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Differential Mortality from Lung Cancer by Occupation

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A NEED for estimating the effect of occupation on mortality has been recognized for nearly 200 years, but very few studies of large population groups have been undertaken.[1] The most extensive compilations to date have been the occupational-mortality reports made by the Registrar General of England and Wales after each decennial census since 1881 (1941 excluded), the most recent of which is for the year 1951.[2] International interest has encouraged the British to continue the series, with an expansion of the analysis. For the United States, data on mortality by occupation were published for the years 1890, 1900, 1930, and 1950.[3-7] These data have not been extensively analyzed, as a result, in part, of questions as to possible bias arising from the manner in which they were compiled.

The major objection to death rates by occupation as they are usually compiled is that occupational information appearing on the death certificate and used in establishing the numerator of the death rate is defined differently and is collected under a different set of circumstances from occupational information collected on census schedules and appearing in the denominator of the death rate. The occupation item on the death certificate is ordinarily obtained by the funeral director from a relative or some other person who can provide the necessary facts, while in the population census information is obtained from the person himself or from some other member of his household. Moreover, the occupation item on the death certificate calls for "usual occupation," while the occupation item on census schedules asks for "current occupation." Thus, not only is there the possibility of a response difference in occupation, but there is also a conceptual difference.

For the year 1950 a study was made to measure differences between the reporting of occupations on the schedules of the population census and on death certificates of the vital-records system.[8] The results, while supporting the belief that biases exist in mortality data by occupation, indicate that the net errors are in most instances not very great. Possibly more important, this study identifies major occupational groupings where overstatement or understatement of death rates is likely to occur and is of value in interpreting the results of the mortality tabulations prepared by the National Vital Statistics Division for the year 1950.

This is an analysis of mortality from cancer of the trachea, bronchus, and lung* by occupation for the year 1950.† A detailed description of the method by which data were compiled appears elsewhere.[7] Cancer of the trachea, bronchus, and lung has been chosen for study because of its importance as a cause of death in the working population, and because causative factors have been demonstrated in certain occupational environments and are strongly suspected in others. To simplify the presentation which follows, cancer of the trachea, bronchus, and lung will be referred to only as lung cancer.

In the data presented, certain precautions have been taken to minimize bias. Only deaths among males at ages 20–64 who have work experience are shown. Occupational attachment and labor-

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*International Statistical Classification (I.S.C.) Codes 162 and 163, World Health Organization, Geneva, 1948.

†Data presented here will be shown in *Mortality by Occupation and Cause of Death Among Men 20-64 Years of Age*, United States, 1950 (Vital Statistics, Special Reports, Vol. 53, No. 3:93; in preparation).

force participation among males is more stable than among females, thus lessening the likelihood of reporting differences between the census and death certificates. Confining data to persons in the age group 20–64 with a work history tends to eliminate problems associated with reporting occupational status of retired persons or persons not otherwise in the labor force.

To assist in drawing conclusions, mortality is presented both in terms of standardized mortality ratios (SMRs) and proportionate mortality ratios (PMRs). The SMRs were derived from ratios of the number of lung cancer deaths observed to the number which would have been expected had the age-specific schedule of lung cancer mortality rates in the total population of males ages 20–64 with work experience prevailed. SMRs are frequently used measures of the force of mortality and can be interpreted in the same fashion as a standardized death rate. They have an advantage over standardized death rates in that expected mortality is always 100, and excess mortality can therefore easily be noted. The PMRs shown are based on ratios of the number of deaths observed to the number which would have been expected had the age-specific schedule of proportionate mortality rates in the total population of males 20–64 with work experience prevailed. A proportionate mortality rate is the ratio between deaths due to a particular cause and deaths due to all causes. Since proportionate mortality for a particular occupation depends only upon information on death certificates, and not upon combining death certificate information with the results of a census, as do SMRs, PMRs are not affected by differences in reporting occupation and industry between census schedules and death certificates. If, for a particular occupation, both the SMR and the PMR are high, there is some assurance, therefore, that this is not due to differences in definitions and collection procedures between death certificates and the census. PMRs tend to avoid a fallacy of a number of studies, noted by Berkson—a tendency to attach significance to a high death rate for a particular disease (based on some preconception) and to ignore high death rates for other causes of death.[9]

