CHAPTER 12. SMOKING HABITS AND AIR POLLUTION IN RELATION TO LUNG CANCER

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SMOKING

Extensive reviews of the literature (1,2) on the relationship between smoking habits and lung cancer have appeared so recently that there is no point in covering the same ground in detail here. Instead, we will present some previously unpublished data from a large prospective study and briefly summarize the results of other epidemiological, pathological, and experimental investigations.

In 1939 Müller (3) reported that a history of cigarette smoking was far more common in a sample of lung cancer patients than in a sample of patients with other diseases. In the same year, Ochsner and De Bakey (4) observed that nearly all of their lung cancer patients were cigarette smokers. This attracted little attention until the late 1940's when mortality statistics from many countries indicated that death rates from lung cancer had been increasing rapidly during the preceding two or three decades. The concomitant increase in both cigarette smoking and air pollution of certain types suggested that one or the other of these two factors might be the culprit. The association between cigarette consumption and lung cancer death rates in various countries -- and the reportedly higher lung cancer death rates in urban areas than in rural areas -- pointed to these same two factors.

In 1950, Wynder and Graham (5) and Levin et al. (6) reported the results of retrospective studies in which a history of cigarette smoking (particularly heavy cigarette smoking) was found in a far higher proportion of lung cancer patients than control subjects. The same was found in 1952 by Doll and Hill (7) and in many retrospective studies caried out by other investigators in later years.

The results of two prospective studies (8,9), first reported in 1954, confirmed the association between cigarette smoking and lung cancer death rates, as did the results of several later prospective studies (10-14). Findings in all of these studies are in such good agreement that it suffices to present data from just one of them as described below.

Starting on October 1, 1959 volunteer workers of the American Cancer Society enrolled over 1,000,000 men and women and requested each of them to answer a detailed questionnaire including questions on smoking habits, place of residence, occupational exposures, and many other factors. The study area covered 1,121 counties in 25 states. Many of these counties are rural and far removed from any large city; but 16 of the 20 largest cities in the United States, as well as many smaller cities, towns, and suburban areas were included. Nearly 99% of the subjects were traced for the ensuing six years; and at two-year intervals surviving subjects were requested to answer brief questionnaires. Causes of death were ascertained from death certificates. Whenever cancer was mentioned on a death certificate, the doctor, hospital, or cancer registry was requested to supply additional medical information.

Findings on smoking in relation to death rates were last presented after the subjects had been traced for four years (15). The data about to be described cover the entire six-year period and 5,736,868 person-years of exposure to risk (2,472,758 man-years and 3,264,110 woman-years) of subjects aged 35-84 at the start of the study. During the six years, 2,063 of the male subjects and 327 of the female subjects died of lung cancer. The subjects were divided into five-year age groups according to their ages at the time they enrolled in the study.

Death rates were computed for each of these five-year date-of-birth cohorts by dividing the number of deaths during the six years by the person-years of exposure to risk. Age-standardized death rates for broader age groups were computed by averaging the component five-year group rates weighted by the total number of subjects in each component five-year age group.

Findings in Men

Table 1 shows lung cancer death rates of the male subjects classified by type of smoking (lifetime history), and by age at time of enrollment in the study. The death rates were lowest in men who never smoked regularly; somewhat higher in pipe and cigar smokers who had never smoked cigarettes regularly; far higher in cigarette smokers who had also smoked pipes or cigars; and highest in men with a history of smoking only cigarettes.

Mortality ratios were calculated by dividing the death rate of men in each smoking category by the death rate of men who never smoked regularly. For age group 35-84, the mortality ratio was 1.00 for men who had never smoked regularly, 2.23 for men with a history of only pipe smoking, 2.15 for men with a history of only cigar smoking, 8.23 for men with a history of cigarette and other types of smoking, and 10.08 for men with a history of only cigarette smoking.

