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Etiology of Lung Cancer: Present Status

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Available evidence points to a number of different possible etiologic factors for lung cancer in man. These include chemicals, radiations, dust or fumes encountered by workers in various occupations, and cigaret smoking. Industries and occupations with evidence of abnormally high lung cancer risks are chromate production; production of illuminating gas (studied in England); mining of uranium ores in Schneeberg, Germany, and Jachymov, Czechoslovakia; nickel refining in South Wales; asbestos manufacturing in England; and metal grinding in England.[1] Recent evidence points also to increased lung cancer among welders and other workers exposed to metal fumes or dust in the United States.[2] Suggestive evidence regarding several other occupations has been reported, and it seems probable that other as yet unknown occupations with high lung cancer risks remain to be discovered.

Evidence for relationship of these occupations to lung cancer consists chiefly of the increased mortality rate from lung cancer observed among workers in these occupations. Exact risks have been estimated for two of these occupations, chromate production (in the United States) and illuminating gas manufacture (in England).[1] For a few there is also experimental evidence of a carcinogenic agent in the material to which workers are exposed, but in no instance has lung cancer been produced in animals by such material. In the case of the chromate industry, in which lung cancer mortality has been shown to be 14 times that of the United States population among white workers and 80 times among Negro workers, application or injection into animals of various materials to which workers are exposed has thus far failed to produce malignant lung tumors. Nevertheless, there is little or no disagreement as to the existence of a lung cancer etiologic agent in the chromate industry.

A relationship between lung cancer and tobacco smoking has been suspected for many years. Statistical studies, of which the first apparently was that of Müller[3] in 1939, have uniformly shown a higher percentage of cigaret smokers among lung cancer cases than among control groups. In the past few years this relationship has received increasing public notice so that it is today widely debated and discussed in the newspapers, in national magazines, and, no doubt, by the public itself. Many physicians, statisticians, and others engaged in cancer research have expressed themselves in the public press as to the significance of the reported studies on this association. Considerable difference of opinion and of emphasis has thus been elicited. Appraisal of the nature of the evidence regarding tobacco as a possible etiologic factor in lung cancer has thus become of increasing importance, because of the widespread public interest in and concern over the subject, the large financial and tax interests at stake, and, most important, the steadily rising mortality from lung cancer reported each year. It is, therefore, necessary that physicians and public health authorities appraise the situation as it now exists to determine what conclusions may be drawn and what action may be required.

Most studies regarding smoking and lung cancer thus far made—13 are listed in a recent article[4]—have compared the smoking histories of lung cancer patients with those obtained from other persons, usually patients with other diseases in the same hospital. Almost without exception, these studies have found more cigaret smokers among lung cancer patients than among other patients. If these observations are valid, it would mean that lung cancer occurs more frequently among cigaret smokers than among nonsmokers.

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Several objections can be raised to this type of study, and these objections must be carefully weighed to determine what possibilities of error exist in such studies, whether these are sufficient to invalidate the conclusions reached, and what bearing the evidence has on the question of smoking as a cause of lung cancer.

The first question which arises with respect to these studies is whether they prove that a real association exists between smoking and lung cancer. In other words, do the studies prove that persons who smoke cigarets develop lung cancer more frequently than do those who have never or rarely smoked, for this is the meaning of "association" as used with respect to this type of evidence. "Association" does *not* mean, as has been implied by some writers in the press, merely that the rise in lung cancer mortality has accompanied the rise in the use of cigarets. The guilt attributed to cigarets is not based on this latter type of association. The concomitant rise of lung cancer and cigaret consumption would be expected to follow a true association between the two, but by itself cannot be considered as more than suggestive evidence of it. The evidence which is at hand is that cigaret smoking is more frequent and heavier among persons who develop lung cancer than among those who do not.

