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A study of lung cancer cases and controls disclosed a number of occupations that appeared to have an increased risk of pulmonary cancer. To examine this possibility a prospective study was undertaken. The results of a preliminary analysis are presented here, and some of the sources of uncertainty are discussed.

LUNG CANCER MORTALITY EXPERIENCE OF MEN IN CERTAIN OCCUPATIONS IN CALIFORNIA

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During the period 1949-1952 a case-control study among male lung cancer cases and matched controls in 11 California hospitals yielded data on occupation and tobacco use as principal variables. The findings in regard to tobacco use supported the now well established positive association of cigarette smoking and liability to death from lung cancer.

In considering the distribution of occupations between cases and controls, it was arbitrarily decided that any case or control would be assigned to a specific occupation if he had worked at least five years in the occupation. Interest was further limited to those occupations to which at least five cases or five controls had been assigned.

This study[1] disclosed a number of occupations to be more frequent among the lung cancer cases than among the controls. For one of these, welders, the excess among cases as compared to controls was statistically significant; for a number of others, the excessive frequency among cases as compared to controls bordered on significance.

On the basis of these findings, we undertook a prospective study in which populations of workers engaged in the suspect occupations were assembled and their lung cancer experience observed during succeeding years through a search of death records. The study began in 1954, and this report is based on death experience through 1958.

Plan of Study

The populations assembled for study were limited to men in the age range 35-64 years. Younger men were excluded because their lung cancer experience would contribute little to the study while their numbers would add considerably to the population lists being searched for matching with recorded deaths. Older workers were excluded because of their small numbers and the uncertainty of the applicable death rates. Estimates indicated that populations ranging between five and ten thousand would provide reasonable assurance of identifying occupations having as little as a twofold increased risk of lung cancer. An expected number of at least 14 lung cancer deaths (when a twofold risk would provide a significant observed number of 21 cases or more with a probability of 0.93) has been shown necessary to fulfill these conditions.[2] A population of the size being sought would produce such an expected number within five years of observation.

Exploration as to the best means of collecting populations suitable for the study led to a decision to work through union organizations. Local union offices provided names and addresses of workers in the occupations of interest, and questionnaires were mailed with a covering letter requesting the furnishing of identifying data and information as to length of time and nature of work experience in the particular occupation. Cigarette smoking experience was also requested.

Further details as to the mechanics of the data collection phase of the study were given elsewhere.[3] Suffice it to say here that the response rate averaged about 85 per cent after three mailings. In addition to the specific occupational groups, the study included a control group representing workers from two public utility electric companies. From this group the few workers engaged in any of the suspect occupations were excluded. The remainder represented a broad spectrum of occupations, as one might expect in the expansion, maintenance, and power distribution of large public utility organizations.

The questionnaires used for data collection from the members of the various occupational groups were as simple and brief as possible in the interest of maximum response. Identifying information, besides establishing age and sex, permitted subsequent death certificate matching. The Social Security number is extremely useful for this purpose. Smoking practice was confined to cigarette use, years of smoking, and current or last average daily consumption. The respondent identified himself in his occupation and the length of time he had been in the occupation. Questions about each specific occupation of interest established the specific nature of the work. Welders, for example, were asked as to kinds of welding equipment, welding rods, and metals with which they worked. Some sheet metal workers do welding and some do not. Within the culinary trade, cooks had to be distinguished from other kitchen workers such as pantrymen, kitchen helpers, waiters, and others. Respondents thus identified themselves as belonging not only in the specific occupations being studied but also in broad subclasses within each occupation for separate examination.

Results

Table 1 gives the number of men collected for each of the study populations within the age span being studied, and their percentage distribution by ten-year age groups. The welders and cooks represent the two extremes in regard to age distribution—the former being the youngest and the latter the oldest. The controls lie near the middle range in respect to age.