Results

Table 1 shows numbers of deaths, SMRs, and PMRs for lung cancer by the intermediate occupational classification used by the U. S. Bureau of the Census.* Ratios have not been calculated where there were less than 20 deaths. There is a good agreement between SMRs and PMRs, suggesting that many of the high ratios are probably not artifacts but may actually represent a relatively high death rate for persons in certain occupations.

SMRs and PMRs for major occupational groups are shown in Table 2 with data from the study of occupation reporting in the census and on death certificates.[8] The latter provide estimates of the extent to which SMRs may be over- or understated because of differences in the manner in which data are collected for these two documents. It must be noted that the ratios shown in the last column apply to deaths for all causes, and it is not known whether for particular causes, such as respiratory cancer, they strictly apply. In the study from which the ratios were taken, it was concluded, however, that in general there were probably no important correlations between broad causes of death and the comparability of reports on occupation. Thus, there is some assurance that these estimates of bias apply to the SMRs shown here.

Table 3 shows two major occupational groupings and 11 subgroupings, excluding certain residual categories, which had both significantly high SMRs *and* PMRs ($p < .05$). The measure of statistical significance is that used by the Registrar General of England and Wales in studies of occupational mortality.[2] It is an approximation and probably slightly understates the significance of some of the ratios. This may be more true for PMRs than for SMRs. The assumptions under which ratios were designated as statistically significant include the following: deaths in various occupations are independent of one another, a test of statistical significance was performed for each ratio, and each test performed was independent of other tests performed.

Data from the study of occupation reporting in the census and on death certificates, shown in Table 2, indicate that there is an overstatement of "craftsmen, foremen and kindred workers" on death certificates. Table 3 shows that SMRs and PMRs were significantly high for this major occupational grouping, and for nine of its subgroupings. No doubt there is an upward bias in SMRs reported for this major occupational group as well as for most of its subgroupings. If the overstatement of SMRs is estimated at 10%, on the

*For technical reasons data could not be shown for every occupation on the intermediate list.

TABLE 1. POPULATIONS, NUMBERS OF DEATHS FROM LUNG CANCER (I.S.C. 162, 163), STANDARDIZED MORTALITY RATIOS, AND PROPORTIONATE MORTALITY RATIOS BY OCCUPATION IN MEN 20–64 YEARS OLD WITH WORK EXPERIENCE, UNITED STATES, 1950*

