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LUNG CANCER

CANCER OF THE LUNG AND LOS-ANGELES-TYPE AIR POLLUTION

Prospective Study

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Questionnaires on cigarette smoking status, residence history and other characteristics were mailed to men of the California Division of the American Legion. Subsequent checking of this population against the California mortality records for 1959 through 1962 disclosed the numbers of deaths, including those due to cancer of the lung and provided 336,571 man-years of observation. The pulmonary cancer gradient by smoking level was less pronounced than that found in other studies. The two major metropolitan areas. Los Angeles and Bay Area plus San Diego, had higher mortality rates for cancer of the lung than remaining mixed rural and urban counties and these differences were relatively greater among nonsmokers. With controls for smoking and length of residence, the risk of pulmonary cancer in Los Angeles, where photochemical air pollution levels are highest, was not greater than in other major metropolitan areas of California.

A DECADE AGO SOME OF THE SAME EPIDEMOlogic studies that gave evidence of the high risk of pulmonary cancer for cigarette smokers also provided evidence of a further risk of the disease for city dwellers.[7, 11] This further risk was modest compared to that for cigarette smokers, but it could not be explained entirely in terms of geographic differences in either smoking habits or in diagnostic efficiency.[1, 2] Air pollution has been the most prominent, if unproven, hypothesis to explain the increased urban risk of cancer of the lung.

AIR POLLUTION IN CALIFORNIA

California is remarkably free of the type of air pollution characteristic of Eastern-United States and European cities, which has been due largely to coal burning. But since the mid-1940's Los Angeles has been affected by photochemical "smog" resulting mainly from the oxidation of hydrocarbons in automobile exhaust under the influence of sun light. From gross observation it appeared that Los Angeles was affected much more seriously by photochemical smog than other metropolitan areas of the state. In fact during the late 1940's it was regarded as a "joke" on Los Angeles even by other Californians. As it increased and spread to other metropolitan communities of the state, it was taken more seriously and systematic study was initiated.

MORTALITY FROM CANCER OF LUNG IN CALIFORNIA CITIES

The rates of mortality from cancer of the lung (Table 1) have been lower in Los Angeles County than in San Francisco, though higher than in the other California counties taken together. San Francisco is rather densely populated but, with its favored location on a peninsula between the Pacific Ocean and

TABLE 1. Deaths from Cancer of the Lung per 100,000* Men Aged 25 and Older in the General Population of California, by Area

Year	Los Angeles County	San Francisco County	All other counties
1950	38.0	44.5	34.3
1960	64.6	68.7	56.0

* Rates are age-adjusted by direct method to California male population, aged 25 and older, 1950. The annual rates shown are each based on annual average numbers of deaths during a 3-year period.

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San Francisco Bay, air pollution there has not been as visibly present as in Los Angeles.

THE PROBLEM

Los Angeles, then, appears to have more air pollution but San Francisco a higher rate of pulmonary cancer. An unsatisfactory feature of the mortality rates, however, is that they may have been influenced by a reduced risk of pulmonary risk by recent immigrants to California. Los Angeles County especially has experienced a tremendous immigration of persons from other states; if the migrants come from regions not subject to high rates of pulmonary cancer, their inclusion in the rates could dilute the presumed effect of long-term residence in Los Angeles. In addition, cigarette smoking is such an overwhelming factor in cancer of the lung that regional smoking differences might affect the rates. Assuming these two conditions, the question is: At comparable smoking levels, do the long term residents of Los Angeles have a higher rate of pulmonary cancer than the long-term residents of other metropolitan areas of California?

METHOD

To answer this question we began in 1957 a prospective study in which we collected information on cigarette smoking and residence history from a population of men in middle and later life. Thereafter the population was followed for several years through the vital statistics index to ascertain the relationship between mortality from cancer of the lung (and other conditions) and residence in Los Angeles and the other metropolitan communities of the state.