The fact that many studies by independent investigators in this country and abroad show the same result is accepted by all or most authorities as proof that *some* association exists, i.e., that cigaret smokers do experience a higher incidence of lung cancer than do nonsmokers. It may be of interest, however, to consider why there should be any doubt at all on this point.

Two possible sources of error must be considered, those due to bias in obtaining the history and those due to bias in sampling. Where the smoking history is taken as part of a special investigation, one must consider whether the interviewer, by reason of his own bias or conviction, influences the patient in the answers the latter gives. In at least two studies the element of interviewer bias would seem to have been eliminated if it existed. Doll and Hill considered that they had demonstrated this error did not exist in their study since in 335 patients believed to have bronchial carcinoma at the time of interview, but shown later not to have the disease, "the smoking habits of the wrongly diagnosed group were sharply distinguished from the habits of the correctly diagnosed groups and were statistically indistinguishable from those of all the other patients suffering with other disease."[1] In the Roswell Park Memorial Institute studies,[5,6] begun in 1938, we consider this source of error to have been eliminated, first, because the studies were undertaken in the belief that no association really existed and, second, because of the fact that the smoking histories were not part of a separate interview but were obtained as part of the routine history taken on admission before any diagnosis had been made.

A second possible source of error which has been pointed out is that one could not be certain that the lung cancer cases studied were representative of all lung cancer cases or that the control patients were representative of the general population. However, these two conditions are not necessary for a valid study of the association of two variables. First of all, the cases and controls need not come from the general population but from the same population, i.e., the controls should be persons of the type most likely to enter the study as cases. Second, the cases and controls need be representative only with respect to the factors studied, in this instance smoking history.

The theoretic sampling questions raised above with respect to the case studies may thus be summarized in the following questions:

1. How likely is it that the control and lung cancer cases in the studies reported were drawn from two different populations which differed significantly with respect to smoking and differed always so that the control cases came from a lighter-smoking population than the lung cancer cases?

2. How likely is it that these sampling biases would be more marked for cigaret smokers than for pipe and cigar smokers and more marked for heavy cigaret smokers than for light cigaret smokers?

3. How likely is it that lung cancer cases who smoke are more apt to go to the hospital or that patients with other diseases who smoke are less apt to do so?

4. How likely is it that these sampling biases should occur repeatedly in studies made in different countries and in different sections of the same country?

None of these contingencies seems very likely and their occurrence to so marked a degree as to show the differences between smokers and non-

TABLE I.—Estimated Prevalence Rates[a] of Lung Cancer per 100,000 Males of Selected Ages and Various Cigaret Smoking Histories[b]

	Number		Estimated Prevalence Rates—Quantity Smoked Daily[c]			Relative Prevalence[d]	
	Lung Cancer	Control	Heavy[e]	All Quantities	None	Heavy	All Quantities
Patients aged 50 to 59 years							
Doll and Hill[2]	276	275	94	42	7	13	6
Wynder and Graham[3]	258	210	117	47	4	27	11
Sadowsky, Gilliam, and Cornfield[4]	198	208	87	44	12	7	4
Breslow, Hoaglin, Rasmussen, and Abrams[5]	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[2]	197	199	137	63	0	..	..
Wynder and Graham[3]	187	160	138	70	5	29	15
Sadowsky, Gilliam, and Cornfield[4]	76	71	44	73	5	9	4
Breslow, Hoaglin, Rasmussen, and Abrams[5]	168	169	433	78	17	25	5
Roswell Park Memorial Institute	197	675	479	280	50	9	5

[a] Estimated according to the method of Cornfield.[8]

[b] All data appearing in this table, except for Roswell Park Memorial Institute figures, are taken from the paper by Breslow *et al.*[5]

[c] Quantity smoked daily, except for the present study, is all forms of smoking expressed as cigarets with pipes and cigars converted to their equivalents in cigarets as follows:
Doll and Hill—1 ounce tobacco = 4 cigarets a day
Wynder and Graham—1 cigar = 5 cigarets; 1 pipeful = 2½ cigarets
Sadowsky, Gilliam, and Cornfield—1 cigar = 10 cigarets; 1 ounce pipe tobacco = 20 cigarets
For the Breslow *et al.* study quantity smoked daily includes only cigaret smoking.

