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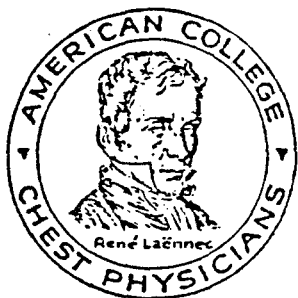
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DISEASES

of the

CHEST

*lung cancer in
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Industrial Aspects of Bronchiogenic Neoplasms

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Medical students usually learn as the classical example of occupational cancer that scrotal cancer occurred among chimney sweeps in 18th century England.¹ Their attention would perhaps more readily be attracted to the story of lung cancer among miners in the Schneeberg² and Joachimsthal mines.³ The fact that approximately half of all deaths among miners in the latter area resulted from lung cancer establishes the occupational origin of this disease, in at least some cases. Furthermore, the striking increase in frequency of lung cancer and the millions of persons employed in the several 20th century occupations now suspected of having a relationship to the disease confirm the importance of this subject today.

Lung cancer now causes more than 18,000 deaths annually in the United States.⁴ Even adjusting for the aging of our population, this represents a four-fold increase during the past two decades.⁵ Diagnostic techniques have improved tremendously. But the fact that lung cancer mortality among males has been rising much more rapidly than among females indicates that we are dealing with a real increase in the disease. It now accounts for more deaths than tuberculosis in many states.

Recently attention has focused on cigarette smoking as a cause of lung cancer. Several studies⁶ based upon interviews with a series of lung cancer patients and a matched group of "controls" have demonstrated a greater frequency of cigarette smoking, especially heavy cigarette smoking, among the lung cancer patients.

As a further investigation of this question⁷ we obtained cigarette smoking histories from 518 lung cancer patients and a like number of matched "controls" in 11 California hospitals. The control group consisted of patients admitted to the same hospitals for conditions other than cancer and other than chest disease—matched for age, sex and race with the lung cancer patients. Tables I and II indicate the similarity of our two groups in respect to biological characteristics. The greater frequency of cigarette smoking, especially in excessive amounts, among lung cancer patients as compared with controls is shown in Table III. In Table IV one may observe that several other measures of the degree of cigarette smoking—age at which began, inhaling, and smoking before breakfast—all confirm that lung cancer patients smoked cigarettes to a greater extent than did the control group. Of particular interest to physicians is that so-called "cigarette cough" occurred among approximately two-fifth of the lung cancer patients; this usually antedated the onset of illness by many years. One

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hundred twenty of the patients stated that they had noted a cough for five years or more whereas only 39 of the control group gave a similar history.

These data, consistent with the other recent well-controlled investigations⁸ of the subject, demonstrate a substantial correlation of cigarette smoking and lung cancer. This correlation increases steadily with the amount of cigarette smoking. Levin⁹ has most recently assembled the findings of these several studies and, using a method developed by Cornfield,⁷ compared the relative prevalence of lung cancer among cigarette smokers and non-smokers. Table V indicates that for men aged 50-59 years lung cancer is four to 11 times as prevalent among smokers as among non-smokers, and seven to 27 times as common among heavy smokers as among non-smokers.

One must accept the conclusion of the New England Journal of Medicine¹⁰ that the evidence for cigarette smoking as a factor in lung cancer is "so strong as to be considered proof within the every day meaning of the word."

TABLE I
AGE DISTRIBUTION OF LUNG CANCER
PATIENTS AND CONTROLS

Age	CASES			CONTROLS
	Adeno- carcinoma	Other Types of Carcinoma	Total	Total
Total	46	472	518	518
Under 40	3	22	25	26
40-49	6	56	62	59
50-59	19	194	213	213
60-69	14	154	168	169
70 and over	4	46	50	51

TABLE II
SEX AND RACE DISTRIBUTION OF
LUNG CANCER PATIENTS AND CONTROLS

Sex and Race	CASES			CONTROLS
	Adeno- carcinoma	Other Types of Carcinoma	Total	Total
Total	46	472	518	518
Total Male	42	451	493	493
White	41	420	461	461
Negro	1	20	20	20
Other	1	11	12	12
Total Female	4	21	25	25
White	3	15	18	18
Negro	1	3	4	4
Other	0	3	3	3

