A CASE-CONTROL STUDY OF RESPIRATORY CANCER AND EMPLOYMENT

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A multiple logistic risk analysis procedure was used to compare data from 346 case/control pairs to determine occupational/industrial risk factors for respiratory cancer. The duration of employment was considered in blue collar production occupations. Five industrial categories were included: shipyard, petrochemical, metal related, construction and a grouping of other occupations under a single heading. The bulk of this grouped category was made up of blue collar employees in the industries of transportation, food production, wholesale and retail trade, professional services and public administration. Specific attention was given to asbestos (1332214) exposure, cigarette smoking, educational level attained, and dietary factors such as consumption of vegetables, fruits, and alcohol. A moderately elevated risk for respiratory cancer existed among employees in the metal industry and grouped categories when employment was over 30 years duration. In the metal industry this increase was almost entirely due to a larger than expected number of cases of larynx cancer. Lack of a significantly increased risk among shipyard workers differs from an earlier study in this area. With the exception of asbestos and the tar, soot and carbon black category, few exposures to specific substances identified as respiratory carcinogens were reported. A negative association of green vegetable consumption with respiratory cancer risk was consistent with evidence on protective effects of foods high in beta-carotene.

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ABSTRACT

A case-control study of respiratory cancer was performed in two California counties. The objective of the study was to investigate occupational/industrial risk factors for respiratory cancer. Telephone interviews were conducted with all cases who could be contacted, and with controls who were matched to cases by sex, race, age ($\pm$5 years) and neighborhood of residence.

Data on 346 case-control pairs were analyzed by means of a multiple logistic risk analysis for matched pairs. The occupational/industrial risk factors investigated in this model consisted of duration of employment in blue-collar production occupations in 5 industrial categories -- shipyard, petrochemical, metal-related, construction, and a heterogeneous "other" category which includes all remaining industrial classifications. The other risk factors in the analysis were asbestos exposure, cigarette smoking, vegetable consumption, dairy product consumption, alcohol intake and education.

With all factors in the analysis adjusted for each other, employment in blue-collar production occupations in the shipyard, petrochemical, and construction industries was not associated with a statistically significant elevated risk. Thirty years of employment in the metal industry category and in the "other" category were each associated with a moderately elevated risk. Metal: RR = 3.37, p = .01; "other": RR= 2.73, p = .003.

Examination of the data indicated that the risk level associated with the metal industry category derived predominantly from the subset of larynx cancer cases.

The case-control distribution of time spent in occupational categories suggests that respiratory cancer risks are associated more with specific occupations, rather than with broad industrial categories.

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INTRODUCTION

This study was directed at determining the role of occupational exposures in the etiology of respiratory cancer. The objective was to determine whether a case-control study of respiratory cancer cases occurring in a geographically defined population during a period of twelve months would detect significant occupational/industrial exposure associations. The major emphasis of the study was on cancer of the lung which accounts for nearly 90 percent of all cancers of the respiratory system.

In the United States, carcinoma of the lung is by far the greatest cause of cancer mortality in men and is fast approaching breast cancer as the largest cause of cancer mortality in women (1); it has been clearly linked to cigarette smoking (2); and it is the most frequent malignancy to be associated with occupational exposures (3,4).

Incidence

Respiratory cancer rates vary with geographic location, but are still increasing over time (4). For the period 1973-77 the age-adjusted incidence rate in U.S. males was 88.7/100,000 for respiratory cancer and 78.3/100,000 for cancer of the lung and bronchus. In females, the corresponding rates were 24.4/100,000 and 22.2/100,000. For cancer of the larynx, the age-adjusted incidence rate was 8.5/100,000 in males and 1.3/100,000 in females (1).

In the San Francisco Bay area, the age-adjusted incidence rates for lung cancer during this period were higher -- 83.2/100,000 in males and 29.8/100,000 in females (1).

Lung Cancer

Overall survival rates for lung cancer are so poor that incidence and mortality rates are practically interchangeable. In the United States and most other developed countries, cancer of the lung presently is responsible for almost 40 percent of male cancer mortality (5). Yet in 1923, the Massachusetts age-adjusted mortality rate/100,000 was 1.55 for males and 1.50 for females (6). The increase, which has taken place during the last forty years, has been related to cigarette smoking (2).

Cigarette Smoking

U.S. men began smoking cigarettes in appreciable numbers at the turn of the century. The habit became more widespread after World War I, and

reached a peak of 65 percent in 1937 (7,8). It began to decline in 1957, falling to about 42 percent in 1970 and 39 percent in 1975 (9). For women, the rise began during World War II, reaching a high of 39 percent in 1961, then falling to 30 percent by 1970 and 29 percent in 1975 (7,9). In males who smoke heavily, the risk of developing lung cancer has been established at about ten times that for nonsmokers (2). The Third National Cancer Survey interview data indicate that for women who smoke heavily, the risk might be as high as sixteen times that for nonsmokers. Smokers of cigars and pipes have approximately a twofold risk of developing lung cancer (10).

It was demonstrated by Burbank (8), who used an estimated latency period of thirty years between the first exposure to smoking and tumor development, and historical data on cigarette consumption, that both male and female lung cancer mortality rates from 1950-68 fit a tobacco dose response curve.

Overall, about 10 percent of cigarette smokers develop lung cancer, and 90% of lung cancer deaths are attributed to smoking (2,4). A clear dose response relationship has been established (2). Other variables that may modify the risk ratio are age at starting to smoke, inhaling practices, type of cigarette and butt length (11).

Occupation

The association of occupation with respiratory cancer was first made about one hundred years ago, when the "mala metallorum" that killed miners in the Joachimstal, in 16th century Germany, was shown to be lung cancer (12,13). In 1936, Kawahata and Kuroda found an increased lung cancer mortality among workers in a steel plant in Japan (14). Since this time, an increased risk for lung and other respiratory cancers has been demonstrated among workers in many occupations and industries (3,4,15,16,17,18,19).