Experience with an earlier prospective study[4] of members of labor unions, with 85% questionnaires returned after three mailings, suggested that working through an organized group would be desirable. The California Division of the American Legion, the veterans organization, agreed to cooperate by furnishing three copies of the mailing list of about 140,000 subscribers to a monthly magazine. A test mailing with an original and two follow-up letters to the membership of two local legion posts led us to believe that between 70 and 75% of subscribers would respond. Unfortunately that test misled us; we received between 50 and 60% returns after three mailings. The rate of return cannot be computed exactly because the subscription list apparently includes many business places, deceased persons and others from whom a return could not be expected. A total of 71,129 questionnaires were returned with answers.

The first mailing took place in May 1957, the third mailing in September 1957 and the last questionnaire in December 1957. The mortality experience of the men was observed by checking against the California death record for five years, January 1, 1958 to December 31, 1962. The few deaths occurring during the collection period, May through December 1957, were ignored. For 1958 and 1959, record linkage was done by visual comparison of death records against the population listing, a laborious procedure which resulted in missing possibly 5 to 7% of true matches. For 1960, 1961 and 1962 the appropriate information from death records was on tape; a computer program was developed and working by 1964 and failure to find true matches became, according to sample rechecks, negligible. By whatever method, the acceptance of false matches was negligible.

There is, then, an undercount of deaths in the first two years. But it is highly unlikely that this has had a biassing effect on results because the undercounting has not been disproportionate in the residence categories used for analysis.

It was not feasible to keep in touch with the men once the data were collected. While this introduces a further undercount of mortality due to men who died after migrating to another state, the loss must be minute: a Current Population Report on Mobility (April 1958 to April 1959)[12] indicates that less than 1.5% of the male population aged 45 and older moved between states annually; the proportion moving out of California must be much lower because immigration to California contributed so much to the figure of 1.5%

After eliminating some unusable questionnaires and imposing a lower age limit of 25, we had the questionnaires of 69,868 men to start the study as of January 1, 1958. The total number of man-years of observation during 5 years, 1958–62, was calculated after observing the annual mortality from any cause and dropping each decedent from the count after assuming that he contributed, on average, one-half man-year of exposure during the year in which death occurred. Calculations were made by 10-year age group, taking account of passage from one age group to the next during the interval. In total we observed 336,571 man-years.

Study Population

The distribution of ages of the men is unusual, as it has two peaks reflecting the mobilization and conscription of men in World Wars I and II. The numbers of men in the study population increased during the age span from 55 to 65 while the general population numbers decrease over these years (Fig. 1). Because of this and other features of the distribution, age adjustment, even by five age groups, would not make the study population comparable to the general population; consequently, no comparisons with general population mortality rates seem to be justified.

When the questionnaire was developed and tested in late 1956, the questions on smoking identified only those with a history of cigarete smoking, without distinction as to whether they had discontinued the practice and did not identify pipe or cigar smokers. While in retrospect it was a mistake to do so, the questions were simply carried over from an earlier questionnaire of 1953 used on a prospective study of selected occupations. In both studies the interest was not in cigarette smoking as a cause of pulmonary cancer but in occupational exposures and air pollution, respectively, as factors in this disease. We were interested in cigarette smoking practices for control of this important variable while examining the variables of major interest. Consequently our results on smoking and cancer of the lung are not fully comparable with those of other studies.[3, 6, 7]

Risk of pulmonary cancer by level of current cigarette smoking frequently is measured against a unit-risk class of those who had never smoked tobacco. In our results the risk by level of cigarette smoking is for combined current and discontinued cigarette smokers and is measured against a unit risk class of nonusers of cigarettes which includes those who smoked pipes and cigars exclusively, as well as nonusers of tobacco. About 28% of the men had no history of regular cigarette smoking, defined as never having smoked regularly for as long as one year.

The pulmonary cancer–cigarette-smoking gradients (Table 2) reveal higher risks with

