Lung Cancer and the Petroleum Industry in Louisiana

Marise S. Cottlieb. M.D.

Death certificates from the period 1960 to 1975 for Louisiana were surveyed for lung cancer deaths and nom cancer deaths among people employed in petroleum mining and reiining to determine ii there were specific occupations within this industry associated with a higher risk of lung cancer. Workers employed as welders, operators, boilermakers, and painters and oilfield workers had the greatest risks. Oil field miners born outside Louisiana had a higher risk than native-born miners. Occupation as listed on death certificates provides a rapid means of identifying those with high risk, as a large part of the population can be rapidly screened, covering employees in many industries.

A study of geographic patterns of cancer in the United States revealed that parishes in Louisiana have some of the highest age-adjusted lung cancer mortalitv rates for 1950 to 1969.[1] Moreover, these parishes are contiguous in certain areas, particularly along the Gulf Coast, the Mississippi River, and urban areas. To determine factors intluencing lung cancer mortality rates in Louisiana. 19 parishes were selected for a case-control death certificate studv.

National correlation studies suggest that occupational exposures in the petroleum, paper, and chemical industries mav account for some of the excess in lung cancer mortality rates for certain U.S. counties.[1] The petroleum industry is a major industry in Louisiana, employing many of the people currently working in the petroleum industry in the U S. An increased relative risk for lung cancer was noted primarily in men over 62 years of age in oil production and refinery industries. and in residents of towns where the petroleum industry was major emplover.[1] Other industries with occupations a associated with lung cancer included shipbuildi machinerv manutacturing, petrochemicals, transpor tion, and construction. In cancer mortality studies employees of oil refineries, no significant associations occupation with cancer risk have been identified, desp the availability of work histories.

Since Louisiana has many oil refineries, a populatic based mortality study allows the identification of greater number of exposed individuals, across individu factories, but with occupations in common. Theriault a Goulet,[4] in comparing the cancer mortality of oil refin workers to the Quebec population, found lung can less frequent than expected, an unusual excess of br cancer in young people, and an elevated SMR for canc of the digestive system plus an elevated number oi dea due to non-neoplastic diseases of the digestive syste Hanis, Stavraky and Fowler,[5] however, found more tha three-fold risk of esophageal and stomach cancer, a twice the risk of lung cancer in exposed compared to n exposed petroleum workers. In the exposed group. creasing risks for both disease categories occurred v increasing duration of employment.

An examination of deaths with a recorded histor employment in the petroleum industry is presented identify associations with the elevated risk from cancer the lung in this industry and occupation.

Methods

Parishes included in the Lousiana studv were: Acad Allen, Ascension, Calcasieu, Concordia, Iberville, Jacks Morehouse, Plaquemines. St. Bernard, St. Charles. lames, St. John, St. Martin, Tensas, Terrebonne, Wash ton, Webster. and West Feliciana. These parishes w selected because ot elevated lung cancer death ra among white males for the years 1950 to 1969 or beca of their concentration of petroleum, chemical, and pa manutacturing industries, or both. Lung cancer dea

Associate Protesror ot Medicine and Epidemiology Tulane University School ot Medicine and Public Health and Tropical Medicine 1430 Tulane 4ve Yew Orleans LA 70112

Table 1. — Reporting of Occupation on Death Certificates for Cancer Deaths and Non-Cancer Deaths Employed in the Petroleum Industry for White and Black Males.

	Petroleum Industry (Codes 049. 377)			
	Cases Occupation		Controls Occupation	
	Reported	Not Reported	Reported	Not Reported
White males	181	12 (6%)	153	12 (7%)
Black males	7	0	5	0
Total		200		170

were identified by ICDA number from a data tape of all Louisiana deaths from 1960 to 1975 compiled by the Louisiana Division of Vital Statistics Notation of cancer appearing anywhere on the death certificate is coded, and retrievable as the underlying cause An equal number ot non-cancer deaths were selected as controls and matched *to* the lung cancer cases by sex, race, year of death, parish of residence at death, and age of death (± two years). The first control, meeting the criteria, in sequence on the tape was selected

The death certificate for each subject was abstracted to obtain information on other contributing causes of death, occupation and industry Occupation and industry were coded by the three-digit classifications of the US Census Bureau [6] Analysis for relative risk with 95% confidence intervals is by the modification of Rothman-Boice.[7] Within the petroleum industry, occupational categories were compared for cases and controls, and for age at death.

