Lung Cancer in Louisiana: Death Certificate Analysis [1, 2]

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ABSTRACT—In a search for etiologic clues, a review was made of death certificates of residents in a cluster of Louisiana parishes, mainly in the southern part of the state, where lung cancer mortality was high. A comparison of the statements on occupation for 3,327 patients with lung cancer and those of 3,327 controls (matched by sex, race, age, and parish of residence) during 1960–75 revealed an approximately twofold excess risk associated with transportation equipment manufacture, mainly shipbuilding, and the fishing industry. Smaller elevations of lung cancer risk were found among older men who had been employed in petroleum exploration and production and among male and female residents of towns where the petroleum industry was a major employer. In addition, Acadian ancestry was associated with a higher risk of lung cancer among older male and female residents.—JNCI 63: 1131–1137, 1979.

Exceptionally high mortality from lung cancer has been reported among males in southern Louisiana parishes along the Gulf of Mexico, the Mississippi River, and the Atchafalaya Basin (*1–3*). Reasons for the excess rates are not clear, but national correlation studies of lung cancer have suggested the role of occupational exposures, including shipbuilding, chemical, petroleum, and paper manufacturing industries (*3, 4*) located in Louisiana. As a preliminary step to field studies in the high-risk parishes, a study was made of occupational, residential, and ethnic factors gleaned from the death certificates of persons who resided in this area and died of lung cancer.

METHODS

Nineteen Louisiana parishes (text-fig. 1) were selected for study because of elevated lung cancer death rates among white males for the years 1950–69 and/or because of petroleum, chemical, or paper manufacturing industries in the area. Of the 19 parishes, 17 had mortality rates that exceeded the national average; in 10, the excess was over 30%. The parishes were typically small, with 1970 populations ranging from 10,000 to 145,000 (median, 30,000).

A computerized listing of death certificates for 1960–75 for the 19 parishes was provided by the Office of Public Health Statistics, Louisiana Health and Human Resources Administration. Certificates for deaths attributed to lung cancer [ICD (*5*): 162.1, 163 for 1960–67; ICD (*6*): 162.1 for 1968–75] were identified and abstracted. Each certificate that reported lung cancer as the cause of death was matched by sex, race, age at death within 5 years, year of death within 1 year, and by parish of usual residence to a control death certificate—i.e., one of a person who died from conditions other than cancer.

Abstracted from each death certificate were the following: patient's name, birthplace, usual residence and residence at time of death, type of industry by which he or she was employed, usual occupation (kind of work done during most of working life, even if retired), marital status, and parents' names. With the use of the 1970 U.S. Bureau of the Census coding scheme (*7*), the statements on occupation and industry were each assigned a three-digit code. Each patient was then classified into 1 of 9 occupational and 1 of 22 industrial categories. We also examined the certificates to determine the likelihood of Acadian ancestry (probable, possible, or unlikely) by comparing birthplace and parents' names to compiled lists of names and updated variants of original Acadian settlers recorded on ships' logs (*8–14*).

The usual residence listed on the certificate was used for classification of each individual as to proximity to each of seven primary types of manufacturing industry in the area. The classifications were based on the predominant manufacturing industry in terms of years in existence and number of employees during 1940–65 (*15*) for the individual's town of residence. In most of the smaller parishes, a town uniquely defined a zip code area, so that each subject was classified as living "near" a particular type of industry only if a factory was located in the zip code area of residence and it was the major one in that area.

Odds ratios were calculated (*16, 17*) by sex and race as estimates of the relative risk of lung cancer associated with each of the 22 industrial categories, 9 occupational groups, residential proximity to the 7 industries, and 3 categories of Acadian ancestry. We examined positive associations in greater detail by calculating odds ratios for substrata and by using logistic models

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Abbreviation used: ICD = International Classification of Diseases.