Table 2 is confined to men who were currently smoking cigarettes regularly at the time that they enrolled in the study (some of them also smoked or had smoked pipes or cigars regularly). They are classified in three different ways: 1) by current number of cigarettes smoked per day; 2) by degree of inhalation of cigarettes smoked; and 3) by age at start of cigarette smoking. These three indices of exposure are highly correlated with each other. For example, men who started cigarette smoking at an early age tend to smoke more cigarettes a day and tend to inhale the smoke more deeply than men who started cigarette smoking later in life (16).

TABLE 1 -- NUMBER OF MEN WHO DIED OF LUNG CANCER, AGE-STANDARDIZED DEATH RATES PER 100,000 MAN-YEARS AND MORTALITY RATIOS, BY TYPE OF SMOKING (LIFETIME HISTORY) AND AGE AT START OF STUDY.

Type of smoking (lifetime history)	Age 35-54 No. of Deaths	Age 35-54 Death Rate	Age 55-69 No. of Deaths	Age 55-69 Death Rate	Age 70-84 No. of Deaths	Age 70-84 Death Rate	All ages 35-84 No. of Deaths	All ages 35-84 Death Rate
Never smoked regularly	21	7	41	19	21	35	83	13
Pipe only	2	5	17	50	15	110	34	29
Pipe and cigar	1	2	9	24	11	81	21	16
Cigar only	6	14	27	46	9	54	42	28
Cigarette & other	145	45	355	167	98	295	598	107
Cigarette only	427	57	743	216	115	311	1285	131
Total	602	41	1192	132	269	155	2063	81

Lung Cancer Mortality Ratios (Men)

Type of smoking (lifetime history)	Age 35-54	Age 55-69	Age 70-84	All ages 35-84
Never smoked regularly	1.00	1.00	1.00	1.00
Pipe only	0.71	2.63	3.14	2.23
Pipe and cigar	0.29	1.26	2.31	1.23
Cigar only	2.00	2.42	1.54	2.15
Cigarette & other	6.43	8.79	8.43	8.23
Cigarette only	8.14	11.37	8.89	10.08

Lung cancer death rates increase with degree of exposure as measured by each of the three indices. For example, the lung cancer mortality ratio (ages 35-84) increased from 4.62 for men who smoked one to nine cigarettes a day up to 18.77 for men who smoked 40 or more cigarettes a day.

In a number of different studies, it has been found that lung cancer death rates are lower among former cigarette smokers who gave up the habit, than among men who continue to smoke cigarettes. One would like to know how soon the risk begins to diminish after the cessation of smoking. This is difficult to ascertain for three reasons:

1) In some instances, symptoms produced by undiagnosed lung cancer may lead a man to stop smoking; and it seems unlikely that giving up smoking would lead to the regression of an already established carcinoma.

2) Unless the number of ex-smokers under observation is extremely large, subjects must be traced for several years to accumulate enough person-years of exposure to risk for lung cancer death rates to be reasonably stable statistically.

3) Many smokers give up the habit for a few months or a year or two and then resume smoking again (16).

Table 3 is confined to men aged 50 to 74 (at the time of enrollment) who either had a lifetime history of only cigarette smoking or who had never smoked regularly. At the time of enrollment, a few subjects said that they had lung cancer; these are excluded. The men are divided into three groups according to their status at the time of enrollment: those who were currently smoking, those who had stopped smoking, and those who had never smoked regularly. The ex-smokers are divided by years since last smoking and by former amount of smoking. The current smokers are divided by current amount of smoking.

TABLE 2 -- NUMBER OF LUNG CANCER DEATHS, AGE-STANDARDIZED DEATH RATES AND MORTALITY RATIOS BY CURRENT NUMBER OF CIGARETTES SMOKED PER DAY, DEGREE OF INHALATION AND AGE BEGAN SMOKING. (FIGURES FOR MEN WHO NEVER SMOKED REGULARLY ARE SHOWN FOR COMPARISON).

