

## United States Non-Hodgkin's Lymphoma Surveillance by Occupation 1984-1989: A Twenty-Four State Death Certificate Study

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Death certificates from 23,890 male and female non-Hodgkin's lymphoma (NHL) cases and 119,450 noncancer controls from 24 states for the period 1984-1989 were used to generate hypotheses regarding occupational associations. Cases were frequency matched by age, race, and gender with five controls per case. Odds ratios were calculated for 231 industries and 509 occupations. Significant associations were observed for a variety of white-collar professionals (i.e., real estate agents, secretaries, bookkeepers, teachers, postal employees, business agents, engineers, chemists, and medical professionals) and blue-collar occupations (i.e., firefighters, farm managers, aircraft mechanics, electronic repairers, mining machine operators, and crane and tower operators).

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**Key words:** occupational exposure, non-Hodgkin's lymphoma, death certificates, mortality odds ratio, African-Americans, blacks

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### INTRODUCTION

United States incidence rates of non-Hodgkin's lymphoma (NHL) have increased nearly 65% over the last 15 years, rising about 4% per year among men and 3% among women [Ries et al., 1991]. This increase is exceeded only by skin melanoma and lung cancer among women. Neither the etiology [Devita et al., 1989] nor the explanation for its rising rates [Devesa and Fears, 1992] is well known. NHL has been associated with various occupational groups, including farmers [Blair and Zahm, 1991]; rubber, plastics, and synthetics workers [Schumacher and Delzell, 1988; Downes et al., 1987]; road transport workers [Balarajan, 1983]; plumbers [Doln et al., 1983; Cantor et al., 1986]; printing workers [Greene et al., 1979; Zoloth et al., 1986]; foundry workers [Giles et al., 1984]; chemists [Li et al., 1969]; funeral directors and embalmers [Linos et al., 1989; Hayes et al., 1990]; and workers exposed to metals and solvents [Blair et al., 1993]. As it is often difficult and expensive to assemble populations large enough to evaluate occupation/disease associations, we

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used death certificates for black and white residents from 24 states for the years 1984–1989 to generate clues to occupational associations with NHL.

## METHODS

The National Cancer Institute, National Institute for Occupational Safety and Health, and the National Center for Health Statistics supported the coding of occupation and industry on death certificates from 24 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, and Vermont). Coding began in 1984, but not all states contributed initially. Three-digit occupation (OC) or industry (IC) classification codes (United States Department of Commerce, 1982) were evaluated. Military, retired with no occupation reported, homemaker, student, volunteer, and never worked or disabled OC codes were added to the 1980 U.S. Department of Commerce code 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.

From 3,159,417 total deaths, 23,890 non-Hodgkin's lymphoma deaths (World Health Organization ICD 9th Revision, codes 200 and 202, except 202.3 and 202.6) among white (94%) and black (6%) men and women were selected. Five controls, dying of diseases other than cancer, were frequency matched to cases by age (5-year age groups), gender and race. For some analyses, controls were restricted to those dying from circulatory diseases (ICD = 390–459) using the same age, race, and gender criteria as above.

Associations between IC/OC code(s) and non-Hodgkin's lymphoma were based on mortality odds ratios [Miettinen and Wang, 1981] using the standard logistic regression procedures in Epicure [Preston and Lubin, 1992]. Decedents with specific OC or IC codes (exposed) were compared to all others not in the category (unexposed). Race- and gender-specific mortality odds ratios were calculated for black female (BF), black male (BM), white female (WF), and white males (WM) and were adjusted for age, autopsy status, urban/rural residence, and geographic region, except where noted. For region-specific analyses, ORs were adjusted for individual state contributions within that region.

All mortality odds ratios (ORs) are reported with 95% confidence intervals (95% CI). Only individual occupation and industry codes with five exposed cases and ORs  $\geq 2.0$ , or statistically significant, are reported.

## RESULTS

Cases and controls displayed similar distributions in residence (rural vs. urban), autopsy status, and geographic region of residence (Table I). Seventeen times as many NHL deaths occurred among whites as among blacks, thus more NHL/occupation combinations could be evaluated among whites.

Among occupations, of 428 occurrences with 5 or more exposed cases, 47 statistically significant (95% CI lower limit  $\geq 1.05$ ) increased ORs occurred, whereas only 10.7 would be expected due to chance alone (Table II). Statistically significant

TABLE I. Population Parameter Distribution for Non-Hodgkin's Lymphoma Cases and Controls