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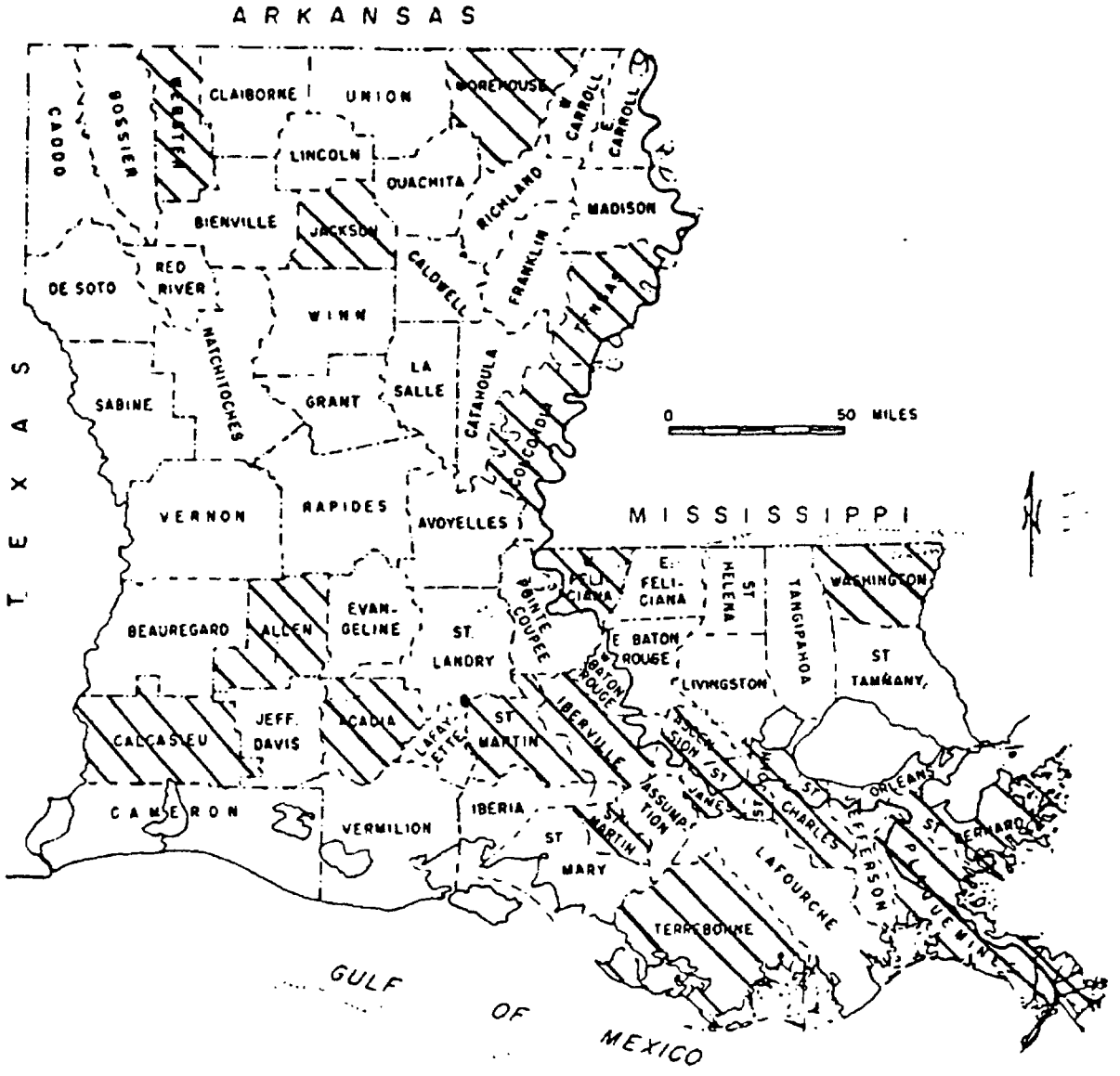

TEXT FIGURE 1.—Louisiana parishes included in the study (*cross-hatched* areas).

to test for interaction and to obtain the maximum likelihood point and interval estimates of the odds ratios after simultaneous adjustment for several factors including age, marital status, year of death, birthplace, and parish of residence [(*18, 19*); Pickle LW, Rohde CA: Unpublished observations]. Further details of the statistical methods are in "Appendix—Statistical Methods."