Number of cigarettes a day, degree of inhalation, and age began smoking	Age 35-54		Age 55-69		Age 70-84		All ages 35-84	
	No. of Deaths	Death Rate	No. of Deaths	Death Rate	No. of Deaths	Death Rate	No. of Deaths	Death Rate
Current No. of cigarettes a day								
1-9	14	37	24	90	5	94	43	60
10-19	35	37	95	189	21	333	151	112
20-30	267	74	390	318	44	502	701	191
40 +	67	80	94	399	9	788	170	244
Degree of Inhalation								
None	9	34	48	212	7	150	64	104
Slight	29	41	86	210	15	260	130	116
Moderate	224	67	338	286	33	418	595	170
Deep	120	79	131	319	23	848	274	221
Age began smoking								
25 +	11	24	28	99	3	60	42	53
20-24	68	50	117	228	11	303	196	131
15-19	217	68	326	310	45	581	588	191
<15	72	105	97	345	16	491	185	218
Never smoked regularly		7		19		35		13

Lung Cancer Mortality Ratios (Men)

Current No. of cigarettes a day				
1-9	5.29	4.74	2.69	4.62
10-19	5.29	9.95	9.51	8.62
20-30	10.57	16.74	14.34	14.69
40 +	11.43	21.00	22.51	18.77
Degree of inhalation				
None	4.86	11.16	4.19	8.00
Slight	5.86	11.05	7.43	8.92
Moderate	9.57	15.05	11.94	13.08
Deep	11.29	16.79	24.23	17.00
Age began smoking				
25 +	3.43	5.21	1.71	4.08
20-24	7.14	12.00	8.66	10.08
15-19	9.71	16.32	16.60	14.69
<15	15.00	18.16	14.03	16.77
Never smoked regularly	1.00	1.00	1.00	1.00

From data obtained in repeat questionnaires we know that some of the men here classified as ex-smokers resumed smoking at a later date (this being most frequent among men who had stopped less than two years before enrollment in the study) (16). We also know that some of those here classified as current smokers gave up the habit at a later date. These changes in habits have not been taken into consideration because we lack information on such changes as may have occurred among men who died during the two-year intervals between repeat questionnaires.

The lung cancer death rates for men who had given up cigarette smoking less than one year before enrolling in the study were about the same as for men who were currently smoking cigarettes at that time. Those who had given up the habit for more than one year had lower lung cancer death rates than the current smokers. Among ex-cigarette smokers, lung cancer death rates decreased with length of time since last smoking.

Findings in Females

In the United States, cigarette smoking became a popular habit among men some years before it started to become popular among women. During the period covered by our study, few women in the older age groups were cigarette smokers; and fewer young women than young men were cigarette smokers. As a group, the female smokers had taken up the habit later in life than the male smokers, smoked fewer cigarettes a day, tended to inhale the smoke less deeply and were more likely to smoke low-tar, low-nicotine cigarettes (17).

Table 4 shows lung cancer death rates of female subjects classified by their smoking habits. Figures shown on the line labeled "history of smoking" include ex-smokers as well as current smokers. On lower lines, current smokers are classified by three different indices of exposure: number of cigarettes smoked per day, degree of inhalation of cigarette smoke, and age they began cigarette smoking. Lung cancer death rates are higher in the smokers than in the non-smokers and increase with amount of cigarette smoking.

TABLE 3 -- AGE STANDARDIZED LUNG CANCER DEATH RATES FOR EX-CIGARETTE SMOKERS WITH A HISTORY OF CIGARETTE SMOKING ONLY, BY FORMER NUMBER OF CIGARETTES SMOKED PER DAY, AND YEARS SINCE LAST CIGARETTE SMOKING. DEATH RATES FOR CURRENT CIGARETTE SMOKERS WITH A HISTORY OF CIGARETTE SMOKING ONLY AND MEN WHO NEVER SMOKED REGULARLY ARE SHOWN FOR COMPARISON. MEN AGED 50-74 WHO DID NOT HAVE A HISTORY OF LUNG CANCER AT THE START OF THE STUDY.