[d] Relative prevalence are the following ratios: heavy = rate among heavy smokers/rate among nonsmokers; all quantities = rate among smokers/rate among nonsmokers.

[e] Heavy smoking is defined as the following number of cigarets or equivalents of cigarets 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, 50 or more.

smokers elicited by the various studies is even less likely. Their likelihood is probably least in studies made in hospitals, such as those at Roswell Park Memorial Institute,[5] in which all patients are admitted without charge, and in the British studies of Doll and Hill, made in patients in hospitals coming within the National Health Insurance scheme. Wynder and Cornfield's study[7] made of smoking histories of physicians who died of lung cancer also is not subject to the possible bias of hospitalized cases.

The fact that 13 separate studies have shown the same result is strong presumptive evidence that an association exists between cigaret smoking and lung cancer, i.e., that lung cancer occurs more frequently among cigaret smokers than among nonsmokers. Indeed, one may predict that the "prospective" studies now under way will fully confirm the fact of a substantially increased risk of lung cancer among cigaret smokers. However, they should provide more precise estimates of the magnitude of this risk.

Magnitude of Increased Risk of Lung Cancer Among Cigaret Smokers

Estimates of the extent of increased risk to lung cancer suffered by cigaret smokers vary markedly. Table I, taken in part from the paper by Breslow *et al.*,[5] indicates that in the age groups fifty to fifty-nine and sixty to sixty-nine years, male smokers have lung cancer prevalence rates from four to 15 times as great as among nonsmokers. Among "heavy" smokers, according to varying definitions, the relative prevalence is estimated at seven to 29 times that of nonsmokers.

Table IIA presents estimated rates based on a tabulation of smoking histories of patients admitted to Roswell Park Memorial Institute from 1938 to the present. These data indicate that cigaret smokers have at least six times the risk of lung cancer incurred by nonsmokers. The excess risk among pipe and cigar smokers is much less.

In Table IIIA these data have been recalculated, after adjusting the place of residence, classified into nine population density categories, of the noncancer cases to that of the lung cancer cases. The indicated relative prevalence among smokers is not significantly altered by this adjustment. The relative incidence ratios between smokers and nonsmokers are based on the assumption that the differences in smoking history between lung cancer patients and noncancer

TABLE II

A. Estimated Annual Incidence of Lung Cancer per 100,000 Population Among Pipe, Cigar, and Cigaret Smokers and Nonsmokers (Males)

Age Group (Years)	Annual Incidence — Nonsmokers	Cigaret Smokers	Pipe Smokers	Cigar Smokers	Ratio of Incidence to Nonsmokers Among — Cigaret Smokers	Pipe Smokers	Cigar Smokers
35 to 44	1.2	10.2	..[a]	..[a]	8.5	..[a]	..[a]
45 to 54	9.3	64.8	15.0	11.3	7.0	1.6	1.2
55 to 64	28.5	196.2	26.4	50.6	6.9	0.9	1.8
65 to 74	55.1	343.5	76.0	49.8	6.2	1.4	0.9
75 and over	16.9	392.1	71.8	91.4	23.2	4.2	5.4

[a] There were no lung cancer cases among pipe and cigar smokers in this age group.

B. Number of Cases

Age Group (Years)	Nonsmokers — Lung Cancer	Nonsmokers — Noncancer	Pipe[a] Smokers — Lung Cancer	Pipe[a] Smokers — Noncancer	Cigar[a] Smokers — Lung Cancer	Cigar[a] Smokers — Noncancer	Cigaret[b] Smokers — Lung Cancer	Cigaret[b] Smokers — Noncancer
35 to 44	1	51	..	11	..	16	30	181
45 to 54	6	122	3	37	2	34	109	318
55 to 64	16	186	6	75	8	52	182	301
65 to 74	13	168	10	93	5	71	72	151
75 and over	1	86	2	41	2	32	7	20
	37	613	21	259	17	205	400	980

[a] Includes "pure" pipe and cigar smokers only.
[b] Includes cigaret smokers who also smoked pipes and/or cigars.