Parameter	Cases n (%)	Controls n (%)
Age group		
<45	1,949 (8)	9,745 (8)
45-64	6,032 (25)	30,210 (25)
≥65	15,909 (67)	79,495 (67)
Race/gender		
Black female (BF)	610 (3)	3,050 (3)
Black male (BM)	744 (3)	3,720 (3)
White female (WF)	11,290 (47)	56,450 (47)
White male (WM)	11,246 (47)	56,230 (47)
Rural/urban		
Metro	15,372 (64)	73,440 (62)
Nonmetro	8,505 (36)	45,919 (38)
Other	13 (0)	91 (0)
Autopsy		
Yes	2,013 (8)	14,266 (12)
No	17,534 (73)	87,574 (73)
Unknown	4,343 (18)	17,610 (15)
Region <sup>a</sup>		
Northeast	2,673 (11)	12,568 (11)
Southeast	7,292 (30)	40,106 (34)
Central	11,423 (48)	54,282 (45)
West	2,502 (11)	12,494 (10)

<sup>a</sup>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.

increased associations occurred among white male and female white-collar professional specialties (OCC = 003-199), technical sales, administrative occupations (OC = 203-389), and several teaching occupations (OC 137-159). While several blue-collar occupations showed excesses, particularly among WM, ORs were typically less than 1.5.

Among industries, of 380 occurrences with 5 or more exposed cases, 28 demonstrated statistically significant (95% CI lower limit  $\geq 1.05$ ) increased associations with non-Hodgkin's lymphoma deaths, while only 9.5 would be expected by chance alone (Table III). Significantly elevated NHL associations were observed among manufacturing industries (IC = 100-472); finance, insurance, and real estate industries (IC = 700-712); professional and related services industries (IC = 812-892); and public administration (IC = 900-932). White male doctors (OC = 084) based in physician's offices (IC = 812) displayed less association than doctors in other settings (Table IV).

#### Geographic Region

Managers and administrators (OC = 019) and elementary school teachers (OC = 156) had elevated risks of non-Hodgkin's lymphoma deaths in most geographic regions (Table V). The risk among farmers was greater among WM, central region farmers (OR = 1.2, 95% CI = 1.1-1.3).

**TABLE II. Mortality Odds Ratios (OR), 95% Confidence Interval (CI), and Cases Exposed for Non-Hodgkin's Lymphoma According to Occupation Code**

Occupation	Cases exposed	OR	95% CI
<b>Manager and professional specialty occup [003-199]</b>			
BF	93	1.5	1.2-2.0
BM	81	1.6	1.2-2.1
WF	1,550	1.3	1.3-1.5
WM	2,490	1.5	1.4-1.5
Administrator (005)			
WM	60	1.5	1.1-2.0
Mkt manager (013)			
WM	48	1.7	1.2-2.3
Education adm (014)			
WM	44	1.7	1.2-2.5
Mgr and adm (019)			
WF	292	1.4	1.3-1.7
WM	889	1.3	1.2-1.5
Personnel training and labor relations (027)			
WM	20	1.8	1.1-3.0
Purchasing agt (033)			
WF	11	2.0	1.0-4.1
Business and promotion agents (034)			
WM	8	2.8	1.2-6.9
Compliance officer (036)			
WF	7	2.9	1.1-7.4
Metallurgical and materials engineer (045)			
WM	12	2.5	1.2-5.0
Elect engineer (055)			
WM	78	1.6	1.2-2.1
Other engineer (059)			
WM	32	1.8	1.2-2.7
Computer sys analyst and scientist (064)			
WM	10	2.1	1.0-4.5
Physicists and astronomers (069)			
WM	8	3.9	1.5-10.2
Nonbiological chemist (073)			
WM	31	2.1	1.4-3.2
Geologist (075)			
WM	13	3.0	1.5-5.9
Physician (084)			
WM	73	1.9	1.4-2.5
Dentist (085)			
WM	27	1.7	1.1-2.6
Art, drama, and music teachers (137)			
WM	5	3.6	1.2-11.5
Post sec teachers unspecified subject (154)			
WM	30	1.7	1.1-2.6

(continued)

**TABLE II. Mortality Odds Ratios (OR), 95% Confidence Interval (CI), and Cases Exposed for Non-Hodgkin's Lymphoma According to Occupation Code (Continued)**

Occupation	Cases exposed	OR	95% CI
Element teachers (156)			
BF	23	1.8	1.1-2.9
WF	451	1.4	1.2-1.5
WM	105	1.6	1.3-2.0
Secondary teachers (157)			
WF	62	1.7	1.3-2.3
WM	33	1.6	1.1-2.3
Other teachers (159)			
WF	31	1.6	1.1-2.4
Psychologists (167)			
WM	6	2.0	0.8-5.4
Clergy (176)			
WM	133	1.9	1.5-2.3
Authors (183)			
WM	6	3.4	1.2-9.9
<b>Tech, sales, and admin. support occup [203-389]</b>			
<b>BF</b>	<b>49</b>	<b>1.4</b>	<b>1.0-2.0</b>
<b>BM</b>	<b>64</b>	<b>1.6</b>	<b>1.2-2.1</b>
<b>WF</b>	<b>1,908</b>	<b>1.2</b>	<b>1.2-1.3</b>
<b>WM</b>	<b>1,768</b>	<b>1.1</b>	<b>1.1-1.2</b>
Real est sale (254)			
WF	40	1.6	1.1-2.2
WM	76	1.4	1.1-1.9
Furniture sales (266)			
WF	6	4.1	1.4-12.4
Radio, TV sales (267)			
WM	7	2.0	0.9-4.4
Street/door-to-door sales (277)			
WM	5	3.1	1.0-9.3
Secretaries (313)			
BF	8	3.4	1.3-9.0
WF	408	1.2	1.1-1.3
Records clerks (336)			
WF	8	2.1	0.9-4.7
Bookkeepers (337)			
WF	192	1.3	1.1-1.5
Postal clerks (354)			
BM	8	2.0	0.9-4.7
WM	60	1.6	1.2-2.1
Mail carriers (355)			
BM	5	2.3	0.8-7.0
WF	7	2.8	1.1-7.2
Traffic, shipping clks (364)			
BM	14	3.0	1.5-5.8
WF	19	2.8	1.6-4.8
Teacher's aides (387)			
WF	17	3.4	1.8-6.4