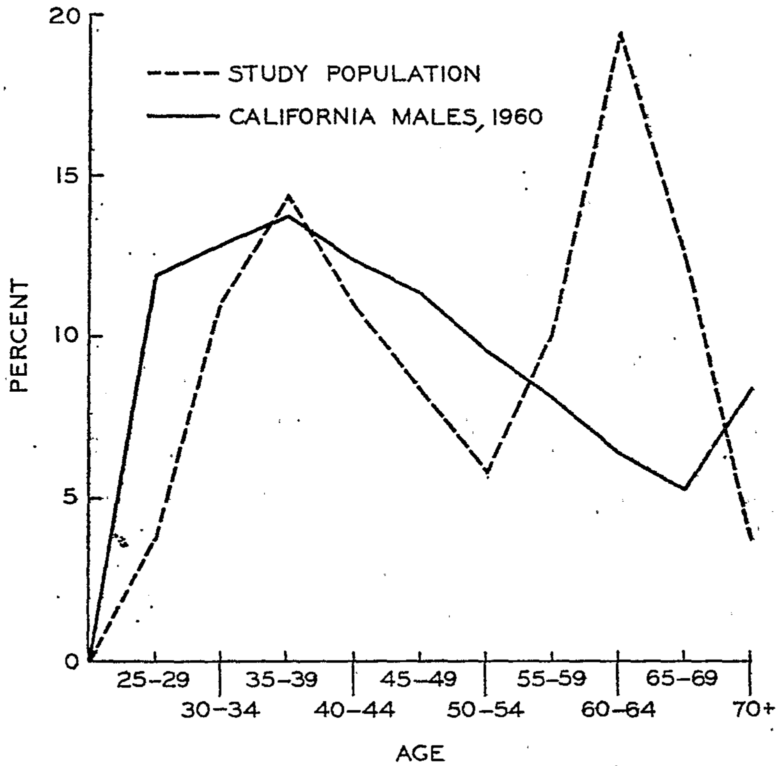

Fig. 1. Percentage distribution by 5-year age group of the American Legion study population and California men, ages 25 and older, 1960.

TABLE 2. Deaths from Cancer of the Lung and Rates per 100,000 Man-years by Smoking Level, American Legion Study Population

Age	No. of deaths from cancer of lung	Cigarette Smoking Class: None	Less than 1 pack	About 1 pack	More than 1 pack
25–	3				
35–	6	8.6		11.9	
45–	17	7.2	11.7	46.9	39.7
55–	119	45.1	86.0	191.1	342.8
65–	143	41.3	169.0	295.3	478.2
75–	16	328.8	217.0	470.9	284.3
TOTAL	304	32.4	75.2	114.2	159.6
Relative Risk Gradient, All Ages		1.0	2.3	3.5	4.9

increasing amount of smoking for each age group except 75 years and older. For all ages combined the risk for the heavy smoker of more than one pack a day is only about five times that of the nonuser of cigarettes though at ages 65 to 74 the risk is greater than 10-fold.

The gradient at all ages is less prominent than that disclosed in several other studies, including prospective studies.[3, 7] In part this may be due to the mixing of current and discontinued smokers in the present study; over time, those who discontinue cigarette smoking have been shown to reduce their risk of developing cancer of the lung. In part it may be due to the inclusion of pipe and cigar smokers in the unit-risk class though the excess risk of developing pulmonary cancer for these smokers is slight compared to that for cigarette smokers. Furthermore, age differences between study populations may result in some difference in pulmonary-cancer–smoking gradients. An additional reason for the modest gradient in the present study becomes apparent later when cigarette-smoking–pulmonary cancer gradients are examined separately for the major residence areas.

In Table 3 the rates of mortality from all causes except cancer of the lung are also given by age and smoking amount. As in other studies, the nonuser of cigarettes generally has a lower mortality risk. Exceptions are those younger than 35 and those 75 and older.

Our primary aim was to compare experience in Los Angeles County, which has over one third of the state's population, with that of the other major metropolitan areas of the state. These other major metropolitan areas include San Francisco County and the other five Bay Area Counties making up the San Francisco-Oakland Metropolitan Area, and also San Diego County. Each of these counties has a much smaller population than Los Angeles. All remaining counties of the state were then combined as a third unit.

The distribution of the study population in the three major areas is shown in Table 4. The percentage distribution of the study population is fairly close to that of the male population of the state in 1960. These data permit contrasts only of major metropolitan areas with other counties having both urban and rural areas because questionnaires from strictly rural areas were far too few to permit rural–urban contrasts.