TABLE III
AMOUNT OF CIGARETTE SMOKING
DURING TWENTY YEARS PRIOR TO STUDY
REPORTED BY LUNG CANCER PATIENTS AND CONTROLS

Packages of Cigarettes Smoked Per Day	CASES		CONTROLS	
	Number	Per Cent	Number	Per Cent
Total	518	100	518	100
None	34	7	124	24
<1—	19	4	50	10
1—	71	14	105	20
1—	304	59	199	38
2 or more	80	15	22	4
Not recorded	10	2	18	3

TABLE IV
AGE OF BEGINNING CIGARETTE SMOKING,
SMOKING HABITS AND "CIGARETTE COUGH"
REPORTED BY LUNG CANCER PATIENTS AND CONTROLS

Cigarette Smoking Characteristics	CASES			CONTROLS		
	Number	Per Cent Based on Cigarette Smokers Only	Per Cent Based on Total	Number	Per Cent Based on Cigarette Smokers Only	Per Cent Based on Total
Total	518		100	518		100
Total cigarette smokers	484	100	93	394	100	76
Began 15 years of age	166	34	32	116	29	22
Began 15-24	286	59	55	243	62	47
Began 25 years of age	32	7	6	35	9	7
"Inhale"	449	93	87	327	83	63
"Smoke before breakfast"	373	77	72	229	58	44
"Cigarette cough"	204	42	39	112	28	22

However it is not the sole cause. Some persons with lung cancer deny ever having smoked cigarettes. Levin¹¹ estimates on the basis of our data that 70 per cent of all lung cancer may be "attributable to smoking." Application of the same method of estimation to other data gives a range of 56 to 92 per cent "attributable to smoking."

In the present and justified concern about cigarette smoking as a cause of lung cancer too little note has been taken of evidence that several occupations may likewise be involved in the etiology of the disease. Unlike the infectious diseases where specific micro-organisms have been identified as the cause, *sine qua non*, cancer appears to result from a variety of exogenous agents.

The classical studies of the Schneeberg and Joachimsthal miners do not stand alone. Machle and Gregorius¹² found that those employed in cer-

tain chromate ore operations in the United States experienced a 16 times greater mortality for lung cancer than did the general population of the same age-sex distribution. Kennaway and Kennaway¹² using death certificate data for England and Wales noted that metal grinders, workers exposed to road dust, coal gas and tar, asbestos workers, cabinet makers and painters were reported as occupations more frequently among lung cancer patients than would be expected from the general mortality of

TABLE V
ESTIMATED PREVALENCE RATES* OF LUNG CANCER PER 100,000 MALE
OF SELECTED AGES AND VARIOUS CIGARETTE SMOKING HISTORIES

	NUMBER		ESTIMATED PREVALENCE RATES, QUANTITY SMOKED DAILY			RELATIVE PREVALENCE	
	Lung Cancer	Control	Heavy ^a	All Quantities	None	Heavy	All Quantities
Patients aged 50 to 59 years							
Doll and Hill ^b	276	275	94	42	7	13	16
Wynder and Graham ^c	258	210	117	47	4	27	11
Sadowsky, Gilliam, and Cornfield ^d	198	208	87	44	12	7	4
Breslow, Hoaglin, Rasmussen, and Abrams ^e	213	213	102	46	6	17	7
Roswell Park Memorial Institute	173	657	141	109	15	9	7
Patients aged 60 and 69 years							
Doll and Hill ^b	197	199	137	63	0		
Wynder and Graham ^c	187	160	138	70	5	29	15
Sadowsky, Gilliam, and Cornfield ^d	76	71	44	71	5	9	4
Breslow, Hoaglin, Rasmussen, and Abrams ^e	168	169	433	78	17	25	5
Roswell Park Memorial Institute	197	675	479	280	50	9	5

*Estimated according to the method of Cornfield.¹

^bAll data appearing in this table, except for Roswell Park Memorial Institute figures are taken from the paper by Breslow et al.²

^cQuantity smoked daily, except for the present study, is all forms of smoking expressed as cigarettes with pipes and cigars converted to their equivalents in cigarettes as follows:

Doll and Hill—1 ounce tobacco = 4 cigarettes a day.

Wynder and Graham—1 cigar = 5 cigarettes; 1 pipeful = 2 $\frac{1}{2}$ cigarettes.

Sadowsky, Gilliam, and Cornfield—1 cigar = 10 cigarettes; 1 ounce pipe tobacco = 20 cigarettes.