Occupational groups in which higher than expected rates of lung cancer have been found include asbestos workers (20,21,22,23), sheet metal workers (24,25), machinists (24,25), painters (24,25,26), carpenters (24,25), electric and electronic workers, aircraft workers (27,28), welders (15,28), workers exposed to chromium compounds (29) and to arsenic compounds (30), cooks (15,32), iron foundry workers (33,34), textile workers (35), butchers (36), sugar cane farm workers (37), petrochemical workers (38,39), nickel workers (40) and uranium miners (41). For uranium miners as well as for asbestos workers, a synergistic effect with smoking has been demonstrated (42,43). The subject of occupational cancer has been extensively reviewed by Cole and Goldman (3), Schottenfeld and Haas (40) and by Decoufle (31).

One of the difficulties in measuring occupational risks lies in the association between occupation and smoking. Both British and American data show considerable variation in smoking habits among workers in different occupations (44,45). The heaviest smokers are found in blue collar occupations, particularly those exposed to fumes, dust, etc. (45).

Air Pollution

There has also been considerable speculation on the extent to which general air pollution contributes to lung cancer mortality in urban areas. It was suggested by Clemmesen that there might be a nonspecific air pollution effect on the bronchial mucosa to make it more susceptible to carcinogens such as tobacco smoke (46). The only general air pollutants known to be carcinogenic are the polycyclic aromatic hydrocarbons (PAH), although a non-PAH fraction which is a potent cell transforming material has been isolated from Los Angeles air samples (Gordon, R.J., personal communication). The most commonly used indicator for polyaromatic hydrocarbons is benzo(a)pyrene concentration (11).

In several studies in the U.S., no association has been found between air pollution and lung cancer (47,48,49). However, Carnow and Meier correlated lung cancer mortality rates in forty-eight states with estimates of cigarette consumption and average pooled concentrations of benzo(a)pyrene, and concluded that an increase of 1 ng/m^3 produced a 5 percent increase in lung cancer mortality (50). Henderson et al. found an increased lung cancer rate in an area in which excess benzo(a)pyrene concentrations were measured (51), but in a subsequent case control study (52) Pike et al. found no association between lung cancer and long-term residence in that area.

Assessing available evidence on benzo(a)pyrene and lung cancer, Pike estimated 10 ng/m^3 of benzo(a)pyrene air pollution to be equivalent in carcinogenic potential to smoking one cigarette per day (11). The question remains controversial. Carnow has (50) concluded that the evidence indicated air pollution to be a significant factor in the production of lung cancer, whereas Friberg and Cederlof (53) stated that there was as yet no epidemiological proof that air pollution per se contributes to lung cancer evidence.

More recently, Vena (55), using total suspended particulates as a measure of air pollution, reported a study of the effects of air pollution in Erie County, Pennsylvania. Vena found evidence which suggested synergism between exposure to air pollution for a period of 50 or more years and smoking, and also possibly between air pollution, occupation and smoking.

Evidence on other pollution components is scanty. Higgins found a correlation between sulfates and lung cancer in 50 SMSA's (49). Blot and Fraumeni, also in an ecological correlative study, found excess lung cancer in residents of counties that had arsenical air pollution from nonferrous metal smelters and refineries (54).

Metabolic Factors

There is evidence that individual variation in tissue enzyme levels is one of the factors which determine susceptibility to carcinogenesis and that this variation might be under genetic control (53). It has been demonstrated that PAH's are metabolized into carcinogenic products by mixed function oxidases (56). One of these, aryl hydrocarbonhydroxylase (AHH), which is inducible in human lymphocytes, catalyzes the metabolism of benzo(a)pyrene (53). Kellerman et al. described a genetically determined trimodal distribution of AHH inducibility among human subjects, and reported high levels in patients with lung cancer (57). For the most part, these findings have not been confirmed in subsequent studies (58).

In an epidemiological study, Tokuhata et al. demonstrated a fourfold risk of lung cancer among first degree relatives of lung cancer patients (59). Excess lung cancer is also seen in families with an excess of other tumors (60). The excess lung cancer in Cantonese women residing in different countries (61,62) is suggestive of a genetic factor for this group.

Nutrition

A nutritional factor suggested for lung cancer has been a protective effect of the consumption of vitamin A or beta-carotene. The role of vitamin A in normal growth and differentiation of epithelial tissues is well established, having been demonstrated both in experimental animals and in organ culture (63).

In experimental animals, retinoid deficiency enhances the susceptibility of respiratory epithelium to chemical carcinogenesis, and the administration of retinoids can prevent the development of epithelial cancer in animals treated with carcinogens (64). For example, Saffiotti et al (65) have reported that vitamin A inhibits the induction of tracheobronchial squamous metaplasia and squamous cell tumors in hamsters. In man, successful therapeutic results have been achieved by the local administration of vitamin A acid to patients with actinic keratoses and basal cell carcinomas (66), leukoplakias of the oral cavity (67) and urinary papillomas (68) -- all epithelial tumors.

In a prospective study of lung cancer in Norwegian men matched for smoking habits (69), Bjelke computed a vitamin A index based on consumption of several vegetables, in particular, carrots, and of milk and

eggs. He found an inverse association between this index and the development of squamous cell and poorly differentiated small cell carcinomas. Since this seminal work, evidence on the inverse relationship between lung cancer and vitamin or provitamin A has been accumulating (70,71). Hirayama found a decreased risk for lung cancer in Japanese who ate green or yellow vegetables daily (72).

In data from China a negative association with the consumption of leafy green vegetables was found by Henderson (Henderson, B.E., personal communication). Mettlin et al., in an analysis of data from Roswell Park, found a reduced risk of lung cancer associated with vitamin A, especially for heavy smokers who frequently ate carrots (73). Basu (74) and Wald (75) have found an association between decreased serum vitamin A level and lung cancer. In the Western Electric Study, Shekelle et al. found evidence to support the hypothesis, advanced by Peto et al. (76), that dietary beta-carotene intake reduces the risk for lung cancer (77).