RESULTS

Residence: The rates of pulmonary cancer in the study population, based on residence categories, are given in Table 5. The pattern formed by the rates effectively disposes of the proposition that rates for cancer of the lung would be higher in Los Angeles than in other major metropolitan areas if the effect of cigarette smoking were controlled and if recent migrants with a presumably lower

TABLE 3. Deaths per 100,000 Man-Years for all Causes Except Cancer of Lung American Legion Study Population

Age	No. of deaths	None	Less than 1 pack	About 1 pack	More than 1 pack	Not reported
25–	112	362.1	302.4	349.1	345.2	2277.9
35–	209	176.6	202.4	232.1	286.8	534.3
45–	366	389.5	443.5	731.9	904.7	421.5
55–	1450	1354.2	1759.0	2102.5	2355.5	2146.3
65–	2587	2555.6	3822.5	4054.5	3977.4	3608.0
75+	376	6986.4	8680.6	6970.0	9951.7	6064.9
TOTAL	5100	1329.2	1738.7	1527.7	1486.9	2320.5

risk of pulmonary cancer did not dilute the rates.

The rates for the Los Angeles study population continue to stand intermediate to those for the Bay Area and for the rest of the state, whether they are rates adjusted for age only (line 1), rates adjusted for age and cigarette smoking (line 2) or age-smoking adjusted rates calculated for those with residence of 10 years or more (line 3). The patterns are generally the same as those already known from the state vital statistics. Any dilution of the over-all rate by inclusion of short-term residents is not greater, in fact is slightly less, in Los Angeles compared to other areas.

The rates for those of unknown length of residence in the metropolitan areas (line 5) seem high though they are based on rather small numbers. Even under the extreme assumption that all unknowns should be distributed in the groups with 10 years or more residence, the pattern is not affected since proportionately more cases would be added to San Francisco Bay Areas and least to all other counties.

Smoking and residence: So strong is the effect of smoking on rates for cancer of the lung that under certain conditions the effect of other factors, such as urban residence, may be obscured. The effect of urban residence in the absence of the effect of cigarette smoking (Table 6), is that rates for nonusers are 2.5 times higher in Los Angeles than in outlying counties and almost four time higher in the Bay Area/San Diego Counties. In contrast, there are differences of 25 to 35% for the total study population, the majority of whom are smokers. (Table 5).

Because the urban factor does affect rates for pulmonary cancer in the absence of the cigarette smoking factor, the conventionally expressed relative risks of cancer of the lung by smoking level will vary according to the kind of population being studied. Table 6, bottom line, sets the nonuser class at unit risk separately in each of the three areas and discloses a considerably weaker relative risk for heavy cigarette smokers in the two major metropolitan areas than in the outlying counties. The risk among heavy cigarette smokers in the otulying counties was 12.3 times as high as among nonusers; in the Bay Area/San Diego Counties the gradient was 5.1 and in Los Angeles 8.6. Considering that 58% of our study population resided in the major metropolitan counties, Los Angeles/Bay

TABLE 4. Number of Man-Years and Percentage Distribution of the Study Population by Major Metropolitan Area, Compared with Male Population California, 1960

	Study population		Male population, California—1960
	No.	%	(%)
Los Angeles County	121,558	36	38
Bay Area plus San Diego Counties	72,859	22	25
All Other Counties	142,154	42	37
TOTAL	336,571	100	100

Area/San Diego, it is not surprising that the pulmonary-cancer–smoking gradient for the total study population was weaker than those for the other studies mentioned above. Here, the urban factor dilutes somewhat the cigarette smoking effect though the latter has the strongest influence on cancer of the lung.

From the present study and from a review of other studies[1] it is clear that both the urban and smoking factors have independent effects on the rate of pulmonary cancer. Table 6 and Fig. 2 also can be interpreted to suggest that their joint action may be additive rather than multiplicative. In Fig. 2 the metropolitan increment in rate, over the mixed rural–urban rate is, with one exception, no greater at each level of smoking than it is among nonusers. The exception is among heaviest cigarette smokers. There are inconsistent results from several studies[1] on this point, retrospective studies especially suggest-

TABLE 5. Deaths from Cancer of the Lung per 100,000 Man-Years American Legion Study Population, 1958-62

Variables	Los Angeles County %	Los Angeles County No.	S. F. Bay Area and San Diego Counties %	S. F. Bay Area and San Diego Counties No.	All other Calif. Counties %	All other Calif. Counties No.
Age adjusted*	95.9	118	104.5	81	75.3	105
Age and cigarette smoking adjusted	95.4		102.0		75.5	
Resident†						
At least 10 yr.	96.6	79	106.3	58	79.9	69
Less than 10 yr.	76.7	27	69.1	13	68.5	30
Unknown	123.4	12	215.3	10	65.2	6

* Age adjusted by the direct method to the total study population.
† Age and cigarette smoking adjusted.