(continued)

**TABLE II. Mortality Odds Ratios (OR), 95% Confidence Interval (CI), and Cases Exposed for Non-Hodgkin's Lymphoma According to Occupation Code (Continued)**

Occupation	Cases exposed	OR	95% CI
<b>Service occupations [403-469]</b>			
BF	171	1.0	0.8-1.2
BM	94	1.0	0.8-1.2
WF	796	0.9	0.8-0.9
WM	602	0.9	0.8-0.9
Private house cleaners and servants (407)			
BF	62	0.7	0.5-0.9
WF	140	0.7	0.6-0.7
Firefighting supervisors (413)			
WM	12	5.6	2.5-12.3
Guards (426)			
WM	63	0.7	0.5-0.9
Bartenders (434)			
WM	10	0.4	0.2-0.8
Waiters (435)			
WF	82	0.7	0.5-0.9
Cooks, non-short order			
WM	19	0.5	0.3-0.8
Supervisors, cleaning (448)			
WM	24	2.0	1.3-3.3
Beauticians (458)			
BF	10	2.5	1.1-5.4
Public transportation attendants (465)			
WF	5	3.7	1.2-11.6
<b>Farming, forestry, and fishing occup [473-499]</b>			
BF	10	0.8	0.4-1.6
BM	47	0.5	0.4-0.7
WF	34	1.1	0.7-1.5
WM	1152	1.0	1.0-1.1
Farmers (473)			
BM	26	0.5	0.3-0.8
Mgr, farm (475)			
WF	5	6.3	1.8-22.4
Farm workers (479)			
BM	9	0.3	0.1-0.8
WM	38	0.7	0.5-0.9
<b>Precision production, craft, and repair occup [503-699]</b>			
BF	10	1.4	0.7-2.8
BM	97	1.0	0.8-1.3
WF	154	1.0	0.8-1.2
WM	2355	0.9	0.9-1.0
Aircraft mechanics (515)			
WM	8	2.5	1.1-6.0
Farm equip't mechanics (517)			
WM	7	2.1	0.9-5.3

(continued)

**TABLE II. Mortality Odds Ratios (OR), 95% Confidence Interval (CI), and Cases Exposed for Non-Hodgkin's Lymphoma According to Occupation Code (Continued)**

Occupation	Cases exposed	OR	95% CI
Electronic repairers (523)			
WM	12	2.1	1.1-4.1
Misc electronic and electrical repairers (533)			
WM	10	2.0	1.0-4.3
Painters (579)			
WM	65	0.6	0.5-0.8
Mining mach opr (616)			
BM	7	3.9	1.4-10.8
Hand molders and shapers (676)			
WM	9	2.0	0.2-4.3
Food batchmakers (688)			
WF	6	2.3	0.9-5.9
<b>Operators, fabricators, and repair occup [703-917]</b>			
BF	53	1.1	0.8-1.5
BM	282	1.0	0.8-1.2
WF	855	1.0	0.9-1.0
WM	2129	0.8	0.8-0.8
Fabricating machine operators (717)			
WF	5	3.2	1.0-10.5
Welders (783)			
BM	6	2.1	0.8-5.8
Assemblers (785)			
BF	5	2.6	0.9-7.7
Crane and tower opr (849)			
BM	5	3.3	1.1-9.8
Construction laborers (869)			
WM	61	0.7	0.5-0.9
Machine feeders (878)			
BM	5	3.4	1.1-11.1
Laborers (889)			
WF	107	0.8	0.6-0.9
Homemakers (914)			
WF	5615	0.8	0.8-0.9
Never employed (917)			
WF	82	0.5	0.4-0.6
WM	23	0.4	0.2-0.6

[nnn-~~nnn~~] = grouped occupations; (nnn) = 1980 Census three-digit occupation code; BF = black females; BM = black males; WF = white females; WM = white males; OR = mortality odds ratio; cases exposed = number of cases with that usual occupation; 95% CI = 95% confidence interval (lower limit-upper limit) rounded to 1 significant digit.

mkt (market), mgr (manager), agt (agent), adm (administrator), elect (electrical/electronic), sys (system), sec (secondary), element (elementary), est (estate), clk (clerk), misc (miscellaneous), equip't (equipment).