Not all the occupations shown in Table 1 were suspected of increased lung cancer risk from the original case-control study. Some came into the present study as by-products of collecting the populations in suspect occupations and are included because of their sizable numbers and for such help as they might provide in understanding the characteristics and biases peculiar to the study. The sheet metal workers not doing welding are one such group; plumbers not working with asbestos another. Two suspect groups—electric bridge crane operators and marine engineers and firemen—could not be found in sufficient numbers for study but are included because they were suspect in the original case-control study. Printers were included because it was possible to collect an adequate population easily, and they have been reported to have an increased lung cancer risk.[4]

To determine the significance of the lung cancer mortality experience in these populations over a period of time, it is necessary to calculate the man-years of exposure to risk of mortality and also to allow for the aging of the populations. The returns from mailed questionnaires for any particular occupation came in over many months. To simplify correction for aging (and not introduce an appreciable error), we considered that each man contributed at his stated age the person-months remaining of the calendar year after the date the questionnaire was completed. He was counted one year older for each succeeding person-year (calendar). This procedure led to the accumulation of person-years by each study population, at the end of calendar year 1958, shown in column (2) of Table 2. We did not correct for person-years lost as a result of general mortality during the time these populations have been followed. Such a correction, however, would involve a person-year's reduction in the order of 2 per cent for any group at the end of 1958. The expected lung cancer deaths, discussed further on, would be reduced by about half a case for the painters, who have the largest expected number, and something less

Table 1—Males 35–64 Years of Age in the Occupational Study Populations

Occupational Group	Total Number	Per cent of Total in Age Groups		
		35–44	45–54	55–64
Welders	10,235	58.0	32.6	9.4
Painters	12,512	36.0	37.4	26.6
Cooks	9,598	30.1	42.1	27.7
Asbestos workers	7,836	38.8	37.3	23.8
Printers	5,424	38.3	39.6	22.1
Marine engineers	1,380	39.7	35.1	25.2
Electric bridge crane operators	318	41.8	39.6	18.6
Plumbers (no asbestos)	7,909	45.1	35.3	19.5
Sheet metal workers	3,013	47.8	33.0	19.1
Controls	8,569	41.7	34.3	24.0

Table 2—Man-Years of Experience for Each Occupation Through 1958, and Observed and Expected Lung and All Cancer Deaths for This Period

Occupational Group (1)	Man-Years Through 1958 (2)	Cancer Deaths* — Lung Cancer: Observed (3)	Expected (4)	Ratio: Observed/Expected (5)	Ratio: Corrected for Smoking (6)	All Cancer Other Than Lung: Observed (7)	Expected (8)	Ratio: Observed/Expected (9)
Welders	42,801	19	16.9	1.12	0.98	43	43.6	0.99
Painters	37,870	35	24.1	1.45	1.26	51	59.9	0.85
Cooks	26,108	23	16.8	1.37	1.41	32	41.7	0.77
Asbestos workers	23,603	19	13.7	1.39	1.22	30	34.3	0.87
Printers	14,292	2	7.7	0.26	0.25	26	19.6	1.33
Marine engineers	5,757	5	3.7	1.35	1.08	8	9.0	0.89
Electric bridge crane operators	1,068	0	0.5	–	–	0	1.4	–
Plumbers	24,908	16	12.9	1.24	1.07	23	32.5	0.71
Sheet metal workers	11,763	3	6.2	0.48	0.48	14	15.6	0.90
Controls	34,333	17	19.8	0.86	0.86	33	49.5	0.67
Totals	222,503	139	122.8	1.13	–	260	307.2	0.85

* Rates per 100,000 for age groups 35–44, 45–54, 55–64, and 65–69 years were for column (4) 8.2, 45.3, 123.2, and 193.7; for column (8) 36.8, 106.5, 289.1, and 557.1.

than this for the other groups. (For interoccupational group comparisons such correction is of little importance.)

Columns (7) and (3) of Table 2 indicate the cancer deaths for all but lung cancer deaths (hereafter referred to as other cancer), and the lung cancer deaths (I.S.C. codes 162-163) that have occurred in the occupational and control populations. An immediate question arises as to the rates to use for computing expected numbers of lung cancer and other cancer deaths to compare with these observed numbers. California has undergone tremendous population growth since 1950 and population estimates by age and sex are uncertain. Such estimates as are available for the California male population in recent years indicate that any change in age-specific rates for men 35-64 years of age for other cancer mortality has been slight. For this preliminary analysis, then, and until the 1960 Census enumeration is available, the 1950 age-specific other cancer rates yield the expected numbers in column (8) of Table 2. The ratio of observed to expected other cancer deaths is less than one for all study groups except printers. The controls are most deficient in other cancer, having only about two-thirds of the expected number, and for all groups taken together the observed number is 85 per cent of the expected number. This apparent deficit in other cancer deaths will be discussed later.