TABLE III

A. Estimated Lung Cancer Annual Incidence per 100,000 Population Among Male Cigaret Smokers and Nonsmokers

Age Group (Years)	New York State[a] — Nonsmokers	Smokers	All Males	Ratio of Incidence Smokers Nonsmokers
30 to 39	0.8	2.9	2.3	3.6
40 to 49	4.2	25.4	18.2	6.0
50 to 59	14.8	108.9	70.7	7.3
60 to 69	50.3	280.4	125.7	5.6
70 to 79	33.6	435.8	124.5	13.0

[a] Rates based on incidence rates for lung cancer in New York State, exclusive of New York City, for 1949–1951.

B. Number of Cases

Age (Years)	Nonsmokers — Lung Cancer	Nonsmokers — Noncancer	Cigaret Smokers — Lung Cancer	Cigaret Smokers — Noncancer	Other — Lung Cancer	Other — Noncancer
30 to 39	1	38	16	170	1	30
40 to 49	3	86	57	244	3	63
50 to 59	8	156	152	366	13	135
60 to 69	23	205	149	225	25	214
70 to 79	4	150	25	72	10	180
	39	636	399	1,077	52	622

proximate true differences in the relative risk of developing lung cancer. These data (Table IVC) indicate that among males aged thirty years and over who are light smokers (less than five cigarets a day) the lung cancer risk is about doubled, in smokers of five to 19 cigarets a day the risk is about six times as great, and in those smoking 20 or more cigarets, approximately nine times as great as in nonsmokers.

In Table V is presented a further analysis of the smoking history of male lung cancer patients at Roswell Park Memorial Institute, compared with patients admitted with a presumptive diagnosis of lung cancer but whose symptoms upon final diagnosis were not due to the presence of lung cancer or any lung tumor. This is a severe test of the difference as to smoking history between lung cancer and other patients since smoking per se

patients reflect similar differences between lung cancer patients and the population from which they come. Since there is no reason to believe that the smoking habit per se influences admission to the hospital, these ratios probably ap-

TABLE IV

A. Estimated[a] Annual Lung Cancer Incidence per 100,000 Among Males, Cigaret Smokers and Nonsmokers, by Average Amount Smoked Daily (New York State[b])

Age (Years)	Daily Cigarets Smoked: Less than 5	5 to 19	20 or more	Nonsmokers	All Smokers
30 to 39	1.8	4.7	3.4	0.8	2.9
40 to 49	8.0	13.8	34.7	4.2	25.4
50 to 59	33.2	86.3	141.4	14.8	108.9
60 to 69	59.1	212.5	479.0	50.3	280.4
70 to 79	82.2	475.6	605.4	33.6	435.8
30 to 79[c]	26.3	92.7	162.6	15.0	180.6

[a] For the method of calculating incidence rates, see Cornfield.[8]
[b] Based on reported lung cancer incidence for New York State (exclusive of New York City) for 1949-1951.
[c] Adjusted to population, males aged 30 to 79 years, New York State, exclusive of New York City, 1950 census.