**TABLE III. Non-Hodgkin's Lymphoma Odds Ratios for Race/Gender Groups Identified by 1980 Census Industry Codes From Death Certificates**

Industry category (code) [Group] (industry specific)	Exposed cases	OR	95% CI
<b>Agric, forestry, and fisheries [010-031]</b>			
BF	9	0.8	0.4-1.6
BM	36	0.4	0.3-0.6
WF	39	1.1	0.8-1.5
WM	1130	1.1	1.0-1.1
Ag. prod., crops (010)			
BM	30	0.4	0.3-0.6
<b>Mining [040-050]</b>			
BM	8	2.3	1.0-5.4
WF	6	0.7	0.3-1.6
WM	250	1.0	0.9-1.1
Coal (041)			
BM	6	2.8	1.0-7.9
<b>Construction [060]</b>			
BM	89	0.9	0.7-1.2
WF	36	1.2	0.8-1.7
WM	1090	0.9	0.8-0.9
<b>Manufacturing (nondurable) [100-222]</b>			
BF	26	1.0	0.7-1.6
BM	64	1.3	0.9-1.6
WF	710	1.1	1.0-1.2
WM	1115	1.1	1.0-1.2
Dairy products (101)			
WF	14	2.1	1.1-3.8
Grain mill prod. (110)			
WM	33	1.8	1.2-2.6
Tobacco manufacturers (130)			
BF	5	2.1	0.7-5.9
<b>Manufacturing (durable) [230-392]</b>			
BF	18	1.3	0.7-2.2
BM	131	1.3	1.0-1.6
WF	485	1.1	1.0-1.2
WM	1819	0.9	0.9-1.0
Iron/steel f'ndries (271)			
BM	7	2.2	0.9-5.7
1° aluminum ind. (272)			
BM	5	3.7	1.2-11.7
WF	6	2.2	0.9-5.9
Transportation equipment aircraft and parts (352)			
BM	5	3.1	1.0-9.6
Ship/boat bldg and rep. (360)			
BM	7	2.9	1.1-7.9
<b>Transportation, communications, and other public utilities [400-472]</b>			
BF	7	2.3	0.9-5.9
BM	88	1.1	0.9-1.4
WF	240	1.3	1.1-1.5
WM	1172	1.0	0.9-1.1
Taxi (402)			
WM	12	0.4	0.2-0.7

(continued)

**TABLE III. Non-Hodgkin's Lymphoma Odds Ratios for Race/Gender Groups Identified by 1980 Census Industry Codes From Death Certificates (Continued)**

Industry category (code) [Group] (industry specific)	Exposed cases	OR	95% CI
Trucking (410)			
WF	28	2.1	1.4-3.3
US Postal Ser. (412)			
BM	19	2.0	1.2-3.5
WF	39	1.7	1.2-2.4
WM	166	1.3	1.1-1.5
Air transport (421)			
WF	14	2.1	1.1-3.9
Pipe lines, except natural gas (422)			
WM	5	2.6	0.9-7.7
<b>Wholesale trade</b>			
<b>Durable goods [500-532]</b>			
BM	5	0.8	0.3-2.0
WF	30	1.2	0.9-2.0
WM	146	1.1	0.9-1.3
<b>Nondurable goods [540-571]</b>			
BM	6	0.9	0.4-2.3
WF	42	1.1	0.8-2.6
WM	209	1.0	0.9-1.2
Paper and paper products (540)			
WM	12	2.2	1.1-4.5
<b>Retail trade [580-691]</b>			
BF	24	0.9	0.6-1.4
BM	40	0.9	0.6-1.3
WF	939	1.1	1.0-1.1
WM	1020	1.0	0.9-1.1
Dpt. stores (591)			
WM	57	1.5	1.1-2.0
Auto/home sup. (620)			
WM	27	0.6	0.4-0.9
Misc. (682)			
WF	27	1.6	1.1-2.3
<b>Finance, insurance, and real estate [700-712]</b>			
BF	10	2.2	1.0-4.7
BM	10	0.9	0.4-1.7
WF	268	1.2	1.1-1.4
WM	358	1.1	1.0-1.3
<b>Business and repair services [721-760]</b>			
BF	7	1.1	0.5-2.6
BM	25	1.1	0.7-1.8
WF	130	1.2	1.0-1.4
WM	393	0.9	0.8-1.0
Dwelling/bldg ser. (722)			
BF	5	8.4	1.5-47.5
Computer/data proc (740)			
WF	7	2.4	1.0-5.9
WM	15	1.9	1.0-3.5

(continued)