RESULTS

In the 19 parishes during 1960-75, 3,327 people died of lung cancer: 2,162 white males, 643 black males, 372 white females, 146 black females, and 4 American Indian males. The median age at death was 62.8 for lung cancer patients and 61.4 for controls.

Usual industry.—Information on 87% of the certificates for white males, 60% for black males, 96% for white females, and 93% for black females was sufficient to classify the decedent's usual industry of employment into 1 of the 22 industrial categories. Table 1 shows the number of male workers and the crude odds ratios for each industry. The odds ratios were significantly high for fishing and for transport equipment manufacture, primarily shipbuilding. Smaller elevated ratios were associated with construction and transportation service. Similar increases were seen for metal and machinery manufacture, oil refining, and business-

TABLE 1 —*Odds ratios according to usual industry among males (both races combined)*

Industry	Census code*	Cases	Controls	Odds ratio (95% confidence limits)†
Agriculture	17-19, 27	459	459	1.00 (0.87, 1.16)
Fishing	28	72	40	1.81‡ (1.22, 2.69)
Crude oil extraction	49	128	116	1.11 (0.85, 1.44)
Mining	47-48, 57-58	15	14	1.07 (0.51, 2.23)
Construction	67-78	346	303	1.16 (0.98, 1.37)
Manufacturing		443	418	1.07 (0.92, 1.24)
Lumber	107-109	47	66	0.71 (0.48, 1.04)
Metal, machinery	147-207	33	26	1.27 (0.75, 2.14)
Transportation equipment	219-238	29	13	2.20‡ (1.14, 4.25)
Food	268-297	88	101	0.87 (0.65, 1.17)
Paper	328-337	103	98	1.05 (0.79, 1.40)
Chemical	347-369	38	34	1.12 (0.70, 1.79)
Oil refining	377-378	76	58	1.32 (0.93, 1.87)
Other	119-138, 248-259, 299-319, 338-339, 337-398	29	22	1.31 (0.75, 2.31)
Transportation service	407-429	201	161	1.27‡ (1.02, 1.58)
Communications, utilities	447-479	35	49	0.71 (0.46, 1.11)
Wholesale	507-598	49	59	0.83 (0.56, 1.22)
Retail	607-698	165	209	0.78‡ (0.63, 0.96)
Finance	707-718	26	39	0.67 (0.40, 1.11)
Business-repair	728-759	61	46	1.33 (0.90, 1.97)
Personal services, entertainment	769-809	52	45	1.16 (0.77, 1.74)
Professional	828-897	67	96	0.69‡ (0.50, 0.96)
Public administration	907-937	156	201	0.76‡ (0.61, 0.95)
Unknown for:				
Whites		274	287	0.95 (0.79, 1.14)
Blacks		256	263	0.96 (0.76, 1.20)
Total		2,805	2,805	

* See (7).
† See "Appendix—Statistical Methods" for definition of interval estimates.
‡ Approximate 95% confidence interval does not include 1