Histology

There is some evidence which suggests that different lung cancer cell-types might be related to specific etiological factors, including occupation. The refinements in classification and the observer variability in histological interpretation (78), make it difficult to interpret the significance of temporal variation in histological frequency distributions. In studies involving reclassification, the rate of agreement with the original reading has been 66 percent (79,80,81).

Kreyberg's grouping (squamous cell or epidermoid, small and large cell anaplastic as Group I, and adenocarcinoma and broncho-alveolar carcinoma as Group II) has been widely used in the study of lung cancer. A large body of data supports his contention that Group I carcinomas are smoking-related and Group II are not (81,82,83,84,85). In 1965, an adaptation of the grouping, the World Health Organization classification (86), was published. This classification, with minor variations, is now used by most pathologists.

Adenocarcinoma is more common in women (87,88,89), both male and female nonsmokers (79) and has been related to air pollution (50). Evidence of specific occupational associations with particular histological types includes a study of lung cancer in the Portland area in which the incidence of oat cell carcinoma was high in nurses and typists and an excess of large cell undifferentiated carcinomas was found in food operatives and farm laborers of both sexes (90). Weiss (91) has reported 11 cases of small cell carcinomas among 91 men exposed to chloromethyl ethers. Wegman and Peters (92) found an excess of small cell carcinomas in transportation operatives. In uranium miners with lung cancer, the proportion of small cell carcinomas increases with increasing cumulative radiation dosage (93).

Studies in which an attempt was made to show a dose-response relationship between smoking and specific histological types have been largely inconclusive (78,79,80), with the exception of one prospective study (94) in which such a relationship appeared to be present for well-differentiated squamous carcinomas, small cell carcinomas and also adenocarcinomas. Since the late sixties, the reported proportion of adenocarcinomas has been increasing for both sexes (78).

The other sites of respiratory cancer are larynx (about 8 percent), nose and sinuses (1 percent) and pleura (1 percent).

Carcinoma of the Larynx

Carcinoma of the larynx accounts for about 2 percent of all malignant neoplasms, being much more common in males than in females (1). The overall survival rate is close to 50 percent (95). In the United States, its distribution by county mortality patterns is correlated with that for lung cancer (96). It has been associated with tobacco and alcohol consumption (97), occupational exposures, and in particular, asbestos (97,98), nickel, isopropanol and mustard gas (99).

Carcinoma of the Nose and Sinuses

Carcinomas of the nasal cavity, sinuses and middle ear are rare, accounting for less than 0.5 percent of all malignancies (1). Clinically, they have been observed in patients with a history of nasal polyps and allergies, particularly aspirin allergy (Dolowitz, D., personal communication). There is some evidence of an increased frequency after nasal surgery (Henderson, B. E., personal communication).

Adenocarcinoma of the nose has been associated with working in the furniture industry (100,101), and to a lesser extent, with woodworking in general (102), and with exposure to nickel (103,104), chromium, isopropyl oil and textiles (14,105) and the boot and shoe industry (106).

Mesothelioma

Until the 1950's, mesothelial malignancies of the pleura and peritoneum were very rarely reported. Since that time, they have been diagnosed with increasing frequency. A positive history of asbestos exposure or shipyard experience has been obtained in most cases (107). The period of latency is usually 30-50 years, and there seems to be no relationship with the duration of the exposure or with cigarette smoking. Animal experiments indicate that mesothelioma formation is related to the size and shape of the asbestos fibrils that reach the alveolae (108,109).

Estimated Amount of Cancer Attributable to Occupation

There has been considerable controversy on the amount of cancer caused by occupational exposures. Estimates have ranged from 1 to nearly 40 percent (110). Doll and Peto recently investigated this subject and calculated that 4 percent of U.S. cancer mortality may be attributable to occupation. For lung cancer, their figures were 15 percent for males and 5 percent for females (4).

After careful consideration, these authors concluded that a "reasonably reliable estimate" of the amount of lung cancer caused by occupation could be made from a case-control study in which occupational histories were taken from approximately 10,000 lung cancer cases.

The study described here could be viewed as a pilot test for a large national study such as that suggested by Doll and Peto.

METHODS

Planning

The study population was drawn from respiratory cancer cases occurring among the 1.76 million residents of Alameda and Contra Costa counties during a twelve-month period, May 1980 to April 1981. Certain aspects of the study design were fixed by contractual requirements: that this be a case-control study with one control per case, matched on sex, age, race and neighborhood and that case interviews be restricted to patients themselves; no proxy interviews were permitted.*

Several factors were considered in the choice of the control population. Lung cancer is known to be more common in lower socioeconomic areas and in blue-collar workers. Blue-collar workers smoke more than white-collar workers and tend to live in lower socioeconomic areas. Smoking is therefore a major confounding factor in occupational lung cancer associations; residential air pollution may be a confounding factor. As the aim of this study was to detect specific occupational exposures associated with respiratory cancer, it was decided that choosing controls matched on neighborhood as well as age, race and sex would have the advantage of controlling for current residential outdoor air pollution, for blue- or white-collar occupational classification and for smoking habits, insofar as these factors are related to neighborhood. Residential patterns of the population, mobility, commuting and employment areas were considered, and it was felt that there was unlikely to be significant residential clustering of workers around particular industries.

A problem in looking for hazardous occupational exposures is the small fraction of the population engaged in a given occupation. To overcome this, it was necessary to group occupations. Consideration was given to using an occupational coding scheme developed for linkage with hazardous exposures (111), but the requirements for this study dictated that occupational coding be the same as that used by the Bureau of the Census. The questionnaire was structured to obtain a complete word picture of each job so as to include substances worked with or around, dust or fumes, etc.