	Smoked 1-19 cigarettes a day			Smoked 20 + cigarettes a day		
Ex-cigarette smokers (years since last cigarette smoked)	No. of Men	No. of Deaths	Death Rate	No. of Men	No. of Deaths	Death Rate
Under 1 year	812	5	114	2,308	32	283
1-4 years	1,990	6	53	5,662	43	162
5-9 years	1,913	2	20	6,108	30	104
10 + years	4,638	2	7	8,681	13	29
Total ex-smokers	9,353	15	28	22,759	118	101
Current cigarette smokers	24,523	154	120	58,739	690	271
Never smoked regularly	62,590	60	16	62,590	60	16

The lung cancer death rates and mortality ratios shown in Table 4 for women are not as high as those shown in Table 2 for men. This is almost certainly due in part to difference in exposure. For example, among men and women who smoked the same number of cigarettes per day, the women, as a group, inhaled the smoke less deeply than the men and had started smoking later in life. This difference in habits between the sexes is more pronounced in older than in younger age groups. However, it probably does not fully account for the sex difference in lung cancer death rates.

Other Evidence

Evidence from histologic studies carried out on men who died and came to autopsy is fully consistent with the evidence from epidemiological studies (18,19). Cigarette smoking is associated with the following changes in bronchial epithelium: loss of cilia in many areas, hyperplasia, squamous metaplasia, a great increase in the number of cells with atypical nuclei, and the occurrence of carcinoma-in-situ. (See Chapter 3.) All of these changes occur more frequently in cigarette smokers than in non-smokers, and increase in frequency with amount of cigarette smoking. Such changes are found to a far lesser extent in former cigarette smokers who gave up the habit some years prior to their terminal illness, than in men who continued to smoke cigarettes up to the time of their terminal illness (20).

Experimental studies have shown that exposure to cigarette smoke inhibits the action of cilia of the bronchial epithelium (21). This reduces the efficiency of removal of foreign material from the bronchial tubes.

Many investigators have produced skin cancer in experimental animals by the application of cigarette smoke condensates (22); and invasive lung tumors (including early squamous cell carcinoma) have been produced in beagle dogs by the smoking of non-filter cigarettes daily for over two years (23,24). Such experiments have been carried out primarily as a means of testing the relative carcinogenicity of various types of cigarettes and various components of cigarette smoke. Hopefully, it may be possible to develop cigarettes which are less potent in respect to the production of lung cancer than are cigarettes which are most popular at the present time.

URBAN AIR POLLUTION

It is well established that occupational exposure to certain specific types of air contaminants carries a greatly increased risk of lung cancer. Here we are primarily concerned with urban air pollution to which all residents of modern cities and metropolitan areas are exposed to a greater or lesser degree. However, we cannot altogether avoid the subject of occupational exposure since, in developed countries, a considerable proportion of all men (including many farmers) are occupationally exposed to air contaminants of one sort or another.

Cancer produced by exposure to a chemical agent typically does not occur until long after initial exposure; and, unless the agent is retained in the body, the risk of developing the disease generally declines if exposure is discontinued. Therefore, the most valid design for investigating the association between exposure to a specified substance and the occurrence of cancer requires knowledge of the lifetime history of the exposure of each subject -- at least a rough estimate of the time since first exposure and a rough estimate of degree of exposure. As previously described, such information was obtained in both retrospective and prospective studies of exposure to tobacco smoke. It has also been obtained with a fair degree of accuracy in many studies of occupational exposure to specific agents. Unfortunately, it would be extremely difficult, if not impossible, to obtain such information on each subject included in a study of general urban air pollution. There are manifold problems:

1) "Urban air pollution" is a non-specific term in the sense that it covers an extremely wide range of different types of pollution: various gases, organic particles, inorganic particles, and even particles too large to be inhaled. There is probably no urban area in which just one type of air pollutant is

TABLE 4 -- LUNG CANCER (WOMEN). NUMBER OF DEATHS, AGE STANDARDIZED DEATH RATES AND MORTALITY RATIOS, BY TYPE OF SMOKERS (LIFETIME HISTORY), CURRENT NUMBER OF CIGARETTES SMOKED PER DAY, DEGREE OF INHALATION AND AGE BEGAN SMOKING; BY AGE AT START OF STUDY.