TABLE 2 —*Odds ratios by race and age group for selected industries*

Industry	Race group				Age group			
	Race*	Cases	Controls	Odds ratio (95% confidence limits)	Age, yr	Cases	Controls	Odds ratio (95% confidence limits)
Fishing	W	65	38	1.7† (1.14, 2.60)	<63	28	17	1.9§ (1.00, 3.42)
	B	7	2	3.0 (0.70, 13.08)	≥63	44	23	1.7§ (1.02, 2.86)
Crude oil	W	126	114	1.1 (0.85, 1.45)	<63	75	87	1.0 (0.70, 1.34)
	B	2	2	1.0 (0.17, 6.00)	≥63	53	29	1.6§ (1.03, 2.61)
Construction	W	286	256	1.1 (0.94, 1.36)	<63	176	182	1.1 (0.88, 1.38)
	B	60	47	1.3 (0.87, 1.95)	≥63	170	121	1.3 (1.00, 1.65)
Metal, machinery manufacture	W	31	25	1.2 (0.73, 2.12)	<63	20	20	1.1 (0.60, 2.12)
	B	2	1	1.7 (0.21, 13.21)	≥63	13	6	1.9 (0.71, 4.85)
Transportation-equipment manufacture	W	25	13	1.9 (0.97, 3.73)	<63	20	8	2.7§ (1.21, 6.22)
	B	4	0	∞	≥63	9	5	1.5 (0.53, 4.52)
Shipbuilding (code 228)	W	21	12	1.7 (0.85, 3.53)	<63	16	8	2.2 (0.94, 5.14)
	B	3	0	∞	≥63	8	4	1.7 (0.53, 5.43)
Chemical manufacture	W	35	31	1.1 (0.69, 1.85)	<63	24	19	1.4 (0.77, 2.62)
	B	3	3	1.0 (0.22, 4.55)	≥63	14	15	.8 (0.40, 1.74)
Oil refining	W	69	55	1.3 (0.88, 1.82)	<63	38	38	1.1 (0.71, 1.79)
	B	7	3	2.2 (0.59, 7.91)	≥63	38	20	1.7 (0.98, 2.94)
Transportation	W	155	127	1.2 (0.97, 1.58)	<63	103	89	1.3 (0.98, 1.79)
	B	46	34	1.4 (0.87, 2.19)	≥63	98	72	1.2 (0.89, 1.69)
Business-repair	W	55	42	1.3 (0.87, 1.98)	<63	33	28	1.3 (0.80, 2.23)
	B	6	4	1.4 (0.42, 4.97)	≥63	28	18	1.4 (0.76, 2.52)
Auto repair (codes 749-757)	W	29	20	1.4 (0.81, 2.58)	<63	20	11	2.0 (0.96, 4.24)
	B	6	3	1.9 (0.49, 7.06)	≥63	15	12	1.1 (0.52, 2.38)

* W = white; B = black.
† Approximate 95% confidence interval does not include 1.

repair. Decreased odds ratios were found for retail sales and for professional and public administration industries.

Table 2 lists odds ratios according to race and age category for selected industries in which the overall ratios were above 1. For nearly every industry shown, the risks were elevated in both whites and blacks. The ratios tended to be higher in blacks, though several industries had few black workers. The major age differences were limited to the oil production and refining industries (excess rates were observed primarily for people over age 62) and to the transport and chemical manufacture and auto repair industries (excess rates only at younger ages).

The logistic analyses suggested that odds ratios for certain segments of the study population were particularly high. The ratio associated with crude oil exploration and drilling rose to threefold among persons over age 62 in parishes with petroleum or paper industries. Although it was based on small numbers, the risk for chemical workers in white-collar trades (7 cases, 1 control) was elevated, but a slight deficit was seen for the remainder of the workers in this industry. The excess associated with fishing was slightly greater than twofold throughout most of the study area.

Although the total risk ratios for workers in wholesale and retail sales were less than 1, we analyzed death certificates on which chemical, oil, or paper and/or wood sales (as opposed to manufacture) were mentioned. No increased risk was seen for chemical or petroleum sales workers. However, significant excess was associated with lumber wholesale and lumber and furniture retail operations among whites, with 24 cases and 10 controls [odds ratio = 2.35, approximate 95% confidence limits (1.12, 4.92)] reporting usual employment in this industry.

Occupation.—The odds ratios for major occupational categories according to sex and race are given in table 3. Among males, the ratios were above 1 for craftsmen and operators and below 1 for professional