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TABLE 6. Deaths from Cancer of the Lung per 100,000 Man-Years* and Relative Risks by Cigarette Smoking Amount and Area of Residence American Legion Study Population†

Cigarette smoking (lifetime history)	Los Angeles County Rate	Los Angeles County Relative risk	S. F. Bay area and San Diego counties Rate	S. F. Bay area and San Diego counties Relative risk	All other counties Rate	All other counties Relative risk
None	28.1	2.5	43.9	3.9	11.2	1.0
Less than one pack	63.6	5.7	77.1	6.9	61.0	5.4
About one pack	126.0	11.3	134.5	12.0	124.9	11.2
More than one pack	241.3	21.5	226.0	20.2	137.5	12.3
Ratio: More than one pack / None	8.6		5.1		12.3	

* Age adjusted by the direct method to the total study population.
† Nonsmokers in all other counties taken as unit risk.

ing that the joint effect of smoking and urban residence is more than additive, but none of them show any unusual interaction for heaviest smokers only. In a review of the problem it was proposed[1] that the evidence is inconclusive and that total exposure to cigarette smoking, including duration of exposure, must be controlled more effectively to disclose the nature of the joint action of cigarette smoking and urban residence.

Occupational effects: Occupational factors in cancer of the lung in this report are important only insofar as they may have elevated the rates for pulmonary cancer in the major metropolitan areas. Mining of uranium and processing of nickel and chromate, the well known industrial hazards of pulmonary cancer, do not occur in any magnitude in California. Asbestos mining does take place but not in the major metropolitan areas so this can be discounted as influencing the rates. Recently, however, it became known that craftsmen in the application of asbestos, as insulators and pipe wrappers, are at special risk of pulmonary cancer[5] and they may be concentrated in metropolitan areas.

If occupational factors in cancer of the lungs do influence the rates by areas, occupations of nonsmokers should reveal that influence. The death certificates of the 31 victims of pulmonary cancer who were nonsmokers were reviewed; only one certificate failed to record last occupation. None of the recorded occupations were in the suspect categories of miner, asbestos worker, etc. In fact, 60% had been white collar workers. The median length of time in last occupation was recorded as 23 years and for 80% was more

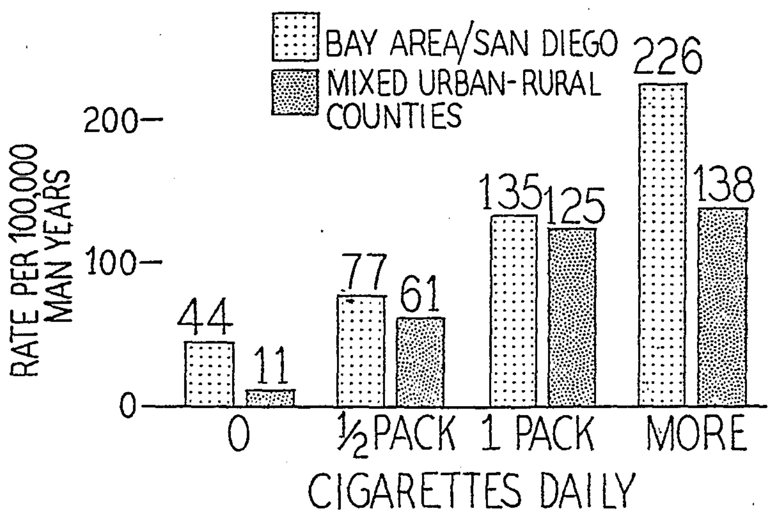

FIG. 2. Mortality rates for cancer of the lung by smoking amount for a metropolitan area and mixed urban-rural California counties, American Legion study population.

than 10 years. In regard to known occupational factors in pulmonary cancer, then, there was no important effect on the lung cancer rates for the major metropolitan areas in this study.