	Age 40-54		Age 55-74		All Ages 40-74	
Smoking history	No. of Deaths	Death Rate	No. of Deaths	Death Rate	No. of Deaths	Death Rate
Never smoked regularly	45	4	121	13	166	8
History of cigarette smoking	94	14	67	31	161	21
Current regular cigarette smoking						
Current No. of cigarettes a day						
1-9	7	6	8	14	15	10
10-19	18	10	16	31	34	19
20-39	51	21	34	63	85	39
40 +	10	53	2	69	12	60
Degree of inhalation						
None	7	10	11	23	18	16
Slight	17	13	13	25	30	18
Moderate	40	13	26	49	66	28
Deep	21	26	9	99	30	57
Age began smoking						
25 +	11	6	40	34	51	18
20-24	24	16	10	42	34	27
15-19	43	20	9	67	52	40
< 15	6	36	-	-	6	20

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Lung Cancer Mortality Ratios (Women)

Never smoked regularly	1.00	1.00	1.00
History of cigarette smoking	3.50	2.38	2.63
Current regular cigarette smoking			
Current No. of cigarettes a day			
1-9	1.50	1.08	1.25
10-19	2.50	2.38	2.38
20-39	5.25	4.85	4.88
40 +	13.25	5.31	7.50
Degree of inhalation			
None	2.50	1.77	2.00
Slight	3.25	1.92	2.25
Moderate	3.25	3.77	3.50
Deep	6.50	7.62	7.13
Age began smoking			
25 +	1.50	2.62	2.25
20-24	4.00	3.23	3.38
15-19	5.00	5.15	5.00
< 15	9.00	-	2.50

present, and probably no two areas with precisely the same qualitative and quantitative combination of pollutants.

2) Within the same metropolitan area, the type and amount of pollution varies in different neighborhoods, and varies from day to day and year to year. Furthermore, qualitative and quantitative analyses of air samples have not been carried out on a routine basis in many localities until recent years. Even now, one may question the adequacy of such sampling for determining the current exposure of individuals living in different neighborhoods of the same metropolitan area.

3) A large proportion of American men live at some distance from their place of work. They may be exposed to different types and degrees of air pollution at home, on their way to work, and in their place of work.

4) Americans are remarkably mobile; many move from one location to another every few years. This complicates the problem of ascertaining the type and extent of exposure. Furthermore, state-of-health can influence whether a person moves from one location to another. This is an additional complicating factor.

Because of these difficulties, we are generally unable to obtain an accurate estimate of the degree of exposure of an individual to each of various types of air pollutants during his lifetime. As a poor substitute, we can divide individuals into groups by residence history and use this as a very crude index of exposure history. Alternatively, we can ascertain lung cancer death rates in various localities which currently differ in type or degree of air pollution. In some instances, a compromise may be made between these two procedures. Whichever procedure is used, smoking habits and occupational exposure should be taken into consideration.

Table 5, based upon data from the American Cancer Society's prospective study previously described, is confined to male subjects who, at the time of enrollment, said that they had lived in their present neighborhood for at least ten years. Thus they had a minimum of ten years of exposure to the type and amount of air pollution occurring in their neighborhoods during those years. The total group was divided into six subgroups: men who never smoked regularly, and five sets of smokers classified by type and amount of smoking. Lung cancer death rates were calculated for men in each five-year group, in each of the six subgroups. These death rates were applied to the man-years of exposure to risk of men in each of the various categories shown in Table 5. The resulting figures represent the expected number of lung cancer deaths in each category, adjusted for age distribution and smoking habits. The observed number of lung cancer deaths divided by the expected number yields the mortality ratio. By definition, the mortality ratio for all subjects combined is 1.00.

The subjects are divided into various groups by place of residence. Within each of these groups they are subdivided according to whether they said that they were or ever had been occupationally exposed to dust, fumes, vapors, gases, or X-rays. The exposures reported covered a wide range (e.g., firemen exposed to smoke, garage workers exposed to automobile exhausts, asbestos workers, miners, farmers exposed to insecticide sprays, etc.) Many of the exposed men probably had only a low level of occupational exposuré for a relatively short length of time. Others may have had a high level of exposure for many years.