**TABLE III. Non-Hodgkin's Lymphoma Odds Ratios for Race/Gender Groups Identified by 1980 Census Industry Codes From Death Certificates (Continued)**

Industry category (code) [Group] (industry specific)	Exposed cases	OR	95% CI
<b>Personal services [761-791]</b>			
BF	102	0.8	0.6-1.0
BM	26	0.9	0.6-1.4
WF	378	0.8	0.8-0.9
WM	183	1.0	0.9-1.2
Private household (761)			
WF	159	0.7	0.6-0.9
Beauty shop (772)			
BF	10	2.2	1.0-4.7
<b>Entertainment and recreation [800-802]</b>			
BM	6	1.0	0.4-2.4
WF	39	1.2	0.8-1.7
WM	80	0.9	0.7-1.1
<b>Professional and related services [812-892]</b>			
BF	118	1.6	1.3-2.0
BM	67	1.3	0.9-1.7
WF	1209	1.3	1.2-1.4
WM	1010	1.4	1.3-1.5
Physicians off. (812)			
WF	62	1.8	1.3-2.4
Other practitioner (830)			
WF	24	1.7	1.1-2.7
WM	6	3.0	1.0-8.4
Hospitals (831)			
BF	43	1.7	1.2-2.5
Elem/sec. sch. (842)			
WF	732	1.5	1.3-1.6
WM	283	1.4	1.2-1.6
Col./univ. (850)			
WF	75	1.4	1.1-1.8
WM	113	1.4	1.2-1.8
Ed. serv. (860)			
WF	25	2.1	1.3-3.4
Museums, art galleries, and zoos (872)			
WF	5	2.9	1.0-8.8
Religious org. (880)			
WF	153	1.8	1.5-2.2
Noncommercial educational and sci. research (891)			
WF	14	3.6	1.8-7.2
<b>Public administration [900-932]</b>			
BF	18	1.5	0.9-2.7
BM	42	1.5	1.0-2.1
WF	272	1.1	1.0-1.3
WM	613	1.1	1.0-1.2
Just./order/safe (910)			
BF	5	4.0	1.2-13.2
WF	195	1.2	1.1-1.4

(continued)

**TABLE III. Non-Hodgkin's Lymphoma Odds Ratios for Race/Gender Groups Identified by 1980 Census Industry Codes From Death Certificates (Continued)**

Industry category (code) [Group] (industry specific)	Exposed cases	OR	95% CI
Adm. human rsems (922)			
BF	8	2.3	1.0-5.2
Adm. envirn/house (930)			
WF	11	2.3	1.1-4.9
WM	36	1.5	1.1-2.3
Adm. economic pgms (931)			
WF	24	2.0	1.2-3.2

Mortality odds ratios (OR), 95% confidence interval (CI), and cases exposed for non-Hodgkin's lymphoma according to industry code.

[nnn-*nnn*] = grouped industry; (*nnn*) = 1980 Census three-digit industry code; BF = black females; BM = black males; WF = white females; WM = white males; MOR = mortality odds ratio (exposure odds ratio); cases exposed = number of cases in that industry; 95% CI = 95% confidence interval (lower limit-upper limit) rounded to 1 significant digit.

ag (agriculture), prod (products), f'ndries (foundries), ind (industry), bldg (building), rep (repair), proc (process/ing), ser (service), dpt (department), sup (supplies), misc (miscellaneous), off (office), sec (secondary), sch (school), col (college), org (organization), just (justice), adm (administration), rses (resources), pgms (programs), envirn (environment/al).

### Multiple Control Group Analyses

Unspecified managers and administrators (OC = 019) showed increased associations for unrestricted exposure (all jobs) and "all circulatory disease" control groups (Table VI). Managerial/professional groups (OC = 001-199) and executives, administrators, and managers (001-037) showed decreased associations. Elementary school teachers showed increased associations for unrestricted exposures and all circulatory disease control groups for all except BMs. Restriction of exposure to white-collar jobs still produced excesses except among BMs. When elementary school teachers were compared with post-secondary school teachers, WF showed some residual association.

### DISCUSSION

Death certificates are often used to examine associations between occupation and cancer [Peterson and Milham, 1980; Milham, 1983; Dubrow et al., 1987; Loomis and Savitz, 1991]. These studies are inexpensive, provide sufficiently large populations to evaluate rare occupations and/or cancers, and can be used to identify mortality changes in a population over some time interval [Dubrow and Wegman, 1984]. Limitations include inaccurate recording of disease and/or occupation [Percy et al., 1981; Selikoff IJ, 1992a, 2b; Selikoff and Seidman, 1992], healthy worker effect [Stewart and Hunting, 1988], and lack of information regarding confounders [Dubrow and Wegman, 1984].

