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LUNG CANCER MORTALITY IN THE UNITED STATES: SHIPYARD CORRELATIONS

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Clues to the origins of cancer are often derived from its geographic patterns. This review notes how United States county mortality data have been used in a stepwise fashion to generate hypotheses concerning the etiology of lung cancer and describes how the leads produced by these data are being tested by analytic epidemiologic studies in areas of the country where lung cancer rates are high, focusing on the associations uncovered with the shipbuilding industry.

GEOGRAPHIC PATTERNS

Mapping the distribution of mortality rates, 1950-69, for lung cancer among white males revealed unexpected patterns.¹⁻³ Rates were high in metropolitan centers of the northeast and midwest, but, surprisingly, the highest mortality clustered in coastal areas of the South. Elevated rates were seen along the Gulf Coast from Texas eastward into the Florida panhandle, with nearly every parish in southern Louisiana being affected. A series of counties along the southeast Atlantic coast from northern Florida through Charleston, South Carolina also showed consistently elevated mortality rates among white males. Among white females, the geographic pattern was similar, although the southern coastal effect was reduced, while in blacks, rates were low throughout the South and high in urban areas of the North.

To seek explanations for the geographic variation in lung cancer across the country, we correlated the county mortality rates with demographic and industrial data available at the county level.³ Regardless of the area of the country, the mortality rates showed a positive gradient with urbanization and a weak inverse relation with socioeconomic indices. From census information on industry for the year 1963, when these data were first available to us at the county level on computer tape, the location and approximate number of employees for every manufacturing plant in the United States were obtained.⁴ With these data, each county of the country was classified as to its relative involvement for each of 18 major two-digit Standard Industrial Classification Code manufacturing categories. When the lung cancer rates were examined in relationship to countywide industrial activity, it was found that mortality tended to be higher in counties with certain industries, namely, the chemical, petroleum, paper, and transportation manufacturing industries. The elevations in rates in these counties were small but were not accounted for by urbanization or other demographic factors and were primarily limited to males.

Shipbuilding is listed as a subcategory of the transportation industry under the classification scheme used. By 1963, few counties had shipbuilding industries, but those that did tended to have high lung cancer mortality rates among white males. During World War II, however, ship construction and repair was the major manufacturing industry in the United States. When mortality rates during 1950-69 were examined for the 49 counties of the country with major shipyards during the war,



there was a consistent pattern of excess rates for respiratory cancer, particularly in the South.⁵ Nearly all of the southern shipyard counties had high rates for cancers of the lung and larynx. Furthermore, in these areas, the rate of increase for respiratory cancer was greater than that seen nationally. Mortality from cancers of the oral cavity, esophagus, and stomach also tended to be high in shipyard counties, whereas rates for most other tumors were roughly comparable to national levels. This constellation of tumors affecting the airways and upper digestive tract has been described previously among workers exposed to asbestos and raises the possibility that wartime exposures to this agent may be related to the current coastal excess of respiratory cancer in the United States.

FIELD STUDIES IN HIGH-RISK AREAS

The mapping and correlation studies raise questions about the causes of cancer rather than answer them. To follow-up on the leads generated by these studies, we have embarked on a series of field studies in several areas of the country where rates for respiratory cancer are unusual. As an initial step in investigating the excess lung cancer in coastal Georgia, we obtained copies of approximately 1700 death certificates; half of the deaths were attributed to primary lung cancer (cases) and half to other diseases (controls).⁶ The statements on occupation and industry on these certificates revealed that more cases than controls worked in the construction industry. There was no differential associated with paper and pulp manufacturing in the "urban" areas of Savannah, Brunswick, and Waycross, but more cases than controls were employed in wood- and paper-related occupations in the surrounding rural counties. Few of the certificates listed shipbuilding as the usual occupation of the deceased.

At the same time, a case-control interview study of lung cancer patients was initiated. Information on the lifetime histories of residence, occupation, and tobacco consumption was obtained on approximately 1100 males, including about 500 with lung cancer diagnosed between 1970 and 1976. Most were long-time residents of the coastal area. Local participation was excellent, with interviews completed for more than 97% of those contacted.

Comparison of the responses among the cases and controls revealed an excess lung cancer risk associated with employment in area shipyards during World War II.⁷ Two large shipyards, in Savannah and Brunswick, began operations in 1942 and by 1943 together employed more than 30,000 persons. Both closed shortly after the war. Over 20% of the lung cancer subjects identified in the survey reported having worked in the shipbuilding industry, almost all for just a few years during the war. The overall relative risk associated with this employment was 1.6, adjusted for age, race, other occupations, and smoking history. However, a strong synergism was seen between shipyard employment and cigarette smoking level, with the greatest excess for shipyard employment among heavy smokers.

Data on possible asbestos exposures were scanty; few persons reported handling asbestos as part of their shipyard duties. Of the approximately 180 persons in the study who reported working in the shipyards, only one was listed as an insulator. When risk ratios were calculated according to type of job within the shipyards, excesses were seen for a variety of trades, not just those likely to have heavy asbestos exposure.

Prompted by the results of the Georgia study, and by reports of mesothelioma among shipyard workers in the United Kingdom and elsewhere in Europe⁸ and reports of asbestos-related lung abnormalities among current shipyard workers in the United States,^{9,10} we have initiated a second case-control interview study of respiratory cancer

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among residents of Tidewater, Virginia. The shipbuilding industry is the large employer in the entire state of Virginia, with large navy and private shipyards in the Norfolk-Newport News area. Data from this survey are not yet available but should help to clarify the possible risk associated with shipyard employment. Since the industry continues to be a large employer today, problems in recalling occupational detail should not be as severe in Virginia as they were in Georgia where the individuals, or their next of kin, were asked to outline events that occurred 30 or more years ago.

The oldest shipyard company in the United States is located in the county of Sagadahoc on the coast of Maine. Here the lung cancer mortality rate is elevated and increasing at a faster pace than the national trend. In this area, the hospital charts of cases and controls are being searched as a preliminary step to possible interview studies that should clarify the carcinogenic hazards of shipyard employment. In addition, plans are being developed to conduct a case-control interview study of lung cancer in southern Louisiana. The petrochemical industry is the large manufacturing employer in this area, but as of 1970 over 12,000 residents were employed statewide in ship construction and repair, with more than three times this number working in Louisiana Gulf Coast shipyards during the war.

The results from this series of epidemiologic studies should help evaluate the contribution of shipyard exposures (to asbestos and possibly other agents) to the geographic patterns of respiratory cancer in the United States.

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