Any uncertainty about the proper age-specific other cancer rates to use is minor compared to finding suitable

Table 3—Cigarette Smoking Practices of the Occupational Populations and Controls

Amount of Cigarettes Smoked	Population Groups—Percentage Distribution*									
	Controls	Welders	Painters	Cooks	Asbestos Workers	Printers	Marine Engineers	Electric Bridge Crane Operators	Sheet Metal Workers	Plumbers
None	28.1	18.4	17.1	26.0	18.6	23.8	17.0	19.6	24.6	18.9
5	4.4	3.1	3.5	6.1	3.6	4.0	3.1	4.1	3.8	2.4
½ pack	12.6	13.7	14.1	17.3	13.4	15.0	11.0	14.9	16.0	12.3
1 pack	37.1	45.0	45.9	34.0	44.2	38.6	38.1	43.7	40.4	44.0
1½ packs	12.8	14.6	13.3	11.0	13.9	13.1	17.8	13.3	10.3	16.3
2 packs	4.1	4.4	4.9	4.5	5.2	4.8	11.9	2.8	3.2	4.9
Not stated	1.0	0.8	1.2	1.2	1.1	0.8	0.9	1.6	1.7	1.2

* Does not include 193 (0.3 per cent of total) for which information on smoking practice was not returned.

age-specific lung cancer rates for computing expected numbers. Lung cancer mortality rates for males have continued to climb since 1950 but how fast and whether the rate of ascent is different for different age groups is uncertain. The estimates of increase for the total United States seemed more reliable than California data because of California's rapid population change. The estimated increase, based on United States data, from 1950 to 1956 for the male age-specific respiratory cancer rates were as follows: 35-44 years, 22 per cent; 45-54 years, 23 per cent; 55-64 years, 40 per cent; 64-69 years, 65 per cent. The corresponding California 1950 age-specific lung cancer rates were increased by these percentages and used to compute the expected numbers of column (4).

Inspection of the observed and expected lung cancer deaths in the various occupational groups indicates that the ratios are all greater than 1.0, except for the sheet metal workers, the printers, and the control population. The only significant deviations from the expected number are an excess of observed lung cancer deaths among painters ($10.9 > 2\sqrt{24.1}$) and a significant deficiency in lung cancer deaths among printers. As noted above, this latter occupational group had an excess of other cancer deaths.

An important factor to be considered in the lung cancer experience of a population is its smoking practices which will be considered next.

Cigarette Smoking Habits

The information collected on smoking practices was limited to cigarette smoking, since the association of this habit with increased risk of lung cancer is firmly established and quantified. Cigarette smokers included anyone smoking cigarettes regularly for at least one year. The majority of regular cigarette smokers apparently think of their daily consumption in terms of packs of cigarettes (or a rough fraction or multiple thereof), but given an opportunity to assign themselves around a modal point they may be psychologically motivated to understate their consumption. The pack-a-day smoker asked whether he smokes more or less than this amount can reconcile the complexities this poses his conscience by believing he smokes a trifle less, rather than a pack or a little more. Our categories, then, for daily consumption were less than five cigarettes; about half a pack; about one pack; about one and a half packs; and about two packs. This was to be answered as of present practice or when last smoking for those who had quit.

Table 3 shows the cigarette smoking pattern for the various study populations. It is immediately apparent that the control population has a larger proportion of nonsmokers than any of the occupational groups.

In considering Table 2 we noted that all the occupational groups except the printers, sheet metal workers, and controls had experienced more lung cancer deaths than might be expected of the California male population. This might be explained, at least in part, by the heavier smoking of the occupational populations.