Miettinen and Wang [1981] introduced mortality odds ratio (OR) analysis as an

**TABLE IV. Non-Hodgkin's Lymphoma Odds Ratios for Whites Employed as Managers and Administrators (OC = 019), Secretaries (OC = 313), Laborers (OC = 889), and Physicians (OC = 084) in Different Industries**

Industry category [group]	Exposed cases	OR	95% CI
<b>Managers and Administrators (019)</b>			
Construction [060]			
WF	9	2.3	1.1-5.2
Manufacturing			
Nondurable [100-222]			
WM	119	1.5	1.3-1.9
Durable [230-392]			
WF	22	2.1	1.3-3.5
WM	137	1.4	1.1-1.6
Transport, communications, and public utilities [400-472]			
WF	19	2.2	1.3-3.7
WM	111	1.4	1.2-1.8
Wholesale trade durable goods [500-532]			
WF	8	4.7	1.8-12.2
Finance, insurance, and real estate [700-712]			
WF	25	2.5	1.6-4.1
WM	63	1.5	1.1-1.9
Professional and related services [812-892]			
WF	49	1.7	1.2-2.3
WM	56	1.8	1.3-2.4
<b>Secretaries (313)</b>			
Manufacturing (nondurable) [100-222]			
WF	36	1.2	1.0-2.2
<b>Laborers (889)</b>			
Manufacturing			
Nondurable [100-222]			
WF	31	0.6	0.4-0.9
Durable [230-392]			
WF	49	0.8	0.6-1.0
Wholesale trade nondurable goods [540-571]			
WF	4	2.0	0.6-6.6
Finance, insurance, and real estate [700-712]			
WF	1	2.9	0.3-32.3
Professional and related services [812-892]			
WF	7	2.1	0.9-5.1
<b>Physicians (084)</b>			
Physician's offices [812]	59	1.8	1.3-2.4
Hospitals [831]	10	2.4	1.1-5.1
Other	4	2.1	0.7-6.5

(OC = nnn) = 1980 Census three-digit occupation code; [nnn-*nnn*] = grouped industry; WF = white females; WM = white males; OR = mortality odds ratio; cases exposed = number of cases with that usual occupation; 95% CI = 95% confidence interval (lower limit-upper limit) rounded to 1 significant digit.

alternative to proportional mortality ratio (PMR) analysis. Its advantages are the use of a case-control design that parallels etiologic case-control studies, which, unlike PMR analysis, is less influenced by over- or under-representation of other causes of

TABLE V. Non-Hodgkin's Lymphoma Cases Exposed, Mortality Odds Ratios (OR),\* and 95% Confidence Interval (CI) for Selected Occupation Codes by Geographic Region

Occupation	Northeast			Southeast			Central			West		
	Cases	OR	95% CI	Cases	OR	95% CI	Cases	OR	95% CI	Cases	OR	95% CI
Mgr and adm (019)												
WF	43	1.6	0.62-2.1	75	1.5	1.18-2.0	141	1.3	1.09-1.6	33	1.7	1.13-2.5
WM	120	1.2	0.83-1.6	283	1.6	1.42-1.9	396	1.2	1.09-1.4	90	1.1	0.89-1.5
Elem teacher (156)												
BF	0	—	—	13	1.4	0.74-2.7	10	2.4	1.04-5.7	0	—	—
WF	55	1.4	0.98-1.9	127	1.3	1.10-1.6	199	1.2	1.05-1.4	70	2.2	1.63-2.9
WM	3	0.5	0.14-1.5	34	2.3	1.50-3.4	50	1.5	1.08-2.1	18	1.7	0.96-2.9
Farmers (473)												
BF	0	—	—	5	0.8	0.30-2.1	1	3.7	0.22-64.0	0	—	—
BM	0	—	—	25	0.5	0.31-0.8	1	0.2	0.02-1.9	0	—	—
WF	2	0.9	0.20-4.1	4	0.9	0.30-2.5	14	1.1	0.61-2.0	2	0.7	0.15-3.1
WM	25	0.9	0.57-1.4	303	1.0	0.84-1.1	587	1.2	1.06-1.3	92	1.0	0.81-1.3

(OC = nnn) = 1980 Census three-digit occupation code; BF = black females; BM = black males; WF = white females; WM = white males; OR = mortality odds ratio; cases exposed = number of cases with that usual occupation; 95% CI = 95% confidence interval = (lower limit-upper limit).

\*ORs reported regardless of number of exposed cases or statistical significance.

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.

death. As a result, mortality odds-ratio analysis contrasts deaths among exposed and unexposed individuals with unrelated diseases.