The charge for this study was to investigate the relationship between employment history and respiratory cancer. This required detailed and accurate information on what could be a lengthy job history from patients who might be very sick. It was important, therefore, to keep the questionnaire reasonably brief. This limited both the number of other variables and the number of questions about them.

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*The initial study design provided for proxy interviews for deceased or otherwise unobtainable cases. These were deleted in accordance with Federal Reports Act review recommendations.

Since cigarette smoking is by far the most important cause of lung cancer, a detailed smoking history was essential. Dietary questions were designed to obtain a crude estimate of vitamin A consumption. Also included were questions on standard demographic variables, alcohol consumption, several previous medical conditions and several specific exposures. Questions on water/bottled water consumption and residential history were added to enable these variables to be investigated at a later time.

Data collection

The potential case population consisted of 1,036 cases of respiratory cancer newly diagnosed among residents of Alameda and Contra Costa counties during the period May 1980 to April 1981. Of these, 946 were cancers of the lung, trachea and bronchus, 71 were cancers of the larynx, 6 were cancers of the nose and sinuses, and 13 were mesothelioma cases. Our aim was to interview cases as quickly as possible after diagnosis. As soon as a case was entered into the study, we contacted the patient's physician to make sure that there were no medical or psychological reasons why we should not contact the patient to request an interview. At this stage, there were 266 patients classified by the physician as deceased or moribund, and 70 patients for whom their physicians did not give a clearance because of possible psychological problems, a language barrier, or other reason which would make an interview difficult.

This left 700 cases whom we tried to contact to explain the study and request a telephone interview. Of these, 136 had died or were too ill to be interviewed, 48 refused, and 72 presented difficulties such as a language barrier, psychological problems, or being unavailable during the study period. A total of 444 cases were successfully interviewed. Of these, 79 were dropped from the analysis because matched controls could not be found. Nineteen subjects with matched controls were subsequently dropped due to inadequate smoking histories for one of the pair. The total number available for analysis was 346 pairs. (Appendix A, Table 10 illustrates this process).

The study was restricted to one control per case. Controls were individually matched to cases by age group ($\pm$5 years), sex, race and neighborhood of residence. The field work to find controls consisted of first identifying the patient's residence and then following one of two algorithms (depending on the configuration of the streets) to locate a residence at which to start household enumeration. A description of the algorithms, the instructions and control location forms are included in the technical appendix.

From the starting point, household enumeration of residences, (i.e., asking the sex, age and race of all household members) was performed in the field until an individual of the same sex and race as the case and

within the defined age range, was located. We explained the study to that individual and requested his or her participation. If no response was obtained at a residence, a minimum of six attempts at contact (frequently more) were made at different times of the day, both weekdays and weekends, before a residence was considered "closed out." If a potential control refused to participate, household enumeration of neighboring residences was continued until a minimum of forty residences had been "closed out." Of the 365 controls interviewed, 77 percent were the first eligible matches, 19 percent were second matches, 3 percent were third matches and less than 1 percent were fourth matches. An average of 12 households was enumerated in order to find a suitable control.

The questionnaire was developed to conform to standard survey research practice. The questions were designed to be read verbatim and were extensively pretested to eliminate any ambiguities. Question order, probes, and skip patterns were organized so that the same instrument would be administered to each respondent. In the interest of both accuracy and of the time required to record the answers, the questionnaire was formatted for ease of administration. The questionnaire was pilot-tested on a small sample of respiratory cancer patients and healthy residents of Alameda and Contra Costa counties who were not included in the study.

A manual of detailed interviewer instructions was prepared. This included a study protocol and question-by-question specifications for the questionnaire.

To ensure the accuracy of the data collection and to minimize refusals by cases and controls, we employed interviewers trained and experienced in survey research interviewing techniques, for both the administration of the questionnaire and for the selection of controls. Interviewer training sessions for the study were held before the start of the field work and at intervals during the study period. They included mock interviewing during the briefing and practice interviews in the field. These were reviewed by the field work supervisor and where indicated, further training was conducted.

Most of the questionnaires were administered to cases and controls in a telephone interview that lasted an average time of 43 minutes. About 25 face-to-face interviews were conducted with respondents who requested them. Interviewers were asked to record their observations on the reliability of the answers and the degree of difficulty respondents experienced in answering the questions. Ninety-four percent of the answers were judged reliable and 74 percent of the respondents were felt to have had no major difficulty in answering all the questions.

Questionnaires were edited and reviewed by the supervisor before being coded and sent for key data entry. After key data entry, we checked

each variable for completeness and performed interfield comparisons for consistency and accuracy.

Analysis

The main analytic tool used in this study was the multiple logistic risk analysis model for matched pairs (112,113,114). The factors investigated in this model were five occupational/industrial employment groups, as well as asbestos exposure, cigarette smoking, diet, alcohol consumption and education. Other factors surveyed in terms of their distribution between cases and controls included person years spent in specific occupations and industries, job related substance exposures, income, and previous medical conditions, including cancer diagnoses.

Estimation of Occupational Exposure

The analysis for occupational exposure associations was based on the classification of occupation and industry titles in the 1980 Alphabetical Index of Industries and Occupations published by the Bureau of the Census (115). The employment groups investigated as risk factors were constructed by selecting the blue-collar production occupations; that is, the occupations listed under the classifications of precision production, craft and repair occupations, and operators, fabricators and laborers, for five industrial groups -- shipyard, petrochemical, metal, construction and all other remaining industries. The industrial and occupational group codes are listed in Appendix D.

Shipyard and construction are single industrial classifications. Petrochemical industries include the manufacture of chemicals and allied products, petroleum and coal products, and rubber and miscellaneous plastics products. Metal industries include metal mining, primary metal industries such as blast furnaces and foundries, metal product manufacturing, and the manufacturing of machinery including electrical and transportation equipment.