Without regard to place of residence, the lung cancer mortality ratio was 1.09 for men with occupational exposure and 0.96 for men without occupational exposure, a relative difference of 13.5%. In large metropolitan areas, the relative difference between the occupationally exposed and unexposed groups was 26%, in smaller metropolitan areas 18%, and in non-metropolitan areas 7%. These differences are probably due to different types of occupational exposures in different areas.

TABLE 5 -- OBSERVED AND EXPECTED NUMBER OF LUNG CANCER DEATHS BY PLACE OF RESIDENCE AND BY OCCUPATIONAL EXPOSURE TO DUST, FUMES, GASES, OR X-RAYS. ADJUSTED FOR AGE AND FOR SMOKING HABITS. CONFINED TO MEN WHO HAD LIVED IN SAME NEIGHBORHOOD FOR LAST 10+ YEARS.

Place of residence	Occupationally exposed to dust, fumes, etc.			Not occupationally exposed to dust, fumes, etc.		
	Obs. No.	Exp. No.	Ratio	Obs. No.	Exp. No.	Ratio
Total, all male subjects	576	530.5	1.09	934	979.7	0.96
Metropolitan area, pop. 1,000,000 +	165	134.1	1.23	281	285.7	0.98
City	92	69.1	1.33	168	158.3	1.06
Town or Rural	73	65.0	1.12	113	127.4	0.89
Metropolitan area, pop. <1,000,000	166	145.4	1.14	271	280.5	0.97
City	92	83.3	1.10	170	184.0	0.92
Town or Rural	74	62.1	1.19	101	96.5	1.05
Non-metropolitan area:	245	251.0	0.98	382	413.5	0.92
Town	102	104.9	0.97	200	199.1	1.00
Rural	143	146.1	0.98	182	214.4	0.85
Los Angeles, Riverside, & Orange Counties, Cal.	30	21.9	1.37	38	39.6	0.96
Farmers	63	77.6	0.81	71	92.9	0.76
8 Cities: High particulates (130-180 $\mu g/m^3$)	45	32.9	1.37	66	73.9	0.89
11 " Moderate " (100-129 $\mu g/m^3$)	21	18.8	1.12	39	49.5	0.79
14 " Low " (35-99 $\mu g/m^3$)	48	37.4	1.28	110	100.1	1.10
9 Cities: High Benz. Sol. (8.5-15.0 $\mu g/m^3$)	28	21.0	1.33	52	51.5	1.01
10 " Moderate " (6.5- 7.9 $\mu g/m^3$)	44	32.7	1.35	65	75.1	0.87
12 " Low " (3.4- 6.3 $\mu g/m^3$)	33	29.2	1.13	76	81.8	0.93

Clearly, occupational exposure should be taken into consideration in any study of the possible effects of general urban air pollution. The simplest way of doing this is to confine attention to men without occupational exposure.

Men Without Occupational Exposure

In the top part of Table 5, the subjects are divided into six groups by size of place of residence according to the 1960 census of the United States. The term "metropolitan area" means a county or a group of contiguous counties with at least one city of 50,000+ inhabitants, or "twin cities" with a combined population of at least 50,000. As used here, the term "town" means a place with a population of 2,500 to 49,999 people, and "rural" means those who live in the country or a village with less than 2,500 people. In some metropolitan areas, legally independent towns abut on a central city and, in a non-legal sense, are actually a part of the city (a situation similar to Greater London in contrast to the City of London).

Generally speaking (but with exceptions), it may be assumed that urban air pollution tends to be greater in large metropolitan areas than in smaller metropolitan areas, far less in non-metropolitan areas, and least in rural parts of non-metropolitan areas. Most of the non-metropolitan areas included in this study are far removed from any city and many do not even contain a large town.