Several studies have reported associations with agricultural occupations [Blair et al., 1990, 1993; Hansen et al., 1992; Vineis et al., 1992; Persson et al., 1989; La Vecchia et al., 1989; Pearce et al., 1987, 1988; Giles et al., 1984; Cantor, 1982], especially among farmers exposed to agricultural herbicides [Vineis et al., 1992; Hansen et al., 1992; Blair et al., 1990; La Vecchia et al., 1989; Persson et al., 1989; Cantor 1982]. Some reports show no herbicide association [Johnson, 1990; Bond et al., 1989; Pearce et al., 1987]. We found a small excess (MOR = 1.1; 95% CI = 1.02-1.2) among farmers (not reported because the rounded lower limit of the 95% CI included 1.0). We report only WF farm managers as showing an association. As previously reported for these data [Blair et al., 1993], NHL risk among WMs was confined to central-region farmers (Table V), a region showing increased risk in other NHL epidemiologic studies [Zahm et al., 1990; Hoar et al., 1986; Cantor, 1982]. Individual farming exposure data were unavailable, and all farmers do not experience the same exposure. Moreover, death certificate data are limited and sometimes inaccurate. As a result, risk estimates will be biased toward the null.

We observed excesses among some occupations, including mechanics, repairmen, welders, and machine operators, where exposure to solvents and metals may occur. These substances have been associated with NHL in other studies [Blair et al., 1993; Spirtas et al., 1991; Dalager et al., 1991; Teta et al., 1990; Christie, 1990; Linos et al., 1991; Brandt et al., 1983, 1989; Corbett and O'Neill, 1988; Olsson and Brandt, 1988; Garland et al., 1988; Tsongas, 1985; Giles et al., 1984; Doln et al.,

**TABLE VI. Non-Hodgkin's Lymphoma Cases Exposed, Mortality Odds Ratios (OR), and 95% Confidence Interval (CI) for Managers (OC = 019) and Elementary School Teachers (OC = 156) Using Different Control Groups**

Race/gender	Control groups								
	Unrestricted exposure category			Restricted exposure (job) categories				Restricted disease category	
	All jobs <sup>a,b</sup> (OC = 001-999)			Mgrs & professional <sup>a,c</sup> (OC = 001-199)		Exec, admin, mgrs <sup>a,d</sup> (OC = 001-037)		All circ diseases <sup>f</sup> (ICD = 390-459)	
Cases	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	
<b>Managers (OC = 019)</b>									
BF	4	0.8	0.3-2.6	0.5	0.1-1.6	0.9	0.1-17.5	1.2	0.2-5.7
BM	12	1.9	0.9-3.9	1.5	0.6-3.8	1.1	0.3-3.8	2.2	0.7-6.5
WF	292	1.4	1.3-1.7	1.0	0.9-1.2	0.9	0.7-1.1	1.2	1.0-1.5
WM	889	1.3	1.2-1.5	0.9	0.8-1.0	1.0	0.9-1.1	1.2	1.1-1.4
<b>Teachers (OC = 156)</b>									
						Post sec teachers <sup>a,e</sup> (OC = 113-154)			
						OR	95% CI	OR	95% CI
BF	23	1.8	1.1-2.9	2.3	1.0-5.2	inf	0.0-inf	1.2	0.6-2.4
BM	5	1.0	0.4-2.6	0.5	0.1-1.5	0.5	<0.0-16.2	0.4	0.1-1.1
WF	451	1.4	1.2-1.5	1.1	0.9-1.2	1.3	0.7-2.5	1.4	1.2-1.6
WM	105	1.6	1.3-2.0	1.2	0.9-1.5	0.7	0.5-1.2	1.5	1.1-2.0

BF = black females; BM = black males; WF = white females; WM = white males; OR = mortality odds ratio (exposure odds ratio); cases = cases exposed; 95% CI = 95% confidence interval; OC = occupational code.

mgrs = managers; circ = circulatory; exec = executive; admin = administrative; sec = secondary school. <sup>a</sup>1980 Census of Population; Alphabetical Index of Industries and Occupations; US Department of Commerce.

<sup>b</sup>All jobs = job codes 001-999, excluding 019 and 156, respectively.

<sup>c</sup>Mgrs & professional = job codes 001-199—"Managerial and Professional Specialty Occupations," excluding 019 and 156, respectively.

<sup>d</sup>Exec, admin, mgrs = job codes 001-037—"Executive, Administrative, and Managerial Occupations," excluding 019.

<sup>e</sup>Post sec teachers = all job codes 113-154—"Teachers, postsecondary."

<sup>f</sup>ICD = International Classification of Diseases, 9th ed.—"Diseases of the Circulatory System," codes 390-459.

1983; Kaneko et al., 1982; Fischmann et al., 1979] and with occupations in which these exposures may occur, including miners [Corbett and O'Neill, 1988; Giles et al., 1984], foundry workers [Giles et al., 1984], petrochemical workers [Christie, 1990], workers exposed to solvents [Brandt et al., 1983, 1989; Fischmann et al., 1979; Vianna and Polan, 1979], plumbers [Doln et al., 1983], and chemists [Teta et al., 1990]. We found no excess among painters, as reported by others [Chow, et al., 1993].