To determine the over-all relative risk of a population for lung cancer as a result of its smoking practices, it is necessary to have relative risks assigned to various quantities of smoking. Others have developed such relative risks, or they can be computed from various bodies of data.[5-8] Since the quantitative scale of smoking in this study is somewhat different from that used by most American studies, the pooled data were used to develop the relative risk due to cigarette smoking among the study populations. The percentage distribution of the combined study populations by smoking categories, number of lung cancer deaths in each category, and computed relative risks are shown in the tabulation below.

Differences in age distribution of smoking category populations are not taken into account in this computation (men over 55 years have more nonsmokers and fewer heavy smokers). However, such correction only increases the relative risks for heavier smoking categories moderately. For interoccupational comparisons of relative risk from smoking the effect is inconsequential.

The relative risks in the various smoking categories here are somewhat higher than have usually been found from other data. (This is not the re-

Amount of Cigarette Smoking

	None	<5	½ Pack	1 Pack	1½ Packs	2 Packs	Not Stated
Population distribution	21.2	3.8	14.1	41.5	13.5	4.8	1.1
Lung cancers	2	3	12	75	32	13	2
Relative risk*	1	8	9	19	25	29	19

* Let p_0 = percentage of population nonsmokers, and p_5, $p_{\frac{1}{2}}$, p_1, . . . etc., represent the percentages in each of the corresponding smoking categories.

Let C_0 = lung cancer deaths in nonsmokers, and C_5, $C_{\frac{1}{2}}$, C_1, . . . etc., represent lung cancer deaths in each of the corresponding smoking categories.

$$\text{Relative risk} = C_5/p_5 \div C_0/p_0 = \frac{p_0C_5}{p_5C_0};\ \frac{p_0C_{\frac{1}{2}}}{p_{\frac{1}{2}}C_0};\ \frac{p_0C_1}{p_1C_0};\ \text{and so forth.}$$

sult of the possible operation of other carcinogenic factors in addition to and independent of smoking in some of these occupational groups; such a factor would actually decrease the gradient.) With unit relative risk based on only two lung cancer deaths among nonsmokers, it is obvious that these determinations are subject to large sampling error. However, as will be shown later, in correcting the lung cancer expectancy of a given population, the population's smoking pattern is a more important variable than is the relative risk smoking gradient.

If the total weighted relative risk is determined for the study groups by multiplying the appropriate percentages of Table 3 with the smoking weighting factors as determined above from the pooled data, and the total weighted relative risk for each population divided by that for the controls, the contribution to relative risk provided by smoking patterns will be as follows:

Controls	1
Welders	1.14
Painters	1.15
Cooks	0.97
Plumbers	1.16
Asbestos workers	1.14
Marine engineers	1.25
Printers	1.05
Sheet metal workers	1.01
Electric bridge crane operators	1.09

As pointed out earlier, the excess of observed lung cancer cases as compared to the expected number might result, in part, from the smaller proportion of nonsmokers in the specific occupational populations as compared to the control population and presumably of the general population of men in California. The observed to expected ratios of Table 2 were divided by the relative risk smoking factors above to obtain the lung cancer relative risks corrected for cigarette smoking in column (6) of Table 2. Only the excess lung cancer deaths for cooks would actually be slightly increased. The excess lung cancer deaths for painters would lose statistical significance with the expected number becoming 27.7 when corrected for smoking pattern of painters ($24.1 \times 1.15 = 27.7$).

This correction for expected lung cancer deaths in the study populations assumes the appropriateness of the lung cancer relative risk assignments for smoking categories; and the smoking pattern of the control study population is representative of that for all men in California. As noted above, the total weighted lung cancer relative risk resulting from the smoking pattern of a population is rather insensitive to the relative risk gradient used. For example, relative risks were adapted from Haenszel and Shimkin[5] as follows: nonsmokers—1; less than a pack—6; one pack—10; more than a pack—13; and not stated—10. Grouping the smoking distributions of Table 3 appropriately and using these relative risks, and again giving the total weighted relative risk of the control population a value of unity, the lung cancer relative risks change little from those last calculated and derived from the weighting factors provided by the pooled data from all study groups. The maximum change was for marine engineers, now 1.21 instead of 1.25. Other changes were limited to differences of 0.01 or 0.02.