For the Breslow et al. study quantity smoked daily includes only cigarette smoking.

^dRelative prevalence are the following ratios: heavy = rate among heavy smokers/rate among non-smokers; all quantities = rate among smokers/rate among non-smokers.

^eHeavy smoking is defined as the following number of cigarettes or equivalents of cigarettes per day: Doll and Hill, 50 or more; Wynder and Graham, 35 or more; Sadowsky, Gilliam, and Cornfield, 41 or more; Breslow et al., 40 or more; present study, 20 or more.

Source: Levin, M. L. Etiology of Lung Cancer: Present Status. New York State J. Med., 54:6, p. 770, Mar. 15, 1954.

perience. Information obtained by interview with hospitalized patients in St. Louis and elsewhere in the United States, studied by Wynder and Graham,¹¹ disclosed that painters and "hot metal workers" stood out as excessive among lung cancer patients as compared with a control group. Mortality experience among industrial policy holders in the Metropolitan Life Insurance Company indicated, according to Lew,¹² several occupations with a higher than average rate from cancer of the lung; Table VI

TABLE VI

"MORTALITY EXPERIENCE AMONG WHITE MALE WAGE EARNERS INSURED UNDER INDUSTRIAL POLICIES IN THE METROPOLITAN LIFE INSURANCE COMPANY 1937-1939: OCCUPATIONS WITH PROBABLY HIGHER-THAN-AVERAGE DEATH RATES FROM CANCER OF THE LUNGS"

Occupational Group	Deaths From All Causes	Deaths From All Forms of Cancer	Deaths From Cancer of Lungs		
			Number	Percentage Relative to Deaths From All Causes	Percentage Relative to Deaths From All Forms of Cancer
All Wage Earners	112,991	13,858	1,682	1.5	12.1
Blacksmiths	503	75	11	2.2	14.7
Brick and Stone Masons*	722	124	18	2.5	14.5
Cooks—Hotel and Restaurant*	345	48	8	2.3	16.7
Coppersmiths, Tinsmiths, Etc.*—Not Roofers	402	61	9	2.2	14.8
Engravers (Metal) and Photoengravers	84	15	5	6.0	33.3
Laundry Workers (Except Laborers)	222	27	5	2.3	18.5
Mail Carriers	242	41	7	2.9	17.1
Miners (Underground, excluding Coal Miners)	222	20	6	2.7	30.0
Painters and Varnishers—House, Shop, etc.	2,821	366	62	2.2	16.9
Plasterers	190	31	5	2.6	16.1
Plumbers, Steamfitters, and Gasfitters*	1,178	156	29	2.5	18.6
Roofers and Slaters*	225	31	5	2.2	16.1
Slaughter and Packing—House Operatives	279	41	7	2.5	17.1
Street Cleaners	336	64	9	2.7	14.1
Tannery Operatives	227	33	5	2.2	15.2
Tailors and Other Clothing Workers	1,564	228	37	2.4	16.2
Traveling Salesman	374	46	10	2.7	21.7
Welders*	216	24	7	3.2	29.2

*In these occupations the mortality from all forms of cancer was somewhat higher than average as follows: Brick and Stone Masons, 155% of average; Cooks—Hotel and Restaurant, 119% of average; Coppersmiths, Tinsmiths, etc.—Not Roofers, 123% of average; Plumbers, Steam Fitters, and Gas Fitters, 110% of average; Roofers and Slaters, 112% of average; Welders, 126% of average.

¹²Lew, E. A., Use of Life Insurance Company Records, for Cancer Studies. Arch. of Ind. Hyg. and Occup. Med., 5:199-203, Mar., 1952.

TABLE VII
CASES AND CONTROLS EMPLOYED FOR AT LEAST
5 YEARS IN SELECTED OCCUPATION GROUPS^a

Occupation	PERSONS EMPLOYED IN OCCUPATION AT LEAST 5 YEARS	
	Cases	Controls
1 Welders and sheet metal workers doing welding	14	2
2 Steamfitters, boilermakers, asbestos workers	10	1
3 Electric bridge crane operators—metal industry	5	1
4 Occupations in the extraction of lead, zinc, and copper ore	9	3
5 Marine engineers, firemen, oilers and wipers	12	6
6 Construction and maintenance painters	22	12
7 Cooks, commercial (excluding cannery cooks)	35	21

^aOccupation groups based on regrouping according to common occupational exposures after detailed examination of records.

shows these occupations. Hueper¹⁶ mentions several exposures suspected of being involved in lung cancer.