Results

The 1970 census for 19 parishes included 346,041 males. A total of 2,803 cases of lung cancer among males were ascertained for the study period For this group, 2,161 were white males and 642 were black

Information was sufficient to classify the decedent's usual industry of employment into one of 22 industrial categories for 87% of white males and 60% of black males. There was no significant difference between the percentage of controls by reported industry for either racial group Occupation could be coded trorn death certificate information for 92% white males and 92% of black males. Occupation was reported for a greater number of cases than controls for both whites and blacks. However, for the petroleum industry, there was no significant difference in reporting of occupation for cases and controls (Table 1). Since there were only 12 black males in the study population who were employed in the petroleum industry, the following results are presented for black and white males combined.

A total of 200 cases were employed in the petroleum industry, 125 in mining and 75 in refining. There were 170 controls employed in the petroleum industry, 112 in mining and 58 in refining. For purposes of analysis the mining and refining data were combined under the heading of "petroleum industry" as many occupations were similar in both categories, and it was assumed that exposure to hydrocarbons was the major factor in both industrial sub categories.

The distribution of occupations for males employed in the petroleum industry is given in Table 2. The odds ratio for cancer for employment in the petroleum industry, 1.19, does not include 1.0 in the 95% confidence limits. Moreover, several occupational categories within the petroleum industry are noted to demonstrate greater risks tor lung cancer mortality. For workers and oilfield workers, welders, operators, boilermakers, and painters, the odds ratio is 2.33. This increase is mainly in those over age *60* at death, as noted in Table 3, where the data are presented for two age-at-death groups, < 60 years and > 60 years. A larger proportion of controls than cases died at less than *60* years of age, particularly in the managerial categories.

No increase in chronic obstructive pulmonary disease was reported in deceased petroleum workers compared to non-petroleum workers. This disease was recorded for

Table 2. — Risk of Lung Cancer Mortality by Specific Occupations in the Petroleum Industry.

Petroleum	Mining and Refining Cases	Mining and Refining Controls	RO with 95% Confidence Interval
Worker, oilfield worker	26	15	
Welder	8	2	
Skilled, pumping and refining			
Operators	28	13	
Boilermakers	4	0	
Painters	3	0	
Subtotal	69	30	2 33 (1 42-3 85)
Other	20	22	
Cooks, chefs, stewards	4	2	
Managerial, professional, sales	37	48	
Skilled, construction	48	44	
Transportaton, guards	10	11	
Not available	12	13	
Total	200	170	1.19 (1 05-1.35)

Table 3. — Distribution of Cancer and Non-Cancer Deaths by Occupation and Age at Death of Males Employed in the Petroleum Industry (Industrial Codes 049, 377).

Occupation	Age at Death (in Years) <60 Cases	Controls	OR	≥60 Cases	Controls	OR
Workers, oilfield workers	6	5	1 36 (024 22 48)	20	10	1.86 (0.91, 3.8)
'Welder	5	1	1 89 (0 48. 7 37)	3	1	0.93 (0.26, 3.4
Cooks chefs stewards	1	2		3	0	
Managerial professional sales	17	34		20	14	
Skilled construction	23	18		25	26	
Skilled pumping and refining	29	26	132 (0 92 190)	25	10	2.43 (1 01, 5.8
Transportation guards	2	8	0 28 (0 23 0 35)	8	3	2 48 (0 49,12.5
	4	6		8	7	
Total petroleum workers	87	95		113	71	
Total lung cancer	1005	1137		1798	1666	

Table 4. — Chronic Obstructive Pulmonary Disease (COPD) in Petroleum Mining and Refining Workers and Matched Controls.

Occupational Group	Cause of Death COPD No.	%	Non-COPD No.
Petroleum-related	11	6.5	159
Non-petroleum-related	13	8 0	155
Relative odds (95% confidence interval)	0.82 0 58-1 17		

ten and fibrosis in one of the 170 petroleum workers dying from causes other than cancer (6 5%). Twelve cases of chronic obstructive lung disease and one case of fibrosis were recorded for the 168 non-cancer deaths in subjects not working in the petroleum industry matched to the petroleum workers dying from lung cancer (8%)(Table 4).

