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Project Summary

Epidemiological Study of the Incidence of Cancer as Related to Industrial Emissions in Contra Costa County, California

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The purpose of this study was to examine the relationship of lung cancer incidence to ambient levels of air pollution in Contra Costa County. It was suspected that the presence of heavy industry in the county, mainly petrochemical plants and oil refineries, could be a contributing factor.

Initially, an incidence analysis established that the industrial section of the county had an excess of lung cancer as compared to the remaining nonindustrial section.

Air pollution patterns were subsequently determined by five permanent air monitoring stations and 10 temporary stations which monitored the levels of 12 air pollutants for a period of one year.

By correlating the 1970-79 lung cancer rates for each census tract and tract levels of air pollution constituents, a statistically significant relationship between ambient air SO_4 and lung cancer in males, but not in females, was found. However, when adjusted for the percent of the working population categorized as blue collar, the association was eliminated.

An interview study of 249 cases and 373 controls was then conducted. Demographic work history, residential history, dietary, and smoking history questions comprised the bulk of the data collected. Analysis indicated that the major contribution to lung cancer in the country was due to cigarette smoking. No significant association between lung cancer risk and measured constituents of air pollution was found. Of five broad occupational categories (indicating possible hazardous exposures) none had any significant relationship to lung cancer.

This Project Summary was developed by EPA's Health Effects Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Contra Costa County, located in the northeastern part of the San Francisco Bay Area, is one of 39 U.S. counties found to have a high mortality rate for specific cancer sites. The fact that the county also has five major petroleum refineries and numerous petrochemical plants, and that 68% of the total stationary air pollution in the Bay Area originates from the county, prompted an epidemiological study of the incidence of cancer in Contra Costa County. The major objective was to determine whether industrial emissions have a measurable effect on cancer occurrence. The study consisted of four parts:

1. A comparison of cancer incidence in heavily industrialized sections of the county to nonindustrialized sections.

2. Ambient air monitoring, consisting of sampling and chemical analysis of components of particulate pollution.
3. Correlation analysis of lung cancer incidence rates with air pollution constituents and census tract characteristics.
4. A case-control study to identify specific environmental factors associated with lung cancer incidence in the county.

Methods

Cancer Incidence

Cases included for analysis were malignant, invasive, resident incidence cases with primary sites of lung, bronchus or trachea for the period of 1969-1978. Age adjusted incidence rates were generated for the industrial and nonindustrial areas.

Air Pollution Monitoring

A total of 15 hi-volume particulate samplers were strategically sited at 13 locations in Contra Costa County and two locations in adjacent counties.

Air particulate material was collected every sixth day at each of the 15 sampling sites from November 1978 to October 1979. Particulate matter was analyzed for total suspended particulates (TSP), benzene soluble organics (BSO), sulfate (SO_4), nitrate (NO_3), lead (Pb), selected polycyclic aromatic hydrocarbons (PAH), and mutagenic activity. Standard chemical techniques were used to analyze TSP, BSO, SO_4, NO_3, and Pb. Specific PAH were separated by high performance liquid chromatography and analyzed using ultraviolet absorption and fluorescence. Mutagenicity was measured using the Ames test.

Correlation of cancer incidence data to air pollution measurements required interpolation of the station data to 115 census tract population centroids using a contour mapping program called SYMAP.

Correlation Analysis

Pearson correlation coefficients for census tract data between each air pollutant constituent and the 5- and 10-year average annual age-adjusted lung cancer incidence rates were computed for white males and females (two atypical tracts were removed from the analysis). Partial correlation coefficients for the same data were compared using socioeconomic variables as controls.

Case-Control Study

A case-control questionnaire study was conducted. All cases of cancer of the trachea, bronchus or lung among black or white residents of Contra Costa County, diagnosed between May 8, 1980 and July 31, 1981, and who were at least 35 years of age and less than 75 years of age at diagnosis, comprised a group of 332 eligible cases. Proxies were interviewed where cases were too ill or were deceased.

Controls were matched to cases of the same race and sex, and 5-year age group in each of 32 age, race, and sex strata. Controls were selected from the general population of Contra Costa County by random digit dialing.

At the end of the matching and data editing processes 19 cases and 37 controls were deleted leaving 249 cases and 373 controls for analysis.

The measure of the respondent's exposure to air pollution was expressed as an estimated cumulative dose for each pollutant, based on the residential history in the county.

The respondent's smoking experience was characterized by several parameters; total smoking duration, total pack years and average packs smoked per day.

The occupational exposure analysis was based on the coding of each work experience using occupation and industry titles in the Census' *1980 Alphabetical Index of Industries and Occupations*. Each blue collar job experience was assigned to one of four broad industry categories: construction, petrochemical, metal, and other industries.

The duration of time worked in an industrial category was calculated and accumulated for each respondent.

An asbestos exposure variable was created from various occupational categories. All shipyard occupations plus all other jobs for which asbestos exposures were reported were combined to form a total duration of asbestos exposure per respondent.

Each respondent was assigned a water source based on the water source for each census tract of residency at the time of interview or, for cases, diagnosis.

Certain census tracts in Contra Costa County contain known dumps of toxic or chemical waste. Each respondent was coded to indicate whether or not their census tract of residence contained a dump site.

To evaluate possible response variation among controls, the number of controls expected from each census tract was computed and compared to the number actually obtained. One area of the county was overrepresented and a separate small area of the county was underrepresented so that these responses were appropriately weighted in the analysis.

The amount of alcohol consumed per week was determined by history and formed an estimate of alcohol consumption. A dietary questionnaire provided estimates of weekly consumption of certain dietary items.