Interviews with lung cancer patients and a control series in our study⁷ included life-long occupational histories taken by persons skilled in occupational analysis. Information about every occupation in which the person had engaged was so detailed that the session often lasted two hours or more. It covered an exact description of the work, the industry, the duration of employment, known exposures to toxic materials, and other factors. Interviewer bias as to the occupational data can be practically ruled out inasmuch as both lung cancer patients and the controls mentioned hundreds of occupations, none of which was suspected by the interviewers.

Although the information included type of industry and exposure to known toxic agents, efforts to analyze these were not productive. Therefore major emphasis in the analysis went to occupation itself, coded according to the United States Dictionary of Occupational Titles (Second Edition) Washington, D. C.: U. S. Employment Service, 1949. This lists 367 categories.

Table VII presents a list of apparently significant occupations based upon our study. This tabulation was developed by first observing the relative frequency of occupations in which individuals of the case and control series had spent at least five years. This gave leads for further study. Thereafter, since the code used was not designed to reflect common occupational exposures, analysis was carried to the examination of records of individual cases and controls. Regrouping of occupations based upon common exposures resulted in Table VII. It appears that exposure to metallic particles or fumes, asbestos, paint and other materials appear to play some role. Similarity of this list to other studies, particularly that of Lew¹⁵ is immediately apparent.

Comparability of the findings in four studies is shown in Table VIII. These separate investigations, extending over a 20-year period and two

countries, utilized general mortality statistics, life insurance statistics and interviews with hospitalized patients. The fact that such varied data, analyzed in different ways, consistently identify certain occupations attests their probable significance in the development of lung cancer. Besides the occupations listed repeatedly in Table VIII—painting, welding and other metal work, steam fitting and other asbestos work—additional types of work are mentioned frequently in the findings of studies of occupational aspects of lung cancer. These include furnace men, engineers, workers exposed to petroleum and petroleum combustion, carpenters, cabinet makers and wood workers generally.

Thus, several types of employment may constitute etiologic factors in lung cancer. The most clear-cut evidence pertains to the Schneeberg and Joachimsthal mines and to chromate ore operations in the United States: in fact, one can hardly doubt the causative role of work exposure in these groups. Other studies, including our own, strongly implicate the occupations shown in Table VIII: painting, welding and other work involving hot metals, commercial cooking, metal mining, steam fitting and other asbestos work.

We are now engaged in another type of investigation designed to confirm or refute the hypothesis that these latter occupations carry an excessive risk for lung cancer. This involves obtaining information about employment from persons engaged in suspect occupations. It will include cigarette smoking history as well as details about type of work and duration of employment in it. Such information is being assembled for approximately 10,000 persons in the age range 35-64, now employed in each of the suspect occupations listed in Table VII. During the next few years we will observe the mortality experience of these groups through checking

TABLE VIII
CORRESPONDENCE OF FOUR STUDIES IMPLICATING
SELECTED OCCUPATIONS IN LUNG CANCER

<i>Kennaway^a</i>	<i>Wander-Graham^b</i>	<i>Leu^c</i>	<i>Breslow, et al^d</i>
Painters	Painters	Painters and varnishers—house, shop, etc.	Construction and maintenance painters
Metal grinders	Welders, foundry and steel-mill workers and other "hot metal" workers	Welders, copper-smiths, tin-smiths, etc. blacksmiths	Welders and sheet-metal workers doing welding. Electric bridge crane-operators, metal industry
		Cooks—hotel and restaurant	Cooks, commercial (excluding cannery cooks)
		Miners (underground, excluding coal-miners)	Occupations in the extraction of lead, zinc and copper ore
Asbestos workers		Plumbers, steam-fitters and gas-fitters	Steamfitters, boilermakers, asbestos workers

with the vital statistics index of the California State Department of Public Health. Thus, the actual lung cancer mortality rates will be determined for persons in occupations identified by previous studies as possibly having etiologic significance. Comparison of the rates with that of the general population of the state (corrected for age-sex distribution) will indicate the degree of excessive risk, if any, in the occupational groups. If their lung cancer mortality rate substantially exceeds the rate for the general population, one may conclude that some occupational exposure is involved. Thereafter it will be necessary to determine the precise environmental agent and undertake preventive measures.