Results of two other California studies permit a test of the second assumption, i.e., regarding the smoking pattern of all California males. The first is a study of urban air pollution effects on lung cancer experience of about 70,000 California men, respondents from the California Division of the American Legion. They replied to the same smoking questionnaire as that used for the occupational populations, with results by age groups, and compared to the controls of the present study, as shown below.

There is obviously good agreement between these two studies of the reported smoking practices, by age groups.

Also, the California Health Survey of 1956, based on household interviews of a probability sample of the California population and including information on smoking practices, showed close agreement in the proportions of nonsmokers with the findings from the air pollution study population and the occupational study controls. The California Health Survey quantified smoking differently from the latter two studies; this makes the comparison of distribution by smoking categories unsatisfactory.

It seems reasonable to say that the cigarette smoking pattern of the occupational controls is more like that of all California men than is that of any of the specific occupational groups with the possible exception of the cooks.

Other Considerations

To summarize the analysis of data at this point, it appears that the occupational groups now under study have some increased frequency of lung cancer deaths. Part of this excess, at least, is apparently the result of the more universal and heavier cigarette consumption by the occupational groups being studied as compared to the control population, and California males generally. After removing the excess attributable to smoking practices, some excess lung cancer mortality persists in most of the study populations.

Several other considerations could affect the results of analysis. The first is the reliability of the age-specific male cancer death rates used for computing the expected lung and other cancer deaths in the study populations. Second, losses could result from failure to identify all cancer deaths that may have occurred in the study populations through oversight during death search, out-of-state migration, etc. And third, is the deficit one would expect (and generally found in other similar prospective studies) in the early period of follow-up of a working population assembled for study because those incapacitated and dying of disease at the time the population was assembled would most likely be missed.

Study Groups

	35–44		45–54		55–64	
	Air Pollution Study	Study Controls	Air Pollution Study	Study Controls	Air Pollution Study	Study Controls
Nonsmokers	26	28	24	25	30	34
Less than one pack	14	16	15	15	17	20
One pack	37	39	37	39	34	31
More than one pack	22	16	22	20	17	14
Amount not stated	1	1	2	1	2	1
Total	100	100	100	100	100	100

The first consideration has already been discussed. We have no way of knowing what proportion of our study populations, and the deaths that may have occurred among them, have been lost by outmigration. A rough estimate from looking at fragments of data indicates that this may not be more than 2 per cent per year. Some of these may become subsequent inmigrants. The loss from oversight on death searching we believe is inconsequential. Independent searches with the same certificates have resulted in near perfect duplication of findings.

To examine the third question, we determined for all cancer deaths in our population whether death had occurred within the first year starting with the date the questionnaire was completed, or after the first year. The population for computation of rates for the first person-year was the number in the occupational study group, and thereafter the total person-years minus the number in the study group. The lung cancers and other cancers found in these two periods in all study groups combined and the corresponding rates are given in Table 4.

Contrary to the findings of other similar prospective studies, there is no evidence of a large deficit of lung cancer and other cancer deaths during the first person-year of follow-up as compared to the period after the first person-year. The population is moving up out of age group 35-44 and up into the age group over 65 years as it ages, causing constantly changing age distribution patterns in these age groups. Age groups 45-54 and 55-64 are best suited, there-

Table 4—Death Rates Per 100,000 for Lung Cancer and Other Cancer During First Person-Year and After First Person-Year for All Study Groups Combined

Age Group	First Person-Year				
	Number	Lung Cancer Deaths	Lung Cancer Rate	Other Cancer Deaths	Other Cancer Rate
35–	27,717	4	14.4	10	36.1
45–	24,478	18	57.2	20	81.7
55–	14,599	20	123.3	39	294.5
65–	—	1*		4*	
Total	66,794	43		73	

Age Group	Person-Years After First				
	Number	Lung Cancer Deaths	Lung Cancer Rate	Other Cancer Deaths	Other Cancer Rate
35–	50,167	1	2.0	18	35.9
45–	61,085	43	60.6	62	101.5
55–	38,222	70	138.7	84	219.8
65–	6,235	15	192.5	22	368.9
Total	155,709	129		186	

* Only men 35–64 are included in study groups. One lung cancer and four other cancer deaths of men 64 when entering the study but dead at age 65 after less than a year are included with deaths of those age 55–64 for first person-year.

fore, for examining this question. For these two age groups there is some increase in the age-specific rates after the first person-year except for other cancer for age group 55-64.