Increased risk of NHL has been reported among physicians [Grufferman et al., 1976, Vianna et al., 1974; Petersen and Milham, 1980; Milham, 1983; Dubrow and Wegman, 1984; Scherr et al., 1992; Blair et al., 1993]. We also found a statistically elevated association. Risks were higher among hospital-based physicians than office-based physicians. It is possible that hospital-based physicians are more likely exposed to potential carcinogens.

NHL was elevated among a number of white-collar occupations. Of the 66 job

titles appearing in Table II, managers and professional specialty occupations represent only 25% of the jobs analyzed, but 37% of the jobs in the table. Additionally, unclassified managers and administrators (OC = 019) and elementary school teachers (OC = 156) also were associated with NHL deaths. This may reflect socioeconomic status (SES), confounding, or biases associated with control selection, but a possible role for an infectious agent other than HIV [Gail et al., 1991] has been suggested by Mueller et al. [1992]. Others have linked lymphoma cases with prior close, personal contact with other cases [Schimpff et al., 1975; Smith et al., 1977].

The association between NHL and HIV is well established [Shiramizu et al., 1994; Biggar and Rabkin, 1992; Cote et al., 1991], but these investigations generally show no association with the occupation of HIV-infected individuals and NHL. Available evidence suggests that host rather than environmental factors are responsible for AIDS-related immunoblastic and CNS lymphomas [Biggar and Rabkin, 1992].

The risk among managers and teachers was not concentrated geographically, since excess NHL was elevated among managers from several different industries and risk of both occurred in all geographic regions.

NHL is reported fairly accurately on death certificates (i.e., 83% detection and 88% confirmation rates) [Percy et al., 1981]; however, ICD classification poorly differentiates NHL's diagnostic subtypes [Weisenburger, 1992; Jaffe et al., 1992]. If these subtypes have different etiologies, analyzing them together would weaken associations. Since only deaths are included, associations could be missed if the etiology of surviving cases differs from dead cases [Gordis, 1982; McLaughlin, et al., 1985a,b]. Although death certificates contain little information regarding potential risk factors, this may not be much of a problem because NHL's etiology remains obscure. For example, alcohol and tobacco consumption, potential confounders of many cancers, are at best weakly associated with NHL [Brown et al., 1992a,b; Heineman et al., 1992]. The lack of data from nonparticipating states with large African-American and other minority populations, such as New York, Pennsylvania, Illinois, Michigan, Texas, and California, resulted in less stable estimates for these populations [Burnett, 1993]. Lack of individual exposure data could also bias estimates toward the null, and multiple comparisons may have created some false-positive associations [Rothman, 1986].

Control selection can be a problem in studies based on death certificates, since good health is a selection factor related to initial and continued employment [Monson, 1986; McMichael, 1976]. We tried to counter this problem in two ways.

One approach involved selecting controls from individuals with circulatory disease as the underlying cause of death to minimize the influence of diseases more strongly linked with low socioeconomic status. Miettinen and Wang [1981] emphasized the importance of selecting controls from an "unrelated" disease group, and while cardiovascular disease is commonly used, this may lead to problems. In working populations the healthy worker effect may cause PMRs and MORs to overestimate cause-specific mortality [Stewart and Hunting, 1988]. In addition, the healthy worker effect is sometimes greatest for cardiovascular disease controls [Walter, 1986]. Odds ratios for teachers and managers, using circulatory disease controls, were similar to estimates based on all causes of death (Table V, "all job" category). The two occupations showing consistent excesses in these data—teachers and managers—are generally healthier than other workers [Olsen and Jensen, 1987].

A second approach involved a change in the definition of unexposed. For the basis of analysis, cases and controls were stratified into the occupation of interest (i.e., teachers) and all other occupations. We also calculated ORs for managers or teachers restricting controls to managerial and professional specialty occupations (OC codes 001–199, excluding codes 019 and 156 for managers and teachers, respectively). This difference suggests that excesses among teachers and managers is in part related to their socioeconomic status rather than exposures specifically associated with their particular jobs and has been reported elsewhere for other occupational categories [Milham, 1985]. The potential socioeconomic bias that might occur because of exclusion of blue-collar occupations resulted in reduced MORs. A similar analysis of selected blue-collar occupation deaths (OC codes 503–889,  $n = 29,808$ ) demonstrated a very small increase in ORs (approximately 0.1) when cases in blue-collar occupations were compared with blue-collar controls. This was probably due to the absence NHL non-blue-collar deaths where rates were higher.

## CONCLUSIONS

Despite weaknesses, death certificate analyses have been useful in generating clues to possible occupational exposures. This allowed analysis by occupations and diseases for rare race and gender groups. Few strong associations were observed. Links between NHL and white-collar occupations (i.e., teachers and managers) in part reflect socioeconomic factors. Excess among various occupations engaged in machine operation and repair may indicate etiologic roles for solvents and metals. A positive association among central region farmers was consistent with earlier findings [Zahm et al., 1990; Hoar et al., 1986; Cantor, 1982]. Further investigation and analyses may explain this region-specific observation.

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