Birthplace: We coded residence histories to size of place at birth, according to data from the census nearest the birth date of the subject. As a result of a retrospective study of residence, smoking, and cancer of the lungs, Haenszel et al.[6] suggested that size of place at birth and current residence made the best set of limited categories for study. The minimal size place used by them was rural farm and, next, rural nonfarm (up to 2500 population). Unfortunately our lowest category is "less than 10,000 population" because the additional work of classifying places to smaller categories for each decennial census for the huge number of documents necessary in this prospective study would have been too great.

A finding emphasized by Haenszel et al. was that smokers, particularly heavy smokers, migrating from farm to city experienced the highest risk. This led them to speculate about a physiologic adaptation hypothesis whereby an abrupt transition to urban atmosphere "added to cigarette smoke might overload and inhibit the action of respiratory cilia in particle transport and permit longer contact of particles and any carcinogens . . . with epithelial cells."[6]

In Table 7 the rates for heavy smokers are shown by birthplace and current residence. A finding to support the hypothesis would be higher rates in major metropolitan areas for those born in places with less than 10,000 population than for those born in larger places. But Table 7 shows that this is not the case; however, our classifications by birthplace could be missing the critical size appropriate to testing the hypothesis.

Haenszel et al. also found higher rates of pulmonary cancer for foreign-born men. Here, too, our findings disagree: The rate for native born, age-smoking adjusted, was 87.0 per 100,000 and for foreign born 85.2. But we suspect that foreign-born men in the American Legion, which requires U. S. military veteran's status, may not be representative of foreign-born men in the United States.

Other chronic respiratory diseases: Deaths from bronchitis and emphysema (ICD 500 to 502, 527) totaled 144. As a group these diseases showed a prominent association with cigarette smoking: Results of the first two years of observation, given in The Report to the Surgeon General,[10] showed an 8-fold excess of deaths in smokers compared to nonsmokers. With the full 5 years of observation this is now reduced to a 5-fold excess. But no association with metropolitan residence appears in this study. One of the highest rates was experienced by the long-term residents of counties outside the major metropolitan counties, and the lowest rate in the Bay Area/San Diego counties (Table 8).

Regional differences in efficiency of diagnosis may affect these data but it is usually presumed that this efficiency is greatest in major metropolitan areas. It may be doubtful, then, that inefficiency of diagnosis has caused the low rate in the Bay Area. In any case, when rates for these chronic respiratory diseases are added to the rates for cancer of the lung, the pattern does not alter the conclusion that Los Angeles fails to show a higher rate of pulmonary cancer than the Bay Area.

TABLE 7. Deaths from Cancer of the Lung per 100,000 Man-Years* for Heavy Smokers by Size of Place at Birth and Current Residence American Legion Study Population

Size of birthplace	Current residence: Los Angeles County	S. F. Bay area and San Diego counties	All other counties
<10,000	224.1	267.2	171.9
≧10,000	258.3	373.0	147.7

* Age adjusted by the direct method to the total study population.

TABLE 8. Deaths from Other Chronic Respiratory Diseases* per 100,000 Man-Years† American Legion Study Population

	Los Angeles County		S. F. Bay area and San Diego counties		All other counties	
	%	No.	%	No.	%	No.
Total	46.7	57	34.0	26	44.4	61
Resident 10 or more yr	38.4	31	28.3	15	45.6	40
Resident less than 10 yr	41.2	14	45.6	8	41.3	17
Unknown time	139.1	12	59.8	3	39.7	4

* Includes bronchitis (ICD 500-502) and other diseases of lung including emphysema (527)
† Age and smoking adjusted by the direct method to the total study population.

DISCUSSION

The rates for cancer of the lung of long-term residents of major metropolitan areas of California have been compared and, insofar as such a comparison affords the basis for an inference, there is no discernible effect of photochemical air pollution on rates for cancer of the lung in Los Angeles County. The San Francisco Bay/San Diego Counties had higher rates.