B. Per Cent Distribution[a] of Cigaret Smokers by Daily Number of Cigarets Smoked[b]

Age (Years)	Daily Number of Cigarets: Less than 5 — Non-cancer	Less than 5 — Lung Cancer	5 to 19 — Non-cancer	5 to 19 — Lung Cancer	20 or More — Non-cancer	20 or More — Lung Cancer	Nonsmokers — Non-cancer	Nonsmokers — Lung Cancer
30 to 39	2.74	5.56	23.19	16.67	46.01	63.67	15.63	5.56
40 to 49	3.59	1.59	23.00	57.14	37.34	71.43	20.69	4.76
50 to 59	6.33	2.99	20.65	53.89	29.55	59.28	22.41	4.62
60 to 69	5.39	2.56	15.81	38.97	12.10	46.15	29.09	11.68
70 to 79	4.21	2.78	6.54	30.56	6.84	33.34	37.58	10.26

[a] Adjusted to place of residence of the lung cancer group.
[b] Pipe and cigar smokers not shown in this table.

C. Comparison of Estimated Relative Incidence of Lung Cancer Among Cigaret Smokers and Nonsmokers

Age (Years)	Daily Cigarets Smoked: Less than 5	5 to 19	20 or More	All Quantities
30 to 39	6.0	2.1	4.4	3.6
40 to 49	1.9	3.3	8.5	6.0
50 to 59	2.2	5.8	8.5	7.3
60 to 69	1.2	4.2	8.9	5.6
70 to 79	2.4	14.1	18.0	13.0
30 to 79[a]	1.8	6.2	10.8	7.2

[a] Relative incidence (smokers/nonsmokers) obtained after adjusting all rates to the male population, New York State, exclusive of New York City, 1950 census.

TABLE V. Cigaret Smokers Among Patients with Lung Cancer and with Other Diseases of the Lung (Nontumors) in Males (Roswell Park Memorial Institute)

Age (Years)	Lung Cancer: Cases[a]	Lung Cancer: Cigaret Smokers: Number	Lung Cancer: Cigaret Smokers: Per Cent	Lung Nontumors[b]: Cases	Lung Nontumors[b]: Cigaret Smokers: Number	Lung Nontumors[b]: Cigaret Smokers: Per Cent	Indicated Relative Incidence Smokers to All Others[c]
35 to 44	31	30	96.8	17	11	64.7	16.5
45 to 54	120	109	90.8	37	28	75.7	3.5
55 to 64	218	182	83.5	46	26	56.5	3.9
65 to 74	110	72	65.5	17	4	23.5	6.2
75 and over	14	7	50.0	1	0	0	...
	493	400		118	69		

[a] Includes 38 cases with history of combination pipe and cigar smoking, not tabulated in Table IIB.
[b] Includes chronic bronchitis, bronchiectasis, emphysema, and other diagnoses.
[c] Comparison here is between cigaret smokers and "all others" including nonsmokers and pipe and cigar smokers.

known to cause in some individuals chronic inflammation of the trachea and bronchial tree. The differences in per cent cigaret smokers between the two groups is statistically significant,

and the indicated relative prevalence, from these data, of lung cancer among smokers compared to nonsmokers is still considerable (approximately five times as great).

Because the routine method of obtaining smoking histories is known to understate the prevalence of smokers, there is reason to believe that these estimates of relative risk are too low rather than too high. These data confirm those of previous reports from Roswell Park Memorial Institute[5,6] and by many other investigators that the lung cancer risk among moderate and heavy cigaret smokers is several times that of nonsmokers.

Etiologic Significance

The fact that cigaret smokers suffer an appreciably increased risk of lung cancer does not of course amount to proof that this increased risk is caused by cigaret smoking. It could also be due to the fact that cigaret smoking was in turn associated with some other factor or factors which were carcinogenic or that cigaret smoking enhanced the effect of other carcinogenic factors. Possible factors of this kind which have been suggested are atmospheric pollution by industrial wastes, engine exhaust fumes, dust from tarred roads, and occupational exposure to carcinogenic dusts or fumes or radiations. The air of some industrial cities is known to contain benzpyrene and arsenic, and mortality rates from lung cancer are higher in cities than in rural areas in this country, in England, and in Denmark. However, this would fail to explain the marked excess incidence of lung cancer among males in cities as well as in rural areas. The extensive British studies of Doll and Hill[9,10] also showed the same excess risk among smokers when attention was confined to residents of London. Doll[10] has recently reported that the lung cancer incidence among nonsmokers in England was about the same in London as in rural areas and in females as compared to males. These findings suggest that the difference in lung cancer incidence between the sexes and between rural and urban dwellers may be due to differences in the prevalence of cigaret smokers in these groups, either alone or in combination with other factors. It has not been established that exposure to air pollution, to engine exhaust fumes, or to dust from tarred roads is significantly higher among lung cancer cases than among the population from which they come.