Occupation	*Estimated population*	*No. of deaths from lung cancer*	*Standardized mortality ratio*	*Proportionate mortality ratio*
Professional, technical, and kindred workers	2,950,400	498	83	89
Accountants and auditors	324,997	78	115	111
Architects	23,036	8	—	—
Artists and art teachers	48,472	7	—	—
Authors, editors, and reporters	70,062	19	—	—
Chemists	67,870	6	—	—
Clergymen	151,075	27	63	54
College presidents, professors, and instructors (n.e.c.)	95,456	3	—	—
Dentists	68,492	19	—	—
Designers and draftsmen	143,655	19	—	—
Engineers, aeronautical	17,651	—	—	—
Engineers, civil	122,474	28	93	92
Engineers, electrical	108,376	14	—	—
Engineers, mechanical	111,860	10	—	—
Other technical engineers	168,433	26	87	118
Lawyers and judges	163,131	36	80	86
Musicians and music teachers	79,384	25	**192***	114
Natural scientists (n.e.c.)	34,802	2	—	—
Pharmacists	78,132	35	152	117
Physicians and surgeons	167,280	24	59	62
Social scientists	24,144	5	—	—
Social, welfare, and recreation workers	32,265	2	—	—
Surveyors	24,319	2	—	—
Teachers (n.e.c.)	288,663	16	—	—
Technicians, medical and dental	33,660	9	—	—
Other professionals, technical, and kindred	502,711	78	92	90
Farmers and farm managers	3,834,661	660	54	59
Managers, officials, and proprietors, except farm	4,331,784	1,207	94	103
State and local administrators	103,057	19	—	—
Other specified managers and officials	478,765	180	120	135
Managers, officials, and proprietors (n.e.c.)				
Manufacturing	611,787	162	90	105
Wholesale and retail trade	1,918,158	508	94	93
Miscellaneous industries	1,220,017	338	90	109
Clerical and kindred workers	2,524,175	477	95	108
Bookkeepers	160,153	17	—	—
Mail carriers	164,736	36	92	133
Other clerical and kindred workers	2,199,286	424	97	109
Sales workers	2,406,102	503	103	101
Insurance agents and brokers	272,770	61	103	97
Real estate agents and brokers	106,936	54	135	104
Other specified sales workers	74,954	27	142	104
Salesmen and clerks (n.e.c.)				
Manufacturing	299,050	74	123	128
Wholesale trade	392,935	47	61	98
Retail trade	1,160,477	220	106	98
Other industries	98,980	20	100	97
Craftsmen, foremen, and kindred workers	7,840,330	2,478	**130**	128
Bakers	106,920	43	**172**	126
Blacksmiths, forgemen, and hammermen	53,796	38	**190**	152
Boilermakers	40,045	22	**183**	129
Cabinetmakers and patternmakers	105,224	23	79	92
Carpenters	947,908	316	112	127

*Significantly high mortality ratios have been set boldface ($p < .05$); "n.e.c." means "not elsewhere classified."

(*continued*)

TABLE 1 (*continued*)

Occupation	*Estimated population*	*No. of deaths from lung cancer*	*Standardized mortality ratio*	*Proportionate mortality ratio*
Compositors and typesetters	163,530	53	143	120
Cranemen, hoistmen, and construction machinery operators	221,844	50	119	139
Electricians	328,869	89	131	111
Foremen, manufacturing (n.e.c.)				
Durable goods	284,868	69	93	130
Nondurable goods	190,297	62	129	168
Foremen, nonmanufacturing (n.e.c.)	325,474	106	107	139
Linemen and servicemen, telegraph, telephone, and power	213,673	32	123	123
Locomotive engineers	71,821	48	126	117
Locomotive firemen	57,226	7	—	—
Machinists and job setters	553,458	190	138	106
Masons, tile setters, and stonecutters	178,464	65	148	127
Mechanics and repairmen, airplane	74,559	6	—	—
Mechanics and repairmen, automobile	681,485	119	128	127
Mechanics and repairmen, radio and television	76,284	6	—	—
Other mechanics and repairmen	949,997	236	107	136
Millwrights	60,706	24	150	160
Molders, metal	62,905	34	227	170
Painters (construction), paperhangers and glaziers	442,656	212	167	129
Plasterers and cement finishers	96,491	38	158	141
Plumbers and pipefitters	295,379	127	174	146
Printing craftsmen, except compositors	86,487	25	139	139
Shoemakers and repairers, except factory	51,489	33	194	138
Stationary engineers	215,566	108	159	137
Structural metal workers	55,103	15	—	—
Tailors and furriers	72,733	64	206	136
Tinsmiths, coppersmiths, and sheetmetal workers	130,143	46	184	159
Toolmakers and die makers	157,213	26	68	79
Other craftsmen and kindred workers	487,717	146	129	133
Operatives and kindred workers	8,416,334	1,656	107	128
Apprentices	97,737	—	—	—
Attendants, auto services, and parking	203,514	16	—	—
Brakemen and switchmen, railroad	145,982	41	114	105
Bus drivers	156,361	23	79	115
Filers, grinders, polishers, metal	148,829	19	—	—
Furnacemen, smeltermen and heaters	67,576	19	—	—
Laundry and dry cleaning operatives	141,881	37	148	116
Meat cutters, except slaughter and packing house	170,219	44	122	94
Mine operatives and laborers (n.e.c.)	613,355	214	174	94
Motormen, street, subway and elevated railway	27,336	6	—	—
Painters, except construction and maintenance	107,122	16	—	—
Power station operators	21,515	5	—	—
Spinners and weavers, textile	82,645	16	—	—
Stationary firemen	123,438	34	83	113
Taxicab drivers and chauffeurs	217,178	77	188	128
Truck drivers and deliverymen	1,616,558	219	106	108
Welders and flame cutters	275,265	34	92	103
Other specified operatives and kindred workers	196,292	48	114	145
Operatives and kindred workers (n.e.c.)				
Sawmills, planing, and misc. wood products	165,573	23	72	79
Furniture and fixtures	95,966	7	—	—
Stone, clay, and glass products	138,056	28	108	122
Primary metal industries	253,889	77	145	143

