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Occupational Differences in Rates of Lung Cancer

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Many investigators have associated lung cancer with occupational exposure.[1-17] In an earl'er study, we reported an excess of lung cancer in males in the industrialized south-central area of Los Angeles County. This may have been the result of air pollution of industrial origin, specifically, elevated levels of polycyclic aromatic hydrocarbons.[18] However, since the excess was confined to males, occupational exposure would be an alternative explanation.

Interest in better understanding the different factors affecting lung cancer in Los Angeles County, in drawing clues toward identification of high risk occupations, and in setting a base line for future occupational observation and control programs led us to review five years of lung cancer data for white males in the county.

Methods

Subjects. — All 2,161 death certificates mentioning lung cancer (trachea, bronchus and lung) in white males, ages 20-64, for the period 1968-1970,* and all 1,777 incident cases of lung cancer in white males of the same age group reported to the Los Angeles County Cancer Surveillance Program (CSP)[19] for 1972-1973, were reviewed. These mortality and morbidity data were pooled; we consider this justified because of the high mortality rate of lung cancer and the relatively high accuracy of death certification regarding lung cancer.[20,21] During this reporting period, the CSP abstracted all incident cancer cases from 198 hospitals and six private laboratories in Los Angeles County, including all hospitals known to treat cancer. The primary source of case selection was hospital pathology files, including hematology, cytology and autopsy reports. The medical chart was reviewed when necessary to establish primary site, or first date of diagnosis of the malignancy, or to determine missing demographic data. Pathology records of nearby out-of-county hospitals were searched for inclusion of residents of Los Angeles County who were cancer patients. All Los Angeles County death certificates mentioning malignancies were reviewed to further insure completeness of incident case ascertainment. The study was limited to the age group 20-64 to minimize the number of retired persons without stated occupations. Of the 3,938 subjects, 689 (424 deaths, 265 incident cases) had no reported occupation, and 1,222 (619 deaths, 603 incident cases) had no reported industry of employment.

Classification of Occupation. — One occupational title, and one industry of employment were obtained per subject. California death certificates include the subjects' last occupation, name of last employing firm, and type of industry. The CSP demographic data were abstracted from hospital admission sheets, and in some cases medical records, and represent the last occupation and industry of employment which the patient or next of kin reported at admission. The occupation and industry of each subject were coded into one of 417 occupational codes, and one of 215 industry codes, per the 1970 U.S. Census occupational classification system.[22]

Analytic Methods. — Detailed occupation and industry populations-at-risk for white males in age groups 20-24, 25-34, 35-44, 45-54, and 55-64 were developed from the two Public Use Samples (PUS) of Basic Records from the 1970 Census for Los Angeles County.[23] These included respondent information on current occupation and industry. Combined use of the two PUS provided a 1-in-50 sample of Los Angeles County. There were 31,216 white males, aged 20-64, in the combined sample.

Expected deaths and expected incident cases were calculated for each specific occupation assuming the age-specific rates of cancer in each occupation were the same as those for all occupations. The ratio (%) of observed deaths plus incident cases to expected deaths plus incident cases, hereinafter referred to as a Standard Mortality Ratio (SMR), was then used as the measure of risk for the individual occupations. In a similar way, an SMR was calculated for each industry assuming the age-specific rates of lung cancer in each industry were the same as those for all industries. The Mantel-Haenszel method was used to measure statistical significance.[24]

Results

The occupations with statistically significantly increased Standard Mortality Ratios for lung cancer are listed in Table 1. Among

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the populations in these occupations there were 942 observed lung cancers compared to an expected 537 cases The Standard Mortality Ratio for lung cancer among these combined workers was 175 There were 16 occupational groups with an SMR of 200 or greater Twenty-nine percent of the lung cancer in males ages 20-64, who reported an occupation, occurred in the high risk workers listed in Table 1 who comprise only 15% of that sex-age group The number of deaths (1968-1970), and the number of incident cases (1972-1973) were listed separately; the proportion of lung cancer cases from death certificates and the CSP was consistent across the occupations listed with few exceptions. All but one of the high risk occupations were among craftsmen, operatives, laborers, and service workers. There were two occupations, bookbinders and blasters, which were calculated to be at greater than fourfold risk to lung cancer, but where the risk calculation was based on so few cases that any inference drawn would be speculative

There were 16 occupations with an SMR below 70, including pharmacists, assemblers, cranemen, physicians, barbers, foremen, sales managers, checkers, judges, secretaries, teachers, personnel workers, dentists, stock brokers, photographers, and school administrators

The Standard Mortality Ratios of workers in Los Angeles County to lung cancer by industry are given in Table 2 Workers in 13 industries were at significantly increased risk with SMR's ranging from 127 to 279. Forty-two percent of the lung cancer in males reporting an industry of employment, age 20-64, occurred in these high risk workers who comprised 27% of that sex-age group. The proportion of lung cancer cases from death certificates and the CSP in these industries were consistent with few exceptions.