Lung cancer cases known to arise in occupations which involve increased risk to lung cancer at present account for only a relatively small percentage of the total cases. Admittedly, there may be many more such cases than are recorded and more such occupations than are now known. Two studies correlating smoking history and occupation in lung cancer cases have been reported. In 1,357 male lung cancer cases and 1,357 matched controls, Doll[1] found an important excess in the cancer group in only one occupation, the production of illuminating gas: "The cancer group contained 23 such men, the control group 14." Although this difference was not significant, it corroborated other evidence (gathered also by Doll) that gas workers have an excess risk to lung cancer. Breslow[2] in a study of the smoking and occupational histories of 518 lung cancer cases and 518 controls found 77 lung cancer cases (about 15 per cent) "had an exposure of more than five years to suspect occupations." In one of these, welders and sheet metal workers doing welding, part of the excess risk was attributable to the high proportion of smokers, and a significant portion could not be so explained. Unless occupational hazards causing lung cancer are many times more prevalent than any existing evidence indicates, they could not possibly explain more than a minor fraction of the observed increase in lung cancer or the excess risk among smokers.

This conclusion has been further tested by a study of the occupational histories and smoking histories of male lung cancer patients and other male cancer patients at Roswell Park Memorial Institute. In this study (to be reported more fully in a subsequent publication) 137 male lung cancer cases and 396 control cases were matched for age and place of residence and adjusted for occupation. The excess of cigaret smokers among the lung cancer cases remained after the factors of age, residence, and occupation were equalized (Table VI).

Interpretation of the etiologic significance of the smoking-lung cancer association rests on several types of evidence. First, it conforms with what is known about other carcinogenic agents. Tobacco smoke is known to be an irritant and to come into contact with the bronchial mucosa. All or most known carcinogens may be classed as irritants, although the reverse is not true, and direct contact is one of the most frequent modes of effective application of carcino-

TABLE VI.—Estimated Relative Risk of Lung Cancer by Smoking Categories and Occupation (Males)

	Smoking Categories (Per Cent)								
			Cigarets by Daily Units and Duration						
			Less than 20 per Day		20 or More per Day				
	Non-smokers	Other than Cigarets	Under 40 Years	40 Years or More	Under 40 Years	40 Years or More	Total Cigaret Smokers	Total Cases Number	Total Cases Per Cent
Unadjusted for occupation									
Lung cancer	5.11	8.03	13.87	10.95	27.01	35.03	86.86	137	100.0
Control (other cancer)	24.24	28.28	10.61	9.85	13.89	13.13	47.48	396	100.0
Lung cancer incidence among cigaret smokers compared to nonsmokers	1.00	1.33	6.24	5.29	9.24	12.71	8.71	...	...
Control cases adjusted to occupational distribution of lung cancer cases	23.02	27.81	11.87	9.38	14.18	13.74	49.17	...	100.0
Lung cancer incidence among cigaret smokers compared to nonsmokers, adjusted for occupation	1.00	1.32	5.32	5.32	8.64	11.59	8.05	...	...

gens. Second, it rests on the failure to demonstrate other known causes of lung cancer among smokers, as compared with nonsmokers, to explain the excess risk among the former. Third, and more indirectly, it rests on the conformance of the etiologic hypothesis with the known epidemiologic facts. These require that the suspected etiologic agent be one known to have increased markedly in prevalence within the past thirty years, as has cigaret smoking, and to have affected males more extensively than females. The production of skin cancer in mice by tar obtained from cigaret smoke, reported by Wynder, Graham, and Croninger,[4] adds further support to the belief that cigaret smoke may be a truly etiologic factor in lung cancer.