The remaining group of industries - other - includes agriculture, the manufacturing categories of food and tobacco, textiles, paper and printing, leather, lumber and furniture, stone products, and professional equipment, the transportation, communication and public utilities industries, wholesale and retail trade, repair and personal services, and professional and public administration.

For the purposes of this analysis the white-collar occupations (managerial, professional specialty, technical, sales and administrative), the service occupations and the farming, fishing and forestry occupations were designated as a comparison group.

The asbestos exposure group was formed by selecting from all employment groups those jobs for which respondents reported working with asbestos.

An initial frequency distribution of respondents who reported work in a shipyard or exposure to asbestos prompted a careful review of all such job histories. A positive asbestos "exposure" response could be obtained either from a general question, "What substances did you work with or work around on this job?" or a direct question on handling or being exposed to asbestos.

Responses were evaluated and classified without regard to case or control status, e.g., a respondent who reported occasional use of asbestos gloves while transferring hot materials was classified as negative; a respondent who reported sweeping asbestos powder off the floor was classified as positive.

The employment groups were analyzed in terms of exposure (ever/never having worked for 6 months or longer in the specific category) and duration (number of years from first employment in that category to 5 years prior to the study). This time period was selected as a reasonable time interval to allow for carcinogens acting at an early or late phase of the cancer induction period.

Estimation of Cigarette Exposure

Respondents were questioned about each cigarette smoking experience, dating from the start of regular smoking. Regular smoking was defined as smoking one or more cigarettes a day for at least 12 months. The information obtained for each experience consisted of the time period of every cigarette brand, type and amount smoked. These data were used to calculate cumulative values for total duration of smoking, the total amount smoked, the total amount adjusted for tar content of the cigarettes, the average amount smoked per day and the average amount adjusted for tar content. This procedure is described in Appendix E.

Preliminary analyses of the relationship between cigarette smoking and lung cancer indicated that of the smoking measures, smoking duration was the best predictor of lung cancer. Duration and average amount smoked per day were used as the smoking variables in the multiple logistic analysis. Further work has been planned for studying both the amount and the tar adjusted amount smoked by calendar decades.

Relatively few respondents reported smoking cigars or pipes. These factors were not used in the analysis presented here.

Dietary Factors

Accurate diet histories are notoriously difficult and time consuming to obtain. Therefore, the dietary questions in this study were designed to obtain only a crude measure of respondents' vitamin A intake over the previous 10 years. The intent was to estimate beta-carotene intake from

the reported consumption of green and yellow vegetables, retinol from reported consumption of dairy products and eggs. Also examined was the use of vitamin supplements. Values per serving of these food categories were estimated from values reported in nutrition manuals and food composition tables published by the United States Department of Agriculture (121,122) and from a random survey of the vitamin A content of vitamin preparations for sale. Yellow vegetables are, for the most, high in beta-carotene; green vegetables vary, from spinach and broccoli which are high, to lettuce and cucumbers which are low but are more commonly eaten than are spinach and broccoli. The amount of retinol in dairy products varies with the amount of butterfat. There is wide variation in the amount of vitamin A contained in both multivitamins and vitamin A preparations and many respondents were unable to recall the brands of vitamins consumed. After initial attempts to explore the dietary factors in terms of average vitamin A content of the food categories, the number of servings per week was chosen as the unit for each category. For the vitamin preparations, the vitamin A content was estimated at 40 units per vitamin A tablet and 10 units per multivitamin tablet.

Alcohol Intake

Information pertaining to alcohol intake for the last 10 years was obtained from the respondents' history of beverage consumption. The consumption of alcohol was estimated on the basis that the amount of alcohol in an average glass of wine, a can of beer and a jigger of spirits or liquor is approximately the same. The number of each of these drinks consumed per week was added up to form a total number of servings per week, and was treated as a continuous variable.

Education

Five educational levels were used to classify respondents: no schooling or some schooling, high school graduate, some college, college graduate, and post-graduate.

Other Factors

Factors not included in the multiple logistic analysis were surveyed in terms of their distributions between cases and controls. Case-control distributions of the factors included in the analysis were examined to gain insight into the nature of the differences contributing to the various relative risks.

Comparison of the Study Sample with Case Population

We compared interviewed and noninterviewed cases by sex, race and age distributions, county of residence and cell-type distribution. For some of the Contra Costa County cases, we were able to compare levels of

reported income and education with estimates of the mean income and education levels for the census tracts, in which they resided (123). Mean income and education levels for census tracts were obtained from the Contra Costa County Special Census (123).

RESULTS

Case Studies vs. Total Cases

The analysis was performed on 346 matched case-control pairs. In the comparison between the cases interviewed and the total case population, we found no substantial differences in site and sex distribution (Appendix A, Table 11), lung cancer cell type distribution (Appendix A, Table 12), nor in sex and age group distribution through age group 65-69 (Appendix A, Table 13). In the 70 and over age group the proportion of male cases in the analysis was about half that of the cases not analyzed. (The difference in this group was distributed evenly over the younger age groups).

The proportions of Alameda County and of Contra Costa County residents were the same in the analyzed cases as in the total case population. Of the Contra Costa County cases for whom we were able to compare their reported education levels with the average education levels of the census tracts in which they lived, 34 percent of the cases had the same educational level as the census tract mean and 54 percent had a lower level. This difference in education is noteworthy. Of those cases for whom income information was available, 54 percent had a higher income than the census tract mean and 16 percent had less. As the interview information was derived from 1979 income figures and the census tract information from the 1975 census, which was probably based on 1974 income figures, the difference in income seems reasonable.

Cases vs. Controls

The distribution of the risk factors between the cases and controls is shown in Appendix A, Tables 14-26. These tables show the overall characteristics of the case-control population in the study. The site, sex and age distribution of the cases is shown in Table 14. The distribution of lung cancer by cell type, race and sex is shown in Table 15.