Discussion

There were clear occupational differences in rates of lung cancer among white males in Los Angeles County. These occurred by broad occupational group, and by individual job classification. However, there are limitations to the epidemiologic techniques used and, whether these risk differences were the result of occupational carcinogens, or reflected differences in smoking habits and other factors (e.g., general air pollution), cannot be determined Thus, the absence of information on smoking limits our ability to delineate the risk of lung cancer due to occupational exposure alone. However, the pattern of these Los Angeles data, their consistency with earlier reports of excess lung cancer risks in certain occupational groups (asbestos workers, machinists, cooks, painters), and their consistency with reports of other occupational diseases related to airborne agents (skin cancer, silicosis, asbestosis, pneumoconiosis, bronchitis), suggest that the data may be generally indicative of the impact of occupational exposure on lung cancer rates.

Occupational groups found to be at excess risk who have not been previously implicated included roofers, dental lab technicians, decorators, nonautomotive mechanics, photoengravers,

Table 1. — Standard Mortality Ratios (SMR = 100 for All Occupations) for Occupations at Significantly Increased Risk to Lung Cancer, White Males 20-64 Years, Los Angeles County.

Occupation	Estimated Population at Risk (23)	No. of Deaths 1968-1970	Incident Cases 1972-1973	SMR
Asbestos, Insulation Workers	400	3	2	878
Roofers	2 000	6	5	496
Heat Treaters	550	1	3	433+
Dental Lab Technicians	900	2	3	405
Decorators	1,200	6	1	358
Taxi Drivers	3,100	16	7	344
Mechanics, Excl Auto	8 050	19	27	332
Photoengravers	1,350	4	4	320
Pressmen	5,300	10	10	276
Clothing Ironers	1,100	6	3	267
Mariners, Longshoremen	3,150	11	12	266
Shoe Repairers	1,350	3	4	233+
Mine Operatives	1,250	5	3	217+
Electricians	12,400	40	18	205
Bartenders	7,100	16	19	204
Plasterers, Dry Wall Workers	3,800	3	14	200
Cooks	11 450	23	18	180
Machine Shop Workers	52,550	117	82	167
Truck Drivers	34 800	58	51	165
Restaurant, Bar Managers	8,150	16	11	159
Painters	19,500	45	42	158
Plumbers	9 700	25	11	138+
Welders	15,300	21	27	137+
Janitors	27 050	48	61	127
Subtotal	231,500	504	438	175
All Occupations	1,560,800	1,738	1,511	100

+If so denoted $p < 0.05$, else $p < 0.01$

clothing ironers, electricians, bar and restaurant managers, and janitors. Occupational groups found at high risk who have been reported elsewhere included asbestos workers,[25 26] heat treaters,[15] machine shop workers,[2-5 15] pressmen, [2 27-29] longshoremen,[3 14 15] shoe repairmen,[3 5 15] mine operatives,[5 15] bartenders,[5 9 15] plasterers,[5 15] cooks,[5 14 16] taxi and truck drivers,[2 5 11 15 16] painters,[3-6 12 15] plumbers,[2 5 15 16] and welders.[2 15 16] Industry groups not previously implicated include radio-TV broadcasting, dairy, leather, food and drink, bakery and auto repair. Industry groups at high risk to lung cancer in Los Angeles County which have been previously reported include steel,[30] paper,[31] petroleum refining,[31] and transportation.[31]

No significant risk to lung cancer was detected among chemical and rubber workers; both groups have been found to have elevated risks in other studies.[31-34] This discrepancy in our data may be due to the small number of such workers in Los Angeles County and to geographical variation in the types of exposure within the industry.

Most of the risk to lung cancer associated with the high risk occupations and industries listed in Tables 1 and 2 may be related to exposure to asbestos or polycyclic aromatic hydrocarbons (PAH) or both. Asbestos has been identified as a potent carcinogen both in animal studies and in occupational studies of humans.[25 26 35 36] Besides asbestos (insulation) workers, ship and shipyard workers, including stevedores, have been reported at excess risk to lung cancer elsewhere.[3 14 15] Other risk groups who

Table 2. — Standard Mortality Ratios (SMR 100 for All Industries) of Lung Cancer, By Industry, White Males 20-64 Years, Los Angeles County.