The location of the lung cancer is indicated in 27% of the cases. Particulate matter is preferentially expected in the right lung. Among the 200 lung cancer deaths in petroleum workers, the right lung was indicated for 32 cases and the left lung was indicated for 22 cases. The difference was noted largely in those categorized to petroleum mining (Table 5). However, interpretation is difficult due to the large number with unspecified location.

The mean age of death of the cases was 60.5 years. A large number (58%) of petroleum worker controls died at 59 years of age or younger, and more than half of these deaths were due to trauma or myocardial intarction.

The distribution of cases and controls by their ages in 1945 (around the time of the offshore oil boom) is given in Table 6. The controls were generally younger than the cases; 59% of controls were 34 *or* younger compared to 35% of cases. This again reflects premature death from other causes in the controls A chi-square analysis of the distribution of cases and controls born in Louisiana and out-of-state reveals an excess of cases in the high-risk petroleum mining occupations (welders and oilfield workers) born out-of-state (Table 7) [RO 2 27 (95% Confidence interval 0 58, 8 83)] This association did not appear for refining workers

Discussion

The elevated risk of lung cancer mortality among petroleum workers in these selected Louisiana parishes is attributable largely to several occupational groups, welders, oilfield workers, operators, boilermakers, and painters An excess in cases among boilermakers and painters was observed for the entire data set (across industry categories) as well as for the petroleum industry alone However, the excess among cases who were welders, which is apparent in the petroleum industry, was not observed across all industry categories It is possible that different factors are operating in the etiology of lung cancer for these three occupational groups The operator and worker categories are specific to the petroleum industry

The association between chronic obstructive pulmonary disease (COPO) and petroleum-related 0 —— was also examined This can be considered a measure of the relative amount of cigarette smoking by workers in this industry To measure this association, the matched controls (non-cancer) of the cases working in a non-petroleum-related industry were compared with all controls who were reported to have worked in the industry The resulting percentage of COPD deaths for petroleum-related occupations, and non-petroleum-related occupations was 6.5 and 8.0, respectively (Table 4). This indicates the accuracy and similarity of diagnostic reporting in the

Table 5. — Laterality of Lung Cancer in Petroleum Mining and Refining Workers and Matched Non-Petroleum Workers.

Occupations	Laterality Specified Right No.	%	Left No.	%	Unspecified No.
Petroleum mining	20	63	12	38	93
Petroleum refining	12	55	10	45	53
Non-petroleum-related	25	54	21	46	124

Table 6. — Petroleum industry Cohort Age in 1945.

Age	Cases No.	Cases %	Controls No.	Controls %
0-19	10	5	21	12
20-34	59	30	79	47
35 +	130	65	70	41
Age in 1945 not available	1		0	
Total	200		170	

groups, and the security that all cases of lung cancer were likely identified and reported, or one might have expected to have identified more non-specific lung disease. The similarity in the proportion of petroleum-related controls with COPD compared to that from non-petroleum-related controls suggests that cigarette smoking does *not* differ in the *two* groups, and that the higher rate of lung cancer associated with the petroleum industry is not likely to be related to cigarette smoking alone. The reported rate of 6% COPD is lower than that found in a similar comparison of workers related to the shipbuilding industry.[7]

The laterality of lung cancer was also investigated in occupational groups, since particulate substances tend to be trapped preferentially in the right lung due to the configuration of the right bronchus. To measure this application, the cases not working in the petroleum industry who were matched to the controls working in these occupations were compared with cases working in petroleum industry occupations. The resulting proportion of right lung cancer in the petroleum industry occupations was not increased significantly above that of lung cancer cases in the non-petroleum industry occupations. However, information on laterality was specified in only 27% of the cases.