In white males and females, adenocarcinomas form approximately 25 percent of the total. The proportion is higher in black males and females but the numbers are too small to be meaningful. Squamous cell carcinomas are more frequent in both white and black males; large cell anaplastic tumors are more frequent in white females. The proportion of adenocarcinomas in smokers, both male and female, in age groups under 55, and 55 and older, was constant at approximately 23 percent. In nonsmokers the proportion was 48 percent, dominated by females 55 and older.

The multiple logistic risk analysis is presented in Appendix A, Tables 1-6. This model was used to study the risk of respiratory cancer in 346 matched case-control pairs. The risk factors studied were

grouped occupational exposures, cigarette smoking, dietary factors, alcohol consumption, and education.

In this model, risk of respiratory cancer, R, is represented by the equation:

$$R = 1/\left[1 + e^{-(B_0 + B_1X_1 + \ldots + B_kX_k)}\right]$$

where B_0, B_1, $\ldots B_k$ are the k + 1 logistic coefficients for the i^{th} matched case-control pair.

For the risk levels encountered in the respiratory cancer data, e^{B_i} gives an approximation of the relative risk (odds ratio) per unit change in the level of risk factor, X_i. For example, asbestos exposure (Table 2) is a dichotomous variable for which the approximate relative risk in those ever exposed (coded 1), compared to those never exposed (coded 0), is $e^{.60} = 1.82$. For continuous variables, such as the duration of asbestos exposure, which is measured in years, a unit change of one year represents too small a difference in the risk factor. The logistic coefficients were, therefore, adjusted to units approximately equal to either the standard deviation of the distribution or the mean of the values among respondents exposed to the factor. For factors with a normal distribution, such as vegetable and dairy product consumption, we used the standard deviation. For factors such as asbestos exposure, the five occupation/industry exposures, smoking, vitamin A supplementation and alcohol intake, a substantial percentage of respondents reported no exposure. For these factors, the mean value for those exposed provided a more appropriate unit.

The association between cigarette smoking and respiratory cancer was explored for six different measures separately (Table 1). The measures were too highly correlated to permit adjustment for each other. The risk factors, ever having smoked regularly, smoking duration, total cigarette consumption, total tar-adjusted cigarette consumption and the average amount smoked per day all showed a strong and statistically significant ($p<.001$) association with lung cancer. As the smoking measures increased in specificity, the relative risks and their 95% confidence intervals decreased (Table 1).

The associations between occupational exposures and respiratory cancer were explored for ever having worked in the category and for the duration of time worked, both with and without adjustment for the other occupational exposures (Tables 2-5). For the exposure categories coded ever/never (Tables 2 and 3), only asbestos showed a moderate and statistically significant elevated risk (RR = 1.82, p = .02 unadjusted; RR = 1.89, p = .03 adjusted).

The associations were also calculated for occupational exposure periods of 30 years (the average time period for occupational exposures among those who were exposed). Asbestos was the only strong and statistically significant risk factor (RR = 3.86, p = .01) when each analysis was performed separately, without adjustment (Table 4). When the six occupational exposure categories were adjusted for each other (Table 5), the asbestos risk remained strong and significant (RR = 4.13, p = .01). In addition, three other categories showed a moderate and statistically significant association: metal (RR = 2.19, p = .04), construction (RR = 2.20, p = .04) and the "other" category (RR = 2.04, p = .003).

When the occupational exposure associations were further adjusted (Table 6), for cigarette smoking (30-year duration and smoking one pack per day, the average amount for those who smoked), dietary factors, vitamin A, alcohol intake and education, the risks associated with asbestos become stronger (RR = 8.03, p = .009). The risks associated with the metal (RR = 3.37, p = .01) and the "other" category (RR = 2.73, p = .003) were also increased slightly. The moderate risk associated with the construction industry category was no longer statistically significant (RR = 2.04, p = .18). The risk level associated with the petrochemical industry was also not statistically significant (RR = 2.17, p = .32).

The consumption of both milk and of alcohol was associated with a weak but statistically significant risk level (milk: RR = 1.44, p = .006, alcohol: RR = 1.40, p = .003). A moderately decreased risk, which was marginally statistically significant (RR = .68, p = .10), was shown for the intake of green vegetables. Education was associated with a weak decreased risk (RR = .78, p = .03).

The multiple logistic risk model implies a multiplicative risk for the factors analyzed. Thus, from Table 6 the relative risk for 30 years of smoking and 30 years of asbestos exposure would be 6.06 x 8.03 = 48.66. An additional interactive term between asbestos and smoking did not produce a statistically significant risk estimate.

The case-control distribution of person years spent in blue-collar occupations in the industries which make up the category "other" can be seen in Table 7. Looking at industries for which more than 200 person-years have been reported and case-control differences are more than 40 person-years, it can be seen that cases spent more time than controls in blue-collar occupations in the industries of transportation, retail trade, professional and related services and public administration. Controls spent more time than cases in the industries of personal services, lumber and furniture manufacturing. These distributions have not been adjusted for smoking or other risk factors.

Table 8 presents the person-year distribution of occupations without regard to industry. Blue-collar occupations in which cases spent more time than controls include food preparation and services, health and building services, mechanics and repair trades, construction trades, assorted precision production trades, butchers and bakers, welders, motor vehicle operators, truck drivers, material moving equipment operators and laborers.

The case-control distribution of usual occupations, defined as occupations held the longest (Appendix A, Table 22), shows that 67 percent of male cases and 52 percent of male controls reported blue-collar occupations. For females, there is little difference in the proportion of cases and controls who reported blue-collar occupations as their usual occupation, 30 percent for cases and 27 percent for controls. The distribution of smoking in these groups can also be seen in Table 22. Table 23 shows the distribution of asbestos exposure and smoking. Ninety-four percent of cases and seventy-one percent of controls who reported asbestos exposure were smokers. Usual (i.e., longest-held) occupations reported more frequently by cases than controls include mechanics and machine operations, transportation and laboring occupations.