It is not unlikely that some workers sick or ailing at the time they received their questionnaires were disposed to respond since the study was concerned with health aspects of their occupations. This was evidenced by a number of death records within the first month following completion of the questionnaires. An extreme example is one printer's questionnaire (which was eliminated) submitted subsequent to his recent death by his widow. Lung cancer deaths occurring during the first person-year were scattered fairly evenly over the 12 months following response. Deaths from other cancers were somewhat more frequent in the middle and later months of the first person-year than in the earlier months.

Earlier it was pointed out in Table 2 that all study groups combined showed a 15 per cent deficit of other cancer deaths (Observed/Expected=0.85). The possible sources of deficit that have been examined make it seem likely that this may be an adequate approximation of what the deficit may prove to be. Using this as a measure of the probable deficit in lung cancer deaths as well, we can arrive at some revised estimates of the observed and expected lung cancer deaths in the various occupational study groups. In the following table, the observed lung cancer deaths of Table 2 have been increased to eliminate the estimated deficit by dividing each by 0.85. The expected lung cancer deaths are corrected for smoking practice by multiplying the expected number for each occupational group in Table 2 by the smoking factor as determined for that occupation. (Thus, expected lung cancer deaths for welders are $16.9 \times 1.14 = 19.3$; for painters—$24.1 \times 1.15 = 27.7$; for cooks—$16.8 \times 0.97 = 16.3$; etc.) The resulting observed over expected ratio will then be as shown.

Occupational Group	Lung Cancer Observed	Lung Cancer Expected	Ratio Observed/ Expected
Welders	22	19.3	1.14
Painters	41	27.7	1.48
Cooks	27	16.3	1.66
Asbestos workers	22	15.6	1.41
Printers	2	8.1	0.25
Marine engineers	6	4.6	1.30
Electric bridge crane operators	–	0.54	–
Plumbers	19	15.0	1.27
Sheet metal workers	4	6.3	0.63
Controls	20	19.8	1.01

Under these conditions the painters and cooks would have significant excesses of lung cancer.

Discussion

The analysis of the data from this study is far from definite at this time. Perhaps not until the 1960 Census data make possible the computation of age-specific cancer mortality rates for the intercensal years in California will the final analysis be possible. Also this will allow time for all the study populations to accumulate five years of mortality experience.

It is clear that over-all increased relative risks, such as lung cancer in certain occupations being investigated here, can be misleading when a powerful and almost universally acting factor is operating. Cigarette smoking is one such factor in lung cancer. The identification of a second variable positively associated with lung cancer but independent of smoking becomes difficult.[9] This swamping effect was well demonstrated by Stocks and Campbell.[10] They found that a ninefold increased risk for lung cancer among urban nonsmokers as compared to rural nonsmokers all but disappeared when urban-rural comparisons were made between heavy smokers.

To illustrate the point, let us assume that we have a population of 100,000 men among whom 30 per cent are nonsmokers (Table 5). Assume also that the lung cancer rate for nonsmokers is ten per 100,000 and for all categories of smokers together it is ten times greater, or 100 per 100,000. In such a population of men, then, the annual lung cancer rate will be 73 per 100,000

$$\left(\frac{10 \times 30{,}000}{100{,}000} + \frac{100 \times 70{,}000}{100{,}000}\right).$$

Assume now we have a second population of men that is identical to the first except the men in the second population are exposed to a pulmonary carcinogen that acts independently from tobacco usage; and assume that the lung cancer rate for the second population is 110 per 100,000 (1.5 times that of the first population). The excess of 37 cases per 100,000 over the rate for the first population (110 − 73) is independent of tobacco use and would be found in smokers and nonsmokers with equal frequency. We would expect the lung cancer rate among nonsmokers in the second population would be 47 per 100,000 (10 + 37) and 137 among smokers (100 + 37). The relative risks between the two populations for nonsmokers, then, would be 47/10 or 4.7 and 137/100 or 1.4 for smokers.