TABLE 3.—*Odds ratios for usual occupation according to sex and race*

Occupation	Census code*	Males						Females					
		White			Black			White			Black		
		Cases	Controls	Odds ratio (95% confidence limits)	Cases	Controls	Odds ratio (95% confidence limits	Cases	Controls	Odds ratio (95% confidence limits)	Cases	Controls	Odds ratio (95% confidence limits)
Professional	001–199	70	118	0.58† (0.43, 0.79)	8	16	0.51 (0.22, 1.19)	18	15	1.20 (0.60, 2.44)	2	1	1.68 (0.21, 13.42)
Managerial	201–299	308	363	0.82† (0.70, 0.98)	6	19	0.33† (0.13, 0.81)	15	7	2.11 (0.86, 5.21)	1	0	—
Clerical	301–399	50	65	0.77 (0.52, 1.12)	2	1	1.67 (0.21, 13.21)	14	4	3.31† (1.11, 9.85)	1	0	—
Craftsmen	401–594	570	509	1.16† (1.01, 1.34)	43	30	1.46 (0.90, 2.37)	1	0	—	0	0	—
Operators	601–699	252	203	1.27† (1.04, 1.55)	26	15	1.74 (0.91, 3.33)	6	4	1.45 (0.42, 5.00)	2	1	1.68 (0.21, 13.42)
Transporters	701–739	87	84	1.04 (0.76, 1.42)	21	23	0.91 (0.50, 1.67)	0	0	—	0	0	—
Laborers	740–799	215	197	1.10 (0.90, 1.36)	329	316	1.08 (0.87, 1.36)	2	1	1.67 (0.21, 13.25)	6	3	1.90 (0.49, 7.30)
Farmers	801–899	312	297	1.06 (0.89, 1.26)	131	128	1.03 (0.78, 1.36)	1	3	0.43 (0.06, 3.02)	5	8	0.63 (0.21, 1.94)
Servicemen	901–989	137	126	1.09 (0.85, 1.41)	33	33	1.00 (0.61, 1.65)	17	25	0.67 (0.35, 1.27)	40	30	1.45 (0.84, 2.52)
Housewives	—	—	—	—	—	—	—	290	300	0.85 (0.59, 1.22)	83	95	0.71 (0.44, 1.15)
Unknown	—	161	200	0.79† (0.63, 0.99)	44	62	0.69 (0.46, 1.04)	8	13	0.67 (0.27, 1.66)	6	8	0.75 (0.26, 2.20)

* *See* (7).
† Approximate 95% confidence interval does not include 1.

TABLE 4.—*Odds ratios by sex and race for residence in proximity to industry*

Industry (census code)	Males						Females					
	White			Black			White			Black		
	Cases	Controls	Odds ratio (95% confidence limits)	Cases	Controls	Odds ratio (95% confidence limits)	Cases	Controls	Odds ratio (95% confidence limits)	Cases	Controls	Odds ratio (95% confidence limits)
Sawmills (108–109)	384	393	0.97 (0.83, 1.14)	168	157	1.10 (0.85, 1.42)	58	64	0.89 (0.60, 1.32)	24	37	0.58 (0.33, 1.05)
Metal manufacture (158–168)	25	15	1.65 (0.87, 3.16)	0	0	—	3	3	1.00 (0.22, 4.57)	0	0	—
Canneries (278)	182	198	0.91 (0.74, 1.13)	31	30	1.03 (0.62, 1.74)	23	23	1.00 (0.55, 1.83)	12	7	1.73 (0.67, 4.49)
Grain mills (279)	184	167	1.11 (0.89, 1.39)	34	36	0.94 (0.58, 1.54)	38	41	0.92 (0.57, 1.48)	8	8	1.00 (0.37, 2.72)
Paper manufacture (328–329)	204	216	0.94 (0.77, 1.15)	42	47	0.89 (0.57, 1.38)	33	35	0.94 (0.57, 1.56)	12	14	0.85 (0.38, 1.91)
Chemical manufacture (347–368)	441	485	0.89 (0.74, 1.03)	134	148	0.88 (0.67, 1.15)	90	86	1.06 (0.75, 1.50)	31	38	0.77 (0.44, 1.33)
Oil refineries (377)	306	270	1.16 (0.97, 1.38)	28	15	1.88 (0.99, 3.57)	58	46	1.31 (0.86, 2.00)	10	6	1.66 (0.60, 4.64)
Other	436	418	1.05 (0.91, 1.23)	206	210	0.97 (0.77, 1.23)	69	74	0.92 (0.63, 1.33)	49	36	1.54 (0.92, 2.58)
Total	2,162	2,162		643	643		372	372		146	146	

and managerial occupations. Among white females, however, risk ratios higher than 1 were seen for professional, managerial, and clerical occupations. In fact, regardless of type of occupation, odds ratios for employed women were usually higher than for housewives.