It was requested that each respondent describe, in detail, the activities and duties involved in each job. Substances reported in these job descriptions, were classified according to the evaluation of carcinogenic chemicals and industrial processes prepared by the International Agency for Research on Cancer (99). Substances for which cases reported more person years of work exposure than controls were asbestos, tar or soot, petroleum or benzene, organic chemicals or solvents, and sawdust (Appendix A, Table 9).

The distributions have not been adjusted for the case-control matching or for other risk factors. They present the characteristics of the populations on which the analysis is based. For certain of the characteristics, e.g., substance exposure, further analysis would be desirable.

We looked at the smoking measures for cases and controls by decades. In every decade cases had smoked more than controls, but the controls did a slightly higher proportion of their smoking before 1960, and the cases did a higher proportion of their smoking after 1960. Appendix F, Figure 2, shows a comparison of the pack-years smoked per decade by cases, expressed as a percentage of the total pack-years smoked by cases, and the pack-years smoked per decade by controls, expressed as a percentage of the total pack-years smoked by controls.

Cigar and pipe smoking were not frequent. Among the cases, 6 percent smoked cigars and 9 percent smoked a pipe; among the controls, 9.5 percent smoked cigars and 12 percent smoked a pipe.

Further exploration of the relationship between respiratory cancer and the various smoking measures in this data set has been planned, but is beyond the scope of the present contract.

We reviewed the distribution of the amount of vegetables, dairy products and alcohol consumed by cases and controls. Substantial case-control differences were seen only in respondents who consumed more than 7 servings of vegetables, 21 servings of dairy products or 14 servings of alcohol per week.

In this data set, we found little correlation between duration of cigarette smoking and alcohol consumption ($r=.05$ for males, $r=.15$ for both sexes), duration of smoking and education ($r=-.14$ for males, $r=-.18$ for both sexes), and alcohol consumption and education ($r=.02$ for males, $r=.002$ for both sexes).

A review of previous medical conditions shows that cases reported more previous respiratory illnesses than controls; bronchitis -- cases 19 percent, controls 9 percent, emphysema -- cases 21 percent, controls 6 percent, asthma -- cases 12 percent, controls 9 percent.

DISCUSSION

The results of this analysis indicate that after adjustment for smoking duration, the average amount smoked and other risk factors, time spent in certain categories of blue collar employment is associated with an increased risk of respiratory cancer. In the petrochemical and construction industries the relative risks of 2.17 and 2.04 respectively (Appendix A, Table 6) could have occurred by chance. The metal category and the heterogeneous category, "other industry", showed statistically significant relative risks of 3.37 and 2.73 respectively for 30 years duration of employment.

The relative risk associated with metal decreased and was not statistically significant when the analysis for all risk factors combined was performed on lung cancer cases only (RR = 2.10, p = .17) and on male lung cancer cases only (RR = 1.57, p = .47). These results indicate that the metal association was derived predominantly from the larynx cancer subset of cases. This was confirmed by a review of the data on the larynx cancer cases; the duration of time spent in the metal industry was twice as long for cases than for controls.

Among specific substance exposures reported by respondents, arsenic was the only metal for which more person years of exposure were reported by cases than controls and the numbers are small (36 vs. 7 years). However, cases reported more person years of exposure to organic chemicals (344 vs. 286 years) and unspecified chemicals (191 vs. 142 years); both are commonly used as solvents and degreasers in the metal industry.

The relative risk associated with the "other" industry category was practically unchanged when only the lung cancer cases were analyzed (RR = 2.81, p = .005) but was higher for male lung cancer cases only (RR = 4.14, p = .003). The bulk of the category is made up of blue-collar occupations in the industries of transportation, food production, wholesale and retail trade, professional services and public administration.

Specific occupations which might contribute to the increased respiratory cancer risk associated with the heterogeneous industrial cluster are suggested by the case-control distributions of the various occupational measures (Appendix A, Table 15). In a subsequent analysis, we would like to examine further some of these more specific occupational categories with adjustment for smoking.

Unlike studies in Virginia and Louisiana (124,125,126), this study showed no significant increased risk for employment in a shipyard. Our results are in keeping with the findings of a study of Naval Shipyard workers in Hawaii (127). The Hawaiian cohort had an elevated lung cancer risk only for the group exposed to asbestos. In this Bay Area

study, about half of all respondents with a history of shipyard employment reported exposure to asbestos. Asbestos exposure, which was defined as a report of actually working with asbestos or, as described in the context of shipbuilding, working next to asbestos workers, had a risk of 8.03 for 30 years duration when adjusted for all factors.

Our review of the responses to the direct question on asbestos exposure indicated that, in this geographic area, both cases and controls have been highly sensitized to the dangers of asbestos. One respondent reported that although he did not know it at the time, he had probably been exposed to asbestos during his service in the Navy, because he had been told that all Navy personnel were exposed. Another respondent reported that she had probably been exposed to asbestos because the ceiling of the classrooom in which she had taught had been covered with acoustical tiles. She did not state that the tiles were made of asbestos nor that they were disintegrating. By our criteria these were not classified as exposures. Another possible problem is that some respondents will selectively report substances they have worked with only if they judge the substance to be hazardous.

The 148 positive responses to the direct asbestos question were equally divided between cases and controls. The probe questions produced thirteen responses describing a job situation indicating a likely exposure to asbestos fibers for more than a few days. Our experience relating to asbestos illustrates the difficulty of obtaining an unbiased estimate of asbestos risk from interview data at this time.

Except for asbestos and the tar, soot and carbon black category, few exposures to specific substances which have been identified as respiratory carcinogens were reported in this study. No exposure to chromium or bis(chloromethyl)ether was reported. Only a few person-years of exposure were reported for arsenic, nickel, beryllium and vinyl chloride. This type of information is more reliably obtained from industrial hygiene data than respondent interview data.