Table 5—Illustration of Possible Masking Effect of Smoking Factor for Independently Acting Occupational Lung Cancer Hazard:

Smoking Category (1)	Population (2)	Lung Cancer Death Rate Per 100,000 General Population (3)	Lung Cancer Death Rate Per 100,000 From Occupational Factor (4)	Total* Lung Cancer Death Rate (5)	Relative Risk (5) ÷ (3)
Where Occupational Factor Increases Lung Cancer Rate 1.5 Over That of General Population					
Nonsmokers	30,000	10	37	47	4.7
Smokers	70,000	100	37	137	1.4
All categories	100,000	73	37	110	1.5
Where Occupational Factor Increases Lung Cancer Rate Twofold					
Nonsmokers	30,000	10	73	83	8.3
Smokers	70,000	100	73	173	1.7
All categories	100,000	73	73	146	2.0
Where Occupational Factor Increases Lung Cancer Risk Twofold in Absence of Smoking					
Nonsmokers	30,000	10	10	20	2.0
Smokers	70,000	100	10	110	1.1
All categories	100,000	73	10	83	1.1 (4)

* These examples neglect the instances where the same individual would develop lung cancer from either of two independent causes. The rates as shown would not be changed by this correction.

In a similar manner, if a population engaged in an occupation has twice the rate of lung cancer than would be expected from general population experience, this may actually represent an eightfold increased risk if it could be examined in the absence of the effect of the smoking factor.

The final illustration is concerned with an occupational factor that would double the risk of lung cancer if there were no smoking factor operating. The doubling effect would only be evident among nonsmokers, and for the whole occupational population this hazard would be difficult to identify since it would increase the lung cancer risk only 14 per cent (Table 5, 83÷73=1.14).

If it turns out that some of the occupations being studied do show a significant excess of lung cancer in the range of 1.5- to 2-fold, it is of interest to realize that this could represent a carcinogenic factor of considerable importance in its own right. The converse of this must also be kept in mind as a possibility, with occupational exposure enhancing the effect of smoking.

Summary

A case-control study of lung cancer cases and matched controls disclosed a number of occupations to have an apparently increased risk of lung cancer. To examine these possibilities further a prospective study is now under way. Populations of men engaged in these and other specific occupations, including a group serving as a control population, were assembled and we are now following their lung cancer experience by searching these populations for matches with all male lung cancer deaths of California residents.

Only a preliminary analysis is possible at this time because of uncertain postcensal age-specific cancer mortality rates and the need for additional follow-up time—at least five years. Consideration of sources of deficit of cancer deaths in the study populations indicates the 15 per cent deficit calculated for deaths other than lung cancer to be an adequate approximation.

Most of the study occupations have a larger proportion of cigarette smokers and heavier consumption than is true for the control population. The latter appear to be quite representative of California males generally in respect to cigarette smoking. Relative risks for each occupation as compared to the control population are computed, considering the smoking distribution of the controls as representing unit relative risk.

Correcting the observed lung cancer deaths for the apparent deficit in our study conditions and the expected lung cancer deaths for smoking practice leaves at least two occupations with tentative excesses of lung cancer risk. These are cooks and painters.

The order of magnitude of over-all increased lung cancer risk we can expect in these populations now appears in the 1.5-fold to 2-fold range. This would represent an increased risk from the occupational exposure in the range of 5- to 9-fold for nonsmokers, if the occupation's factor were acting independently from the smoking factor.

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Honors to Canadian Health Workers

At its 51st Annual Meeting, held this year in Halifax, the Canadian Public Health Association honored three public health leaders with Honorary Memberships for outstanding and devoted service over the years. CPHA has been making these awards since 1933. This year the honors went to Russell Johnson Collins, B.A., M.A., M.D., a pioneer leader in tuberculosis control in the Maritimes; to Mona Gordon Wilson, O.B.E., R.N., who as a public health nurse laid the foundations of the provincial health services in Prince Edward Island; and to Eunice Henrietta Dyke, Reg. N., another leader in public health nursing who in 1914 began the development of the generalized public health nursing service in the Department of Health, City of Toronto.