The mean age at death for cases was several years older than that for controls. Similarly, the median age of death for cases[62] was substantially greater than that for controls[57] considering that cases and controls in the original data set were age-matched ± two years. (For all industries combined the median age at death was 62.8 for cases and 61.4 for controls.) These findings may be explained by the fact that many of the deaths for controls in the petroleum industry were accidental and occurred in very young men, who might have become cases, if they survived. This indicates that risk of lung cancer for may be underestimated in this study. A revised odds ratio was estimated after excluding accidental, traumatic or violent deaths, chronic obstructive pulmonary disease, and those whose age was less than 40 years at time of death from the control group. It was 1.29 (1.11 to 1.50) for the petroleum industry. For the high-risk occupation group in this industry, the corrected odds ratio is 3.03 (1.45 to 6.34). a further elevation. This reinforces the significance of the risk of these occupations. The ages of cases and controls relative to a reference date, 1945, were examined to see whether differences in the ages of the two cohorts might result in differing temporal exposures for the two groups. More controls were under 35 years of age and more cases were 35 or over. The older cases probably reflect a longer period of exposure to the industry.

The observation that petroleum mining cases were more frequently born out-of-state than controls is probably related to migration patterns involved with employment in the industry. Those mining workers who relocate frequently at new mining sites are probably long-term employees in the industry and therefore long-term exposure, high-risk employees. The odds ratio for these workers is elevated, but due to the small sample size, was not significant. Retining workers, on the other hand, were not more likely to be born out-or-state.

The observation that lung cancer was recorded more frequently for the right lung than the left lung particularly among the miners is compatible with the idea that airborne particulate substances contribute to the etiology of lung cancer.

Whether or not differences in cigarette smoking patterns associated with social class and occupation is the common denominator in the differences between cancer deaths and non-cancer deaths cannot be directly evaluated from this study. Indirectly, however, the high median age at death in cases and the similarity in percent reported COPD for cancer and non-cancer deaths would tend to require more than differences in tobacco smoking patterns as an explanation

Conclusion

National correlation studies have suggested an association between employment in the petroleum industry and lung cancer mortality. This death certificate study has demonstrated an elevated risk of lung cancer mortality (odds ratio — 1.19) for workers emplbyed in the petroleum industry in 19 selected Louisiana parishes. Individuals with several specific occupations within the petroleum industry (welders, operators, boilermakers, painters, and oilfield workers) appear to be a greatest risk of lung cancer mortality, RO 2.33 (1.42 to 3.85). The petroleum industry has been an important industry in

Table 7. — Distribution of Petroleum Workers by State of Birth — Louisiana and Other.

Petroleum Industry	Occupational Risk	Birthplace: Louisiana Cases	Louisiana Controls	Outside Louisiana Cases	Outside Louisiana Odds Ratio	Outside Louisiana Controls
Mining	All	a2	61	44		30
	High	24	16	17		5
Odds ratio				2 27 [(0 58.8 83)]		
Refining	All	51	39	23		18
	High	20	a	10		3

Louisiana for the past 50 years and may explain part of the excess in reported lung cancer mortality rates.

The use of death certificates representing a large population base whose employees are at an increased risk of cancer is an alternative to studying the work histories of employees of individual companies. The large population base which enables surveillance of many death certificates allows the identification of workers from several companies and a broader identification of those exposed. Only for those individuals with a substantial period of employment is the industry likely to be recorded on the death certificate. This would tend to eliminate casual employees and allow the inclusion into the study of employees who achieved a long period of employment. This is true for cancer and non-cancer deaths. Specific job *titles* were recorded with a high frequency on the death certificate. Although the inherent weakness of death certificate information is well-known, it appears to be a valid screening tool for detecting industrial and occupational associations with lung cancer.

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Aesculapian Authority

Paterson defined medical authority as consisting ot three types: sapiential. moral, and charismatic, combined in a particular manner. He called this "Aesculapian authority."

By sapiential authority, Paterson means the right to be heard that is derived from knowledge or expertness. Such authority resides in the person and not in any position that he may occupy. A person with this kind of authority may advise, inform, instruct, and direct, but not order.

The second ingredient ot Aesculapian authority is moral authority, the right to control and direct that is derived trom the rightness and goodness according to the ethos of the enterprise. The moral authority of doctors, which is expressed in the Hippocratic oath, stems from their doing what is expected of them as doctors and their concern with the good of the patient.

The third ingredient in Aesculapian authoritv is Charismatic authority, the right to control and direct that is derived trom Cod-given grace. This element in Aesculapian authority reflects the original unity of religion and medicine that still exists in manv parts of the world.

– From 'Cod and the Doctor' bv Humphrev Osmond, in *The New England Journal of Medicine*, March6, 1980