All of the available evidence thus indicates that cigaret smoking is one of the contributing causative factors in the production of lung cancer. It does not indicate that it is the sole causative factor or even that it is operative in the absence of other factors, such as susceptibility and, perhaps, other as yet undiscovered etiologic factors.

Perhaps the fairest statement of the case at present is that there is a strong presumption that cigaret smoking is an important etiologic factor in lung cancer. It has been estimated previously[6] that in males cigaret smoking may account for from 50 to 75 per cent of lung cancer on the assumption that other etiologic factors are equal in smokers and nonsmokers. Recently, Doll[11] has estimated that in England, "about one in five of the lung cancer deaths in persons aged twenty-five to seventy-four in 1950 were attributable to causes other than smoking," or about 80 per cent to smoking.

Anticipated Results of Further Research

Total population studies, whether "retrospective" or "prospective," should serve to furnish more precise estimates of the magnitude of the excess risk associated with smoking of various types and durations. Such studies cannot be expected per se to furnish more information than we now have regarding the *etiologic* significance of smoking unless accompanied by a concomitant study of all other known or suspected etiologic factors for lung cancer among smokers and nonsmokers. Experimental studies now aimed at production of cancer in lung tissue by application of the components of tobacco smoke, if successful, may add to our confidence in the etiologic nature of the smoking-lung cancer relation.

Further study is also indicated of the reasons for the much smaller increased lung cancer risk found among cigar and pipe smokers. Possibly, some sensitivity test may be devised to distinguish between the majority of smokers who may smoke with relative impunity and the minority who will develop lung cancer. The identification of and removal from tobacco of the presumed carcinogenic agent, without removal of the tobacco, is a hopeful possibility.

Public Health Implications

Lung cancer is a rapidly increasing cause of death in this country. In New York State it now exceeds tuberculosis in number of deaths among males.

Between 1931–1933 and 1948–1950, age-adjusted lung cancer mortality increased among males in New York State by 385 per cent, among

TABLE VII. AGE-ADJUSTED[a] MORTALITY FROM LUNG CANCER AND ALL OTHER SITES OF CANCER IN NEW YORK STATE[b] (DEATHS PER 100,000 LIVING)

	Lung Cancer	Cancer Other Sites
Males		
1931–1933	4.7	110.3
1948–1950	22.8	112.7
Females		
1931–1933	2.5	151.2
1948–1950	4.2	128.8
Per cent change		
Males	+385	+2
Females	+68	−15

[a] Adjusted to 1940 population, New York State.
[b] Exclusive of New York City.

females by 68 per cent (Table VII). Since cancer is a reportable disease in New York State, it is possible to calculate the probability of developing cancer of various sites throughout the life span. For lung cancer, within the short period between 1942–1944 and 1949–1951, this probability has more than doubled for males (Table VIII). At present rates of incidence, 2 per cent of males may be expected to develop lung cancer. If the present rate of increase continues, this figure may double again within the next fifteen years.

Lung cancer is a public health problem rapidly mounting in importance. Public health authorities as well as private medical practitioners must take cognizance of the available facts regarding its occurrence and etiology. The following approaches to the problem are indicated:

1. *Case-finding:* Since early diagnosis and treatment offer the only hope of cure in lung cancer, early case-finding should be intensified. Special attention should be given to the following groups: (*a*) males aged forty and over, (*b*) cigaret smokers, (*c*) persons exposed to known occupational hazards. The application of the community chest x-ray program, so extensively developed in this State, to the finding of lung cancer has already begun. Further refinement and adaptation of this program to the diagnostic problems of lung cancer are needed.