(*continued*)

TABLE 1 (*continued*)

Occupation	*Estimated population*	*No. of deaths from lung cancer*	*Standardized mortality ratio*	*Proportionate mortality ratio*
Fabricated metal industries	199,993	34	92	121
Machinery, except electrical	291,592	49	84	153
Electrical machinery, equipment, and supplies	161,030	22	88	138
Motor vehicles and equipment	304,726	40	75	121
Transportation equipment, except motor vehicle	90,413	19	—	—
Other durable goods	145,273	35	125	175
Food and kindred products	312,259	43	73	98
Yarn, thread, and fabric mills	226,783	36	84	73
Knitting and other textile-mill products	89,491	14	—	—
Apparel and other fabricated textile products	161,857	48	104	150
Paper and allied products	149,916	17	—	—
Chemical and allied products	148,853	18	—	—
Leather and leather products	143,980	37	103	112
Other nondurable goods	200,900	37	95	123
Transportation, communication and public utilities	173,108	79	176	125
Wholesale and retail trade	169,135	27	77	142
Other industries	213,415	36	80	103
Private household workers	66,181	10	—	—
Service workers, except private household	2,240,266	836	123	105
Barbers, beauticians, and manicurists	185,469	95	151	123
Charwomen, janitors, and porters	543,086	181	89	92
Cooks, except private household	209,031	91	165	92
Elevator operators	56,959	45	214	155
Firemen, fire protection	113,156	40	190	121
Guards and watchmen	216,889	112	111	108
Policemen, sheriffs, and marshals	215,169	74	151	104
Waiters, bartenders, and counter workers	347,941	100	132	111
Other service, except private household	352,566	98	114	98
Farm laborers and foremen	1,481,657	155	54	55
Laborers, except farm and mine	3,456,905	967	127	82
Fishermen and oystermen	68,756	23	144	121
Longshoremen and stevedores	71,853	31	172	103
Lumbermen, raftsmen, and wood choppers	177,406	28	82	58
Other specified laborers	208,634	57	100	108
Laborers (n.e.c.)				
Furniture and fixtures	170,187	44	138	73
Stone, clay, and glass products	76,620	9	—	—
Primary metal industries	224,155	82	167	105
Fabricated metal	53,337	13	—	—
Machinery, including electrical	79,253	28	156	100
Transportation equipment	72,404	30	200	73
Other durable goods	16,413	10	—	—
Food and kindred products	138,963	30	111	61
Textile mills products and apparel	58,298	23	192	128
Chemicals and allied products	65,141	16	—	—
Other nondurable goods	115,456	41	195	108
Construction	740,661	147	98	72
Railroads and Railway Express service	283,070	96	135	78
Transportation, except railroad	109,447	59	295	102
Telecommunication and utilities, and sanitary services	127,474	28	90	88
Wholesale and retail trade	265,236	61	122	72
Other industries	323,938	93	104	73