At the initiation of the study, common observation of the gross presence of air pollution of the type found in California cities of the 1950's was the only basis for judging Los Angeles to have a higher level of pollution than other major metropolitan areas. A network of statewide air-monitoring stations with standardized procedures came later. Data from that network in 1963, however, give no reason to doubt the original observation. Standard readings of oxidant level for 20 stations show much higher readings in the nine Los Angeles stations than in the two Bay Area stations (Table 9). Indeed, the two Bay Area stations are among the lowest though some South Bay communities not represented in the Table have been experiencing high levels of pollution in recent years. San Diego County is also relatively high but this is not representative of air quality in that area in the 1950's.

Using estimates of pollutant emissions rather than air monitoring results, one can compare metropolitan areas for an earlier time also. Estimates of hydrocarbon emissions from motor vehicles, read from graphed data,[9] were in 1945 about 600 tons per day in Los Angeles, about 300 in the San Francisco Bay Area and less than 100 in both San Diego and Sacramento Metropolitan Areas. By 1960 these emissions had increased proportionately the same, a little more than 3-fold, in each of the four areas.

Turning to pollutants that do not have their main source in automotive vehicles, emissions of sulphur dioxide, the bane of air pollution in eastern-U. S. and European cities, were estimated by Leighton[8] to be slightly higher in Los Angeles in 1950 than in the Bay Area in 1959 (no data given for 1950). Particulates on the other hand, may be more of a Bay Area problem. In the Bay Area in 1959 particulate emission was estimated by Leighton to be 355 tons per day, compared to 190 tons in Los Angeles in 1950, with the latter reduced about 40% by 1963. Unless particulate emission increased in the Bay Area by more than 100%, at the same time that it decreased in Los Angeles, we must conclude that the Bay Area in 1950 had greater emissions of particulate matter than Los Angeles.

A time element is of great importance in evaluating the study results. From studies of occupational cancer of the lung, we should probably think of 20 or more years as the average time between first carcinogenic exposure and the appearance of clinical pulmonary cancer, with variation including some shorter development times.

It may, then, be too early to discern an effect of photochemical air pollution on pulmonary cancer. The cancer mortality of the study population was observed during 1958–62; photochemical air pollution became a vis-

TABLE 9. Number of Times the Oxidant Maximum* Hourly Average was .15 ppm or Greater during January through December 1963

Air monitoring station	No. of hourly averages .15 ppm	% of hourly averages .15 ppm	% of total annual hours that were monitored
Los Angeles County			
Azusa	516	6.7	88
Burbank	225	2.8	90
Downtown L. A.	264	3.2	93
Hollywood Freeway†	176	2.9	68
Inglewood	48	0.6	91
Long Beach	26	0.3	89
Pasadena	499	6.2	92
Univ. So. Calif.	296	3.8	90
West Los Angeles	191	2.4	91
Bordering Los Angeles County			
Anaheim	107	1.5	80
Riverside	445	5.8	88
San Bernardino	324	3.9	96
San Diego County			
San Diego City	161	2.2	83
Bay Area			
San Francisco	3	0.1	64
Oakland†	4	0.1	76
In other counties			
Bakersfield	2	0.0	86
Fresno	15	0.2	82
Sacramento	2	0.0	76
Santa Barbara†	13	0.2	79
Stockton	19	0.3	73

* By the potassium iodide method. The hourly average is probably the most useful indicator of pollutant level. Eye irritation, plant damage and reduced visibility, begin to occur at about 0.15 ppm.

† Readings January 1 to December 31, 1963 except for Hollywood Freeway—March through December; Oakland—February through December and Santa Barbara—February through December.

ible problem in Los Angeles between 1945 and 50. Furthermore, the presumed effect due to photochemical air pollution must be detected against a high background rate of pulmonary cancer, due not only to cigarette smoking but to a known higher risk for urban dwellers regardless of photochemical air pollution.

CONCLUSIONS

With controls for cigarette smoking and length of residence, the risk of pulmonary cancer in Los Angeles, where photochemical air pollution levels are highest, was not greater than in other major metropolitan areas of California. Men in the major metropolitan areas had higher rates than those in the rest of the State, with the relative diference greatest among nonsmokers, a confirmation of other reports that urban residence carries a risk of pulmonary cancer. The joint effect of cigarette smoking and the urban factor seem to be additive rather than multiplier but, considering other studies, the evidence on this point is inconclusive.

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