2. *Public education:* The public looks to the medical profession and to public health authorities for information regarding health matters and for an appraisal of existing evidence regarding health hazards. What shall be our reply to questions regarding the relation between cigaret smoking and lung cancer? The existing evidence justifies the following statements: (*a*) Lung cancer occurs more frequently among cigaret smokers, and particularly among heavy smokers, than among nonsmokers. We do not know exactly

TABLE VIII. PER CENT PROBABILITY OF DEVELOPING LUNG CANCER AND CANCER OF OTHER SITES FROM BIRTH ON (1942–1944 AND 1949–1951)

Site	1942–1944	1949–1951	1949–1951 (Adjusted[a])
Male			
All sites	15.43	20.17	18.56
Lung	0.91	2.01	1.87
Female			
All sites	19.37	23.27	21.40
Lung	0.22	0.34	0.31

[a] Obtained by holding 1942–1944 mortality rates from all causes constant and applying 1949–1951 reported cancer incidence rates.

how much more frequently it occurs, but the evidence we have indicates that the excess risk is appreciable. (*b*) In the absence of evidence to the contrary, the most reasonable assumption is that this increased risk is due to the effect of cigaret smoking, either alone or in conjunction with other factors. (*c*) Persons who are concerned about lung cancer cannot be assured that cigaret smoking will not increase their chances of developing the disease. (*d*) Cigaret smokers, particularly those past forty years of age, would be well advised to have chest x-rays taken at least once a year.

3. *Research:* Further research into causes, improved treatment, and methods of control of cancer is a public health responsibility. In New York State this has long been recognized. The expanded Roswell Park Memorial Institute at Buffalo[12] and the Bureau of Cancer Control of the New York State Department of Health are devoting considerable attention to investigation of the relation of tobacco to lung, larynx, lip, oral, and other types of cancer. Investigation is proceeding along the following two main lines: (*a*) investigation of the carcinogenic properties of tobacco smoke components and (*b*) epidemiologic investigation of the characteristics of persons who develop lung cancer and of smokers compared to nonsmokers in an effort to uncover all pertinent associated factors.

Summary

1. The existing evidence regarding the etiology of lung cancer points to the existence of multiple etiologic factors, including occupational hazards and cigaret smoking.

2. Known occupational hazards do not account for more than a relatively small proportion of lung cancer cases.

3. The evidence regarding excess risk of lung cancer attributable to cigaret smoking indicates that it is several times that among nonsmokers

and may account for a major part of the incidence of lung cancer, particularly among males.

4. The evidence for excess risk of lung cancer among smokers persists when comparison is made between lung cancer patients and patients with other conditions affecting the lung and bronchi and when the influence of residence and of occupation is equalized in lung cancer and control groups.

5. The available evidence is sufficient to justify public health action in the direction of case-finding and public health education to the effect that cigaret smoking must be presumed to play an important role in the production of lung cancer.

6. Intensive further research in all aspects of the problem is urgently indicated. Further studies may be expected to provide more precise data on the magnitude of the excess risk to lung cancer among smokers. Additional evidence regarding etiology may be forthcoming from the results of experimental studies but may rest in the final analysis on the study of other possible etiologic factors found in smokers but not in nonsmokers. At present no such differences are known to explain the excess risk among the former. The weight of the evidence therefore indicates that the relationship between cigaret smoking and lung cancer is causal and not merely an "association."

7. In less than a decade the chance of developing lung cancer at some time during life has more than doubled among males in New York State. Two per cent of all males may be expected to develop lung cancer at present rates of incidence. Since a majority of adult males are cigaret smokers and most of those over forty have smoked for many years, a good deal of the smoking effect probably has already been exerted on these. Hence, no appreciable decrease in rates may be expected in the next decade, even if everyone forthwith gave up smoking. Public health efforts hence must concentrate on early case-finding and on research.

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NOTE: Two charts and an additional table will be included in the author's reprints.

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