TABLE 2. STANDARDIZED MORTALITY RATIOS, PROPORTIONATE MORTALITY RATIOS, AND ESTIMATES OF BIAS FOR MAJOR OCCUPATIONAL GROUPS, LUNG CANCER, (I.S.C. 162, 163), MALES 20–64 YEARS OF AGE WITH WORK EXPERIENCE, UNITED STATES, 1950

*Major occupational group**	*Standardized mortality ratios*	*Proportionate mortality ratios*	*Estimates of bias (ratios of death certificate total to census total)†*
Farmers and farm managers	54	59	
Farm laborers	54	55	102
Professional, technical, and kindred workers	83	89	106
Managers, officials and proprietors, except farm	94	103	104
Clerical and kindred workers	95	108	82
Sales workers	103	101	99
Operatives and kindred workers	107	128	90
Service, except private household	123	105	96
Laborers, except farm	127	82	101
Craftsmen, foremen, and kindred workers	130	128	109

*Arrayed by increasing magnitude of SMR.

†This may be considered an estimate of the extent to which the standardized mortality ratios are overstated (ratios over 100) or understated (ratios less than 100). For a more complete explanation of these ratios, see Reference 8.

basis of data shown in Table 2, and if SMRs are reduced accordingly, the major grouping continues to have a significantly high SMR, however, two of its subgroupings, "carpenters" and "automobile mechanics and repairmen," would have to be dropped from Table 3. That is, when SMRs for these occupational subgroups are reduced by 10%, they are no longer statistically significant.

For other occupational groupings shown in Table 3, data from the study of occupation reporting in the census and on death certificates do not indicate that SMRs are overstated. In fact, for "operatives and kindred workers" and its subgroupings, there may be a considerable understatement of SMRs due to an understatement of these occupations on the death certificates.

Because of a probable lack of uniformity in the over-all error recorded for major occupational groupings no formal attempt will be made here to correct occupational subgroup SMRs shown in Table 1. It is not certain, for example, that the error in the major occupational grouping "craftsmen, foremen and kindred workers" applies specifically to "carpenters," and "automobile mechanics and repairmen." These occupations will, therefore, be treated as having significantly high SMRs in the material which follows, although evidence in favor of this is weakened by data from the study of occupation reporting on death certificates and in the census.

Comparisons with Other Data

In 1952 Lew published a list of 18 occupations representing white male wage earners insured under industrial policies with the Metropolitan Life Insurance Company during 1937–39 for which there were probably higher than average death rates for cancer of the lung.[10] For most occupations only a few deaths were observed, so that the results generally lack significance in the usual statistical sense. There were five occupations where more than 10 deaths were observed: blacksmiths (11 deaths), brick and stone masons (18 deaths), painters and varnishers (62 deaths), plumbers, steamfitters, and gasfitters (29 deaths), and tailors and clothing workers (37 deaths). Of these, all except brick and stone masons are represented in Table 3. This is of particular interest in view of methodological differences between the study reported by Lew and the data presented in this report.

Breslow obtained life-long occupational histories on 518 lung-cancer patients and a like number of matched controls in 11 California hospitals and concluded that exposure to metallic particles or fumes, asbestos, or paint seems to play a role.[11] A similar study by Wynder and Graham, involving interviews with 200 hospital patients and 200 controls, indicates an excess of lung cancer among painters and metal workers.[12] Using death-certificate data for England and Wales, Kennaway and Kennaway examined 63 occupations employing about 30% of the male population 20 years of age and over.[13] Applying the test of statistical significance used here to those occupations in which 20 or more lung-cancer deaths were observed for the years 1933–38 reveals nine occupations with significantly high ratios of registered to calculated deaths. These

TABLE 3. OCCUPATIONAL GROUPS WITH SIGNIFICANTLY HIGH ($P < .05$) STANDARDIZED MORTALITY RATIOS AND PROPORTIONATE MORTALITY RATIOS FOR LUNG CANCER, (I.S.C. 162, 163), MALES 20–64 YEARS OF AGE WITH WORK EXPERIENCE, UNITED STATES, 1950