Proximity to industry.—Table 4 presents the number of residents and odds ratios according to the nearness of residence to 7 primary manufacturing industries. Elevated risk estimates for all 4 sex-race groups were elevated only in towns where oil refineries were located. The odds ratios ranged from 1.16 (with approxi-

TABLE 5.—*Odds ratios for Acadian ancestry according to sex and race*

Subjects	Probable Acadian			Possible Acadian			Non-Acadian		
	Cases	Controls	Odds ratio[a] (95% confidence limits)	Cases	Controls	Odds ratio[a] (95% confidence limits)	Cases	Controls	Odds ratio[b] (95% confidence limits)
White males	157	129	1.24 (0.97, 1.59)	443	442	1.02 (0.88, 1.19)	1,562	1,591	0.93 (0.82, 1.07)
Black males	6	6	1.01 (0.33, 3.08)	73	68	1.08 (0.76, 1.55)	564	569	0.93 (0.66, 1.31)
White females	21	21	1.03 (0.54, 1.96)	78	73	1.10 (0.75, 1.62)	173	178	0.92 (0.65, 1.32)
Black females	1	0	—	20	17	1.21 (0.60, 2.43)	125	129	0.79 (0.40, 1.57)

[a] Values are relative to non-Acadian.
[b] Values are relative to possible or probable Acadian.

mate 95% confidence limits (0.97, 1.38)] among white males to 1.88 (0.99, 3.57) among black males. The excess for males was not accounted for by employment in the refineries, although the odds ratios were higher for those who also worked in the industry than for those who did not and was particularly evident in parishes that had both petroleum and chemical plants.

Acadian ancestry.—A gradient of increasing risk associated with the likelihood of Acadian ancestry was seen among white males (table 5). However, the increase was limited to patients of probable Acadian ancestry who died at age 63 or older [odds ratio = 1.51, approximate 95% confidence limits (1.07, 2.12)]. A similar pattern was observed for white female Acadians for whom a twofold risk [2.10 (0.65, 6.76)] was found among women over age 62. Although the original settlers were white, some black decedents were classified as Acadian on the basis of criteria on birthplace and parents' names. The risk ratios were slightly above 1 for blacks of possible or probable Acadian ancestry.

DISCUSSION

This survey of death certificates revealed a number of leads to lung cancer risk, but no single factor was found to be responsible for the excess mortality rates reported for this tumor in southern Louisiana. In a national correlation study, the high lung cancer mortality rates among males residing in counties with petroleum, chemical, paper, and transportation manufacturing industries (*3, 4*) suggested that occupational factors influenced the geographic patterns of this tumor. The present study was conducted to determine whether the associations seen at the aggregate (county or parish) level also existed at the individual level and persisted in the 1970's. There was a twofold excess among males in transportation manufacturing, mainly shipbuilding; however, only slight increases were associated with employment in the petroleum and chemical industries, and no increase was seen with paper and pulp production.

An excess risk of lung cancer has been reported recently among American men who were employed in shipyards during World War II (*20*). Although fewer than 1% of the certificates in this study listed shipbuilding as the usual industry, ship construction and repair was one of the largest industries in Louisiana during the war (*21*). A case-control study conducted in a high-risk area in coastal Georgia indicated that over 20% of the patients recently diagnosed as having lung cancer had worked in the shipyards that operated only during the war (*20*); shipbuilding was rarely listed as the occupation of the decedent on death certificates (*22*). If a similar situation is true in Louisiana, this death certificate survey probably has underestimated the contribution of shipyard exposures to the area-wide lung cancer excess. Moreover, the parishes selected for this study did not include those in the immediate vicinity of New Orleans, where shipbuilding was a major industry.