As occupations are identified as causative factors in lung cancer we will be in a better position to establish control of this disease not only by prevention, but also by intensive case-finding efforts in high risk groups.

SUMMARY

Lung cancer has increased strikingly in recent years; it now causes more than 18,000 deaths annually in the United States. Although much evidence incriminates cigarette smoking as a major factor in the disease, it is not the sole cause. Previous studies are cited to indicate the role played by occupational exposure.

Interviews with 518 lung cancer patients in California hospitals, and a like number of non-cancer "control" patients, confirmed the greater frequency of cigarette smoking among lung cancer patients. The interviews also covered life-long occupational history. Analysis of this data disclosed that the following occupational groups appeared with substantially greater frequency among the lung cancer case histories, as compared with the controls: welding and sheet metal workers doing welding; electric bridge crane operators, metal industry; construction and maintenance painters; commercial cooks; occupations in the extraction of lead, zinc and copper ore; steamfitters, boilermakers, asbestos workers; marine engineers; firemen, oilers and wipers. The correspondence of this list of occupations with those arising from other studies of occupational factors in lung cancer is demonstrated.

Further work is underway to confirm or refute the hypothesis that these occupations carry an excessive risk for lung cancer.

RESUMEN

El cáncer del pulmón ha aumentado notablemente en los años recientes; ahora causa más de 18,000 defunciones al año en los Estados Unidos.

Aunque existen evidencias de que el fumar cigarrillos tiene gran responsabilidad en la enfermedad, no es la única causa.

Existen trabajos anteriores que se citan indicando el papel que desempeña la exposición ocupacional.

Las entrevistas llevadas a cabo con 518 enfermos de cáncer del pulmón en los hospitales de California y con un número igual de enfermos de "control" no cancerosos, confirmó la gran frecuencia del cáncer entre los

fumadores de cigarrillos. Las entrevistas incluyeron también las historias ocupacionales de toda la vida. El análisis de estos datos descubrió que los siguientes grupos de ocupaciones mostraron demodo substancial mayor frecuencia entre las historias de cáncer del pulmón en comparación con los controles: trabajadores en soldadura y en lámina de acero, operadores de grúas eléctricas en los puentes, industria de metales, pintores de construcciones y de mantenimiento, cocineros comerciales, trabajados en la extracción de plomo, zinc y cobre de los minerales, trabajadores en máquinas de vapor, constructores de calderas, trabajadores de asbestos, maquinistas marinos, bomberos, engrasadores y limpiadores. La correspondencia de esta lista de ocupaciones con las que resultan de otros estudios de factores de ocupación se demuestra. Está en preparación más investigación para confirmar o refutar la hipótesis de que estas ocupaciones tienen consigo un riesgo mayor con respecto al cáncer.

RESUME

La fréquence du cancer pulmonaire s'est accrue de façon frappante ces dernières années. Il cause maintenant plus de 18.000 décès par an aux Etats-Unis. Bien que, de toute évidence, on puisse incriminer la fumée des cigarettes comme facteur principal de cette affection, ce n'est pas là la cause unique. L'auteur cite les études antérieures qui ont montré le rôle joué par certains risques professionnels.

L'interrogatoire de 518 malades des hôpitaux de Californie, atteints de cancer pulmonaire, et d'un nombre semblable de malades témoins non cancéreux, confirme la plus grande fréquence des fumeurs chez les premiers. L'interrogatoire porta aussi sur les antécédents professionnels de toute leur existence. L'analyse de ces données a démontré que comparative-ment au groupe témoin, les professions suivantes figurent avec une fréquence notablement plus grande dans les cas de cancers: soudeurs et ouvriers lamineurs travaillant dans la soudure, conducteurs de grue, ouvriers de l'industrie métallurgique, peintres en bâtiments, cuisiniers, travailleurs s'occupant de l'extraction du plomb ou du zinc, ou des minerais cuivreux, chaudronniers, conducteurs de machines à vapeur, ouvriers exposés à l'amiante, mécaniciens de la marine, pompiers, graisseurs et nettoyeurs. Cette liste de professions est en accord avec celles qui ont été établies au cours d'autres études des facteurs professionnels dans la fréquence du cancer.

Des travaux ultérieurs sont en cours pour confirmer ou infirmer l'hypothèse selon laquelle ces professions comportent un risque de cancer extrêmement important.

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