Among men without occupational exposure, the lung cancer mortality ratio was 0.98 for those living in large metropolitan areas (1,000,000+ population), 0.97 for those living in smaller metropolitan areas, and 0.92 for those living in non-metropolitan areas. The highest mortality ratios (1.06 and 1.05) were for men living in cities in large metropolitan areas, and for men living in towns and rural parts of smaller metropolitan areas. The lowest mortality ratios (0.85 and 0.89) were for men living in rural parts of non-metropolitan areas, and for men living in towns and rural parts of large metropolitan counties. The mortality ratio for men living in towns in non-metropolitan areas (1.00) was higher than the mortality ratio of men living in cities in smaller metropolitan areas (0.92). This set of figures gives little or no support to the hypothesis that urban air pollution has an important effect upon lung cancer death rates.

Los Angeles county in California, and major parts of two adjacent counties (Riverside and Orange), have unusually heavy air pollution in respect to oxidants and carbon monoxide (13). They also have high air pollution in terms of total suspended particulate matter and benzene-soluble particulate matter. The lung cancer mortality ratio for men living in these three counties was the same as for all subjects without occupational exposure (0.96).

Data are shown for farmers, including retired farmers living in towns, but excluding: 1) farmers living in metropolitan areas of 500,000+ population and 2) retired farmers living in cities or in metropolitan areas of 500,000+ population. The majority of these farmers lived in strictly rural areas far from any large city -- and far from any major medical center. Their lung cancer mortality ratio was only 0.76. We suspect that this figure is artificially low for two reasons:

1) In strictly rural areas of the United States there are usually few doctors and usually little in the way of medical facilities. Under such conditions, some deaths due to lung cancer may be mistakenly attributed to other causes.

2) In past times, when a farmer's health began to fail, he usually remained on the farm and his son took over the work. Today, he is far more likely to move to a city. This selective removal from rural areas of men in ill health reduces the death rate in rural areas.

Data on the mean level of suspended particulate matter in the air of 57 American cities is provided in Statistical Abstracts in the United States, 1970 (25), for the year 1968. The mean levels ranged from 32 mg/m^3 to 306 mg/m^3. It is likely that the mean level in some of the cities changed considerably during the last four decades or so. However, lacking evidence to the contrary, we will assume that the rank order of these cities in respect to suspended particulate matter did not change greatly. Thirty-three of the cities were included in our study and we divided them into three groups by mean level of suspended particulate matter in 1968.

The mortality ratios (for men without occupational exposure) were: 0.89 for cities with the highest mean levels of suspended particulate matter; 0.79 for cities within the intermediate category; and 1.10 for cities with the lowest mean levels of suspended particulate matter. Since it seems unlikely that suspended particulate matter decreases the risk of lung cancer, we conclude that urban air pollution as measured by this index is unrelated to death rates from lung cancer.

Statistical Abstracts of the United States, 1970 (25) also provides information on the mean level of benzene-soluble organic matter for the year 1968 in the air of 55 cities, 31 of which were included in the study. As shown in Table 5, there appears to be little if any association between lung cancer mortality ratios and this index of urban pollution.

CONCLUSION

In a review of the literature published some years ago (26), the authors concluded that there was no firm evidence in support of the hypothesis that general urban air pollution increases the risk of lung cáncer to an important degree, if at all. Data from our study supports that conclusion; and we are unaware of any evidence which convincingly leads to a contrary conclusion.

Available evidence does not rule out the possibility that general urban air pollution may perhaps lead to a slight increase in the risk of lung cancer. It also does not rule out the possibility that if no efforts were made to control air pollution, then at some future date it might increase to a level such that it would result in a significant increase in the risk of lung cancer. Fortunately, for good and sufficient reasons (other than lung cancer risk), steps are now being taken to reduce air

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pollution. If reasonably successful, these steps should eliminate the possibility that general urban air pollution will result in an increase in risk of lung cancer at some future date.

A WORD OF CAUTION IS IN ORDER -- Up until now, this discussion has been confined to the subject of general urban air pollution to which all persons living in metropolitan areas are more or less exposed. But people who live in the neighborhood of an industrial plant which discharges a specific type of air pollutant in considerable quantities may be in a different position. Some such pollutants (e.g. asbestos dust) greatly increase the risk of lung cancer among occupationally exposed workers; and it is possible that, in some instances, exposure of people living in the vicinity of a plant may reach dangerous levels. This matter deserves more attention than it has received in the past.

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