Occupational group	*Standardized mortality ratios*	*Proportionate mortality ratios*
Major group		
Craftsmen, foremen, and kindred workers	130	128
Operatives and kindred workers	107	128
Subgroup		
Blacksmiths, forgemen, and hammermen	190	152
Carpenters	112	127
Mechanics and repairmen, automobile	128	127
Moulders, metal	227	170
Painters (construction), paperhangers, and glazers	167	129
Plumbers and pipefitters	174	146
Stationary engineers	159	137
Tailors and furriers	206	136
Tinsmiths, coppersmiths, and sheetmetal workers	184	159
Operatives (n.e.c.) in primary metals industry	145	143
Elevator operators	214	155

are: gas stokers and coke-oven chargers; council laborers, road sweepers and dustmen; motor drivers, goods and passengers; cabinetmakers; stonemasons, cutters and dressers; drivers of horse-drawn vehicles; painters; licensed victualers; and printers.

Heuper has reviewed evidence on industrial carcinogens and has prepared a list of occupations in which he believes an excess of lung cancer exists.[14] There is good agreement between occupations identified here and those appearing in Heuper's list. Four of the subgroups shown in Table 3 do not appear, however. These are automobile mechanics and repairmen, carpenters, tailors and furriers, and elevator operators. Two of these, automobile mechanics and repairmen, and elevator operators were not, in fact, noted in any of the studies reviewed above. For elevator operators it seems probable that selective factors are important in the excess mortality from lung cancer, particularly in view of a high turnover in this occupation. In view of recent evidence linking automobile exhausts with lung cancer, the high death rate for automobile mechanics and repairmen is of interest and may be a true reflection of respiratory carcinogens.[15]

Discussion

Excess mortality for lung cancer for the entire United States generally conforms to a pattern which might have been predicted on the basis of other studies. It should be emphasized that the data presented here were not available until recently and are not reflected in previous reports. They represent a considerably greater coverage and a larger number of deaths than have heretofore been available.

Probably of as much interest from an environmental standpoint as occupations having a high mortality are those where mortality from lung cancer is low. While not emphasized in this analysis, these may provide some leads in establishing etiological agents. The very low mortality among agricultural workers, for example, may be of considerable significance in evaluating the effects of air pollution on the incidence of lung cancer, while the below-average mortality for persons in professional and technical occupations may be a gross reflection of the importance of the occupational environment.

Excluding residual occupational groupings, the 11 occupational subgroups identified here with an excess mortality from lung cancer involve a population of over 3 million male workers. Within this group it may be possible in the future to identify further subgroupings with an exceptionally high mortality and, by a study of the working environment of these workers, identify and remove the causal agent or agents.

Summary

Data are presented on mortality from cancer of the trachea, bronchus, and lung for men 20–64 years of age with work experience by occupation for the United States for the year 1950. Precautions are taken to avoid bias in occupational-mortality data which arises because of differences in the way occupational information is collected for census schedules and for death certificates. Two major occupational groups and 11 subgroups are identified with significantly high death rates. There is good agreement between occupations identified in this study and those identified in previous studies.

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International Conference on Tetanus

An international conference on the Prevention and Treatment of Tetanus will be held Nov. 8-10, 1963, in Bombay, India. The language of the conference will be English.

Attention will be given to the incidence of tetanus in various parts of the world and to its epidemiology, etiology, pathogenesis, and clinical features. The dosage of A.T.S., the use of tetanus toxoid, and the use of antibiotics will be discussed in relation to both prevention and treatment of tetanus. The use of artificial respirators and tracheotomy, and the use of muscle-relaxant and anticonvulsant drugs in the treatment of tetanus will be evaluated. In the prevention of tetanus, consideration will be given to separate administration of tetanus toxoid and other preventive vaccines according to a fixed schedule, and combined administration of toxoid and other vaccines in a single formulation.

Further information may be obtained from Dr. J. C. Patel, Organizing Secretary, International Conference on Tetanus, K.E.M. Hospital, Parel, Bombay 12, India.