Petroleum production and refining are major industries in Louisiana, and about 8% of the certificates for male residents listed these as the usual industry of the decedent. The overall relative risk (1.2) was not large but rose to 1.7 for those at older ages. Further, although the risk ratios were small and possibly influenced by factors that could not be accounted for in this death certificate review, the higher ratios among female as well as male residents of towns where refineries are located raise the possibility of community exposures to industrial carcinogens. Only limited data are available on the risks of cancer associated with the petroleum industry, but a recent study of mortality and morbidity statistics in Los Angeles, where the industry is a major employer, revealed a 60% excess risk of lung cancer among petroleum and coal products workers (*23*).

One of the stronger associations in this survey was the excess lung cancer risk among fishermen. An approximate twofold increase among blacks and whites was consistent with other reports (*24, 25*), but an explanation of this finding is unclear. The higher risks for auto repair, transportation services, and lumber and furniture sales industries have been reported in other surveys of lung cancer (*23-25*) and serve as clues to possible occupational hazards.

Acadiana encompasses an area of south central Louisiana where Acadians settled in the 18th century and continue to live as a relatively isolated population; some still maintain an agrarian life-style unique to this group. On the basis of family surnames on death certificates, about 6% of the white residents in the entire study area (or about 10% of the whites in Acadiana parishes) were classified as probable Acadians. About 20% of this group were farmers. Lung cancer risks were elevated approximately 1.5-fold among males and twofold among females with probable Acadian ancestry who died at 63 years of age or older. No excess lung cancer risk was observed at younger ages, perhaps a result of temporal changes in risk factors.

Although death certificate studies are a quick and inexpensive means of assessing whether patterns seen at the aggregate (parish or county) level reflect characteristics at the individual level, the data abstracted from the certificates are obviously limited. The statements on industry and occupation are at best only a crude description of the usual work, with no information as to detail, variety, or duration of employment. Similarly, residential histories are unknown, and information on cigarette smoking (the major etiologic factor for lung cancer) is unavailable, so that causal inferences on specific risk factors cannot be made from this study. Despite these limitations, death certificates represent a practical means of obtaining a large sample extending back over a long term and may be a valuable hypothesis-generating resource. The clues obtained by this study may now be tested by case-control studies in high-risk communities of Louisiana, where more definitive information can be obtained from interviews with lung cancer patients or their next of kin.

APPENDIX—STATISTICAL METHODS

The odds ratios presented in the text are simple cross-product ratios of the stratified 2×2 tables with an adjustment of 0.5 added to each count (*16, 17*). Interval estimates for these odds ratios, $\hat{\theta}$, are of the form: exp [*ln* $\hat{\theta} \pm 2$ (SE of *ln* $\hat{\theta}$)] with standard error defined by $\sqrt{(1/A+1/B+1/C+1/D)}$, where *A*, *B*, *C*, and *D* are the adjusted counts for the 2×2 table.

The logistic model used for further analysis included parameters for various confounders and effect modifiers; this technique has been described in detail elsewhere [(*19*), equations 1-4]. The initial logistic models contained indicator parameters for age (<63 yr, ≥63 yr), marital status (married, other), calendar year of death (1960-63, 1964-67, 1968-71, 1972-75), birthplace (Louisiana, other state, foreign), parish of residence grouping (by major industry), and interactions (effect modifications) between these variables and the case-control indicator. In addition, categorizations of the other variables of interest were included in the models for each industry, e.g., terms representing the 3 Acadian ancestry groups and three broad occupation categories (white- and blue-collar workers and others). Sequential deletions of terms were made to arrive at a final well-fitting model. Decisions concerning parameter deletion were based on the *t*-statistics for significance of the individual parameter estimates, on the changes in the value of the log likelihood, and on the goodness of fit of the model as compared with the observed stratified odds ratios. Interval estimates for the odds ratio are of the same form described above, where *ln* $\hat{\theta}$ is the maximum likelihood estimate of the log of the odds ratio adjusted for any significant confounders, with standard errors obtained from the inverse of the information matrix for each final model. These intervals may be interpreted as either 2-unit support intervals (*26*) or approximate 95% confidence intervals.

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