; the advantages of ORs are discussed there and elsewhere.¹⁴ Briefly, ORs are less influenced by over- or underrepresentation of other causes of death, and they contrast deaths among exposed and unexposed individuals. In addition, Miettinen and Wang emphasized selecting controls from an auxiliary disease not associated with the exposure of interest. To address this concern, we used two control groups: (a) all noncancer

deaths, and (b) all circulatory disease deaths. The cardiovascular disease PMR among elementary teachers in our 24-state data base indicated no association with elementary teaching (PMR = 1.0). A comparison of controls with circulatory disease (ICD = 390-459) produced little difference from "all jobs" ORs but produced higher OR estimates than managerial and professional controls. Therefore, some healthy worker effect is present among cardiovascular disease controls, a major component of "all jobs" effects.

Conclusions

These data provide a simple, economical surveillance tool for occupational cancer risks among women and men. For multiple myeloma, excesses occurred among elementary teachers and for several occupations with potential exposure to solvents, metals, and EMF.

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TABLE 5
Multiple Myeloma Cases Exposed, Mortality Odds Ratios, and 95% Confidence Interval for Elementary School Teachers (Occupational Code = 156) Using Different Control Groups for Comparison

Race/Gender	Control Groups								
	Unrestricted Exposure Category			Restricted Exposure (Job) Categories				Restricted Disease Category	
	All Jobs*,† (Occupational Code = 001-999)			Managers & Professionals*,‡ (Occupational Code = 001-199)		Post-secondary Teachers*,§ (Occupational Code = 113-154)		All Circulatory Diseases (ICD = 390-459)	
	Cases Exposed	Mortality Odds Ratio	95% Confidence Interval	Mortality Odds Ratio	95% Confidence Interval	Mortality Odds Ratio	95% Confidence Interval	Mortality Odds Ratio	95% Confidence Interval
Black females	38	1.6	1.1-2.1	1.3	0.7-2.2	0.2	0.4-1.0	1.3	0.8-2.2
White females	224	1.4	1.2-1.7	1.3	1.0-1.5	1.4	0.6-3.5	1.5	1.2-1.8
Black males	10	1.8	0.8-3.9	1.6	0.6-3.9	0.0	0.0-inf	1.8	0.6-5.5
White males	64	1.9	1.4-2.6	1.4	1.0-1.9	0.6	0.3-1.2	1.8	1.2-2.6

* 1980 census of population; Alphabetical Index of Industries and Occupations; US Department of Commerce.

† All jobs = all job codes 001-999, occupational code = 156.

‡ Managers and professional = all job codes 001-199: "Managerial and Professional Specialty Occupations"; excluding occupational codes = 156.

§ Post-secondary teachers = all job codes 113-154: "Teachers, postsecondary."

|| ICD = International Classification of Diseases, 9th rev.: "Circulatory Diseases"; ICD = 390-459.

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