Industry	Estimated Population at Risk (23)	No. of Deaths 1968-1970	Incident Cases 1972-1973	SMR
Steel Mfg	10,900	39	20	279*
Radio, TV Broadcasting	4,750	10	4	216*
Dairy Mfg. and Sales	5,700	10	15	195*
Leather Mfg. and Sales	4,550	6	8	172†
Eating, Drinking Places	35,600	59	37	171*
Paper Mfg. and Sales	11,900	14	14	171*
Bakery Mfg. and Sales	6,250	10	12	169*
Petroleum, Coal Products	7,900	14	13	160*
Other Food Mfg.	17,500	19	23	148*
Auto Repair	12,050	20	8	146*
Transport Eqt. Mfg. & Sales	154,550	238	205	143*
Public Administration	82,950	78	96	132*
Transportation	73,600	92	74	127*
Other Metal Mfg.	47,350	57	47	126
Telephone, Telegraph	20,650	6	18	123
Electrical Mach. Mfg.	57,500	69	24	119
Textile, Apparel	19,600	27	20	119
Lumber, Wood, Furniture	22,150	20	19	114
Chemical	17,250	11	14	110
Utilities, Sanitary Service	28,800	25	19	108
Rubber	6,450	8	8	105
Stone, Clay, Glass	13,750	18	7	102
Printing, Newspaper	27,850	30	16	98
Entertainment, Recreation	42,900	53	29	97
Personal Services	32,800	41	22	91
Business Repair Services	64,600	63	32	89
Other Retail Trade	138,650	122	78	86
Mining	8,700	12	5	85
Construction	118,700	127	49	84
Plastic	7,200	6	5	84
Non-Elec. Mach. Mfg.	56,800	49	27	82
Finance, Insurance, Real Estate	73,950	43	48	67
Prof Eqt. Mfg.	67,500	20	43	63
Professional	163,400	74	83	58
Wholesale Trade	80,500	43	26	48
Agric, Forestry, Fisheries	15,550	10	5	46
All Industries	1,560,800	1,543	1,173	100

*significantly high, $p < 0.01$
†significantly high, $p < 0.05$

may have been exposed to asbestos include clothing ironers, plasterers, dry wall workers, electricians and plumbers.

PAH compounds have also been identified as carcinogenic in animal and human studies.[38] Exposure to PAH compounds is very characteristic of metal working occupations, and several of these occupations were at excess risk to lung cancer in Los Angeles County, including heat treaters,[39] metal machine shop workers,[40 41] welders,[42] and plumbers. In addition to these groups of metal workers, steel industry workers in Los Angeles County, when analyzed as a single group, were also at elevated risk to lung cancer. Others have reported elevated risk of respiratory disease, including lung cancer, in steel industry workers.[39 43 47] Other groups at high risk to lung cancer who have probably had exposure to PAH compounds include roofers,[48] vehicle drivers,[49-54] employees of auto repair companies, photoengravers,[55] printing trade pressmen,[27-29 40 56 57] cooks, bakers, employees of petroleum refineries,[58 59] and dental lab technicians.[59]

For the remaining occupations and industries at excess risk to lung cancer, specific carcinogenic hypotheses are difficult to propose. Shoe workmen and repairmen have been previously reported at excess risk to lung cancer.[3 5 15] Several investigators have also reported excess nasal cancer in the boot and shoe industry, with the excess apparently associated with the leather and cork dust areas rather than the spraying and lacquering areas.[60 61] Besides shoe repairmen, other workers in the leather industry also were at excess risk in these Los Angeles data. SMR's of 110[15] and 140[4] have previously been reported for such leather workers. Bartenders have previously been reported at greater risk to lung cancer, but to our knowledge no carcinogenic exposures have been suggested. It is possible that these bartenders are heavy smokers, have had heavy exposure to smoke filled barrooms, and thus smoking may have produced an occupational artifact. Janitors have seldom been reported at excess risk to lung cancer,[2] and it is possible that the relative weakness of their risk and their low social class may be indicative of a smoking rather than an occupational effect. Milk has been studied as an eluant of polycyclic aromatic hydrocarbons added to wax,[62] but we are aware of no other data suggesting excess risk in dairy workers. Further investigation of worker groups described herein and their relationship to lung cancer would seem warranted.

Summary

Lung cancer rates in Los Angeles County were reviewed for different occupations and industries. Employment groups found to be at excess risk who have not been previously implicated included roofers, dental lab technicians, decorators, nonautomotive mechanics, photoengravers, clothing ironers, electricians, bar and restaurant managers, janitors: and workers in the radio-TV broadcasting, dairy, leather, food and drink, bakery, and auto repair industries. Most of the occupational and industrial groups found to be at greater risk to lung cancer in Los Angeles County had exposure to asbestos, polycyclic aromatic hydrocarbon compounds (PAH), or both.

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