Within a particular race, sex and 5-year age group, controls were matched to cases by age using a variable matching ratio. Thus a case may have one or more matched controls.

Analysis of the data was carried out using multiple logistics regression procedures.

Conclusions

Incidence Analysis

The incidence analysis established that when the county was divided into two parts, the industrial section of the county had a 40% excess of lung cancer as compared to the nonindustrial section in the 1975-79 time period.

Air Pollution Monitoring

The Pb map was consistent with the fact that the largest source of Pb in the area is the automobile and the map conformed approximately to the paths of freeways. Comparison of the BSO and Pb maps suggests the contribution of the automobile to the BSO levels may be significant. The SO_4 distribution differs from the Pb by conforming to the industrial belt. This is consistent with the fact that SO_2, the precursor of SO_4, is emitted by stationary sources, primarily chemical industries, refineries and power plants, all located along the industrial belt. The patterns of the five PAH are similar to one another and to lead.

The correlation coefficients between pollutants for the 15 monitoring stations show very similar relationships to those based on the 113 census tracts which provided validation for their use in subsequent correlation analyses.

Correlation Analysis

A correlation analysis of 1970-79 lung cancer rates by census tract and various air pollution constituents showed only one statistically significant relationship That relationship was between ambient air SO_4 and lung cancer in males, but not

in females. However, when controlled for the percent of the population categorized as blue collar workers the relationship was eliminated.

Case-Control Study

Using multiple logistics regression analysis, all air pollution constituents were individually reviewed for their relationship with lung cancer. None of the measured air pollutants showed a statistically significant relationship. However, because SO_4 had shown a relationship in correlation analysis, it was included in the study as discussed below.

Because of the relevance of smoking to lung cancer, two statistically significant smoking variables for males ($p<.01$), average packs smoked per day and total smoking duration, were analyzed in conjunction with any other single variable. In this series of analyses only one additional variable emerged as a statistically significant factor in reducing the risk of lung cancer, but only for males. This was an indirect measure of dietary intake of vitamin A: the consumption of green vegetables ($p<0.01$). A similar but not statistically significant effect was found for females ($p<0.16$).

Although no other variables suggested a significant effect on the risk of lung cancer, further analyses were done adding more variables in different combinations, to identify possibly significant relationships obscured in simpler models. In more complex analytical models the effect of SO_4 dose, TSP dose, and other pollutant doses were analyzed separately controlling for the effects of smoking, drinking, diet, occupation and asbestos exposure. Again, no variables for males, other than green vegetables and the smoking variables emerged as statistically significant. For females, one smoking variable, average packs smoked per day, was significant.

The most complex analysis contained all variables which, in simpler models, had shown a statistically significant relationship to lung cancer, or was a known causal factor, or was of particular interest because of previous analyses. This analysis contained a total of 13 variables and represents a "saturated" model. The model included variables related to smoking, diet, alcohol, asbestos, SO_4 dose, occupation, and water source.

No additional statistically significant relationships with lung cancer risk appeared. Other than smoking, and the one dietary factor for males, no other relationships approached statistical significance.

Discussion

This analysis of case-control data suggests that the major contributor to lung cancer in Contra Costa County is smoking. Further, smoking accounts for most of the previously identified difference in lung cancer incidence between the industrial and nonindustrial areas.

There was no identified effect on lung cancer risk contributed from any measured constituent of air pollution. The one air pollutant (SO_4) significantly correlated with male lung cancer incidence in the indirect correlational analysis, had a positive but not statistically significant relationship with lung cancer risk in the case-control analysis only when SO_4 level at the current address was used as the measurement. When a measure of total lifetime dose of SO_4 from Contra Costa County was used, no elevated risk was apparent.

One dietary factor had a significant ($p<0.01$) protective effect for males and a similar but not statistically significant ($p<0.16$) effect for females. This factor, weekly servings of green vegetables, is a crude measure for several dietary constituents believed to reduce the risk of cancer of several types. Both vitamin A and cruciferous vegetables would be included in this dietary measure. The dietary measure, weekly servings of yellow vegetables, did not discriminate between cases and controls.

None of the occupational categories had any significant relationship to lung cancer risk in males. The occupational categories are very broad and undoubtedly contain specific occupations that are of higher and lower risk. The occupational analysis therefore likely explains less lung cancer than potentially it could. This supposition is supported by the fact that a higher proportion of lung cancer among females is explained in the analytical models than among males. Males would be expected to have a higher proportion of their numbers in occupations with carcinogenic hazards. A more detailed analysis of the effect of various occupations on lung cancer risk is planned.

The effect of asbestos exposure, as measured, did not bear a statistically significant relationship to lung cancer in this analysis. In any subsequent analysis a more quantitative measure of asbestos exposure would be desirable.

There was no apparent effect of source of drinking water or proximity to known toxic waste dumps on the risk of lung cancer.

These data confirm the known causal relationship between smoking and lung cancer. They provide some reassurance that constituents of particulate air pollution do not contribute measurably to the risk of lung cancer. This is consistent with the findings of several other studies. These data provide supportive evidence for the protective effect of dietary factors on cancer risk, a finding consistent with other epidemiologic and laboratory studies. The need for a more detailed analysis of occupation and lung cancer risk is apparent.

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The complete report, entitled "Epidemiological Study of the Incidence of Cancer as Related to Industrial Emissions in Contra Costa County, California," (Order No. PB 84-199 785; Cost: $11.50, subject to change) will be available only from:
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