The negative association of green vegetable consumption with respiratory cancer risk, although of only marginal statistical significance, is consistent with other evidence on the protective effect of foods high in beta-carotene (72,76,77). The positive association of milk consumption is consistent with the findings of Kolonel et al., who showed a positive association between lung and laryngeal cancer and cholesterol intake (128). The distribution of the case-control consumption of milk (the difference lies between respondents who consumed more than three servings a day) also suggests the possibility that this measure may be serving as an indicator for a more general dietary or lifestyle pattern associated with a higher respiratory cancer risk. A more detailed analysis of the dietary factors, which includes correlations between the various diet responses, and between the dietary variables and other factors, is indicated.

The weak positive association with alcohol consumption (RR = 1.40, p = .003) is consistent with the known association between alcohol and cancer of the larynx. The association was still evident, although less statistically significant, in the analysis of the subsets of lung cancer cases only (RR = 1.30, p = .02), and male lung cancer cases only (RR = 1.33, p = .06).

The negative association with education (RR = .78, p = .03) remained consistent for lung cancer cases only (RR = .75, p = .03) but not statistically significant for male lung cancer cases only (RR = .79, p = .19). Since the cases and controls were matched on neighborhood, a socioeconomic indicator which should be highly correlated with education, the negative association of education is interesting. At least three possible explanations come to mind.

First is that lower education may be correlated with some aspects of lifestyle that involve higher carcinogenic risks. Second is that education may be associated with differences in smoking habits -- butt length, putting the cigarette down in an ashtray, etc., and that these affect the carcinogenic dose delivered by cigarettes. The third possibility is that within each job classification, persons with less education may have jobs involving more hazardous exposures. The latter possibility could be addressed by further analysis of this data set.

Every retrospective study that is based on interview data is subject to the problem of recall bias, i.e., selectively greater recall of possible hazards by cancer patients who may have spent time thinking about possible causes of their illnesses. In spite of efforts to minimize the bias problem by care in the questionnaire design and administration, and in the review of responses, it has to be considered as a possible explanation of risk factors reported by cases. Another obstacle for retrospective studies -- loss of memory for events of long ago -- would be expected to be similar in cases and controls, except possibly for cases who were very ill at the time of the interview.

An impression gained from this as well as other studies suggests another problem. As evidenced by their job descriptions, individuals differ in their knowledge of substances they have worked with and their awareness of their surroundings on the job. This may be influenced more by their general attitude towards their environment rather than their case or control status.

These characteristics may not be randomly distributed between cases and controls. One could speculate that such characteristics may be associated with differences in health protective behavior, which in turn may be associated with education. In this study, we found a protective effect of education, which was not accounted for by the other variables studied. If the hypothesis is correct, that a higher level of health

protective behavior is associated with increased reporting of hazardous exposures, we would expect a conservative bias in the risk estimates for reporting of exposures such as those listed in Appendix A, Table 9. As stated above, the education variable may point to different levels of exposure within a particular occupational category.

Lung cancer patients, who account for most cases of respiratory cancer, are frequently very ill and die within a short time of diagnosis. We made an intense and sustained effort to speed up all case ascertainment procedures, and to interview cases as soon as possible after diagnosis. In spite of this effort at least 38.8 percent of the patients were moribund or deceased before they could be contacted. The actual proportion was possibly even higher, since some of the cases for whom physicians would not give us clearance or family members did not wish us to contact the patients, were probably in this category. Our patient refusal rate was 4.6 percent. Further losses, due to our inability to locate suitable controls (7.6 percent) and to questionnaires with inadequate smoking data, left us with only 33.4 percent of the cases in the analysis. This raises the problem of selection bias in the sample of the cases analyzed. Proxy interviews for the deceased patients would have increased the number of cases in the sample, but the information thus obtained is usually less reliable and less complete, especially for variables such as occupation. In this study of patients from two counties, 63 percent of the cases came from 12 out of the 52 hospitals from which cases were obtained. Since there is a definite concentration of patients in a few hospitals, in a future study it might be feasible to interview most patients during their initial hospital stay. However, such a strategy would lead to other problems, particularly in the selection of controls.

One of the facets of this study was an attempt to obtain a highly detailed cigarette smoking history -- specific amount and brand information for up to five smoking experiences. We used this information to calculate duration of smoking, amount smoked and to add a tar content weight to the amount smoked. Differences in tar content are more relevant to smoking from 1960 onwards than to previous decades. The difference in proportional amounts smoked by cases and controls before 1960 and after 1960 is intriguing, and, together with the possibility of using the decade specific information to create a more refined smoking measure than duration and amount, warrants further analytic effort.

The issue of possible overmatching in the control population also warrants further analysis. The choice of neighborhood matching was determined by the wish to attain maximum specificity of any occupational differences between cases and controls, to minimize socioeconomic and smoking differences, and to eliminate current residential outdoor air

pollution as a variable. Preliminary calculations indicate that any possible overmatching would not affect the relative risks but that there might be some loss of efficiency in the analysis (R. J. Brand, personal communication).

In this project, because of factors beyond our control, data could not be collected from a relatively large proportion of the subjects. We succeeded in obtaining occupation, smoking, demographic and dietary data on 346 case-control pairs. An examination of the characteristics of both the case sample and of the total case population did not suggest a systematic bias in the case sample. In a separate project, proxy interviews were performed for a portion of the case population investigated here. We intend to use these data to further investigate the issue of sample bias.

We used a multiple logistic risk analysis to look for an association between respiratory cancer and industrial employment categories, using duration of employment as a measure. The industrial categories were created on an a priori basis after consideration of both employment patterns in the area and potential exposure to hazardous substances. Associations with the shipyard, petrochemical and construction industries were not statistically significant. The metal industry category and the heterogeneous "other" category formed by all other remaining industries, were each associated with statistically significant elevated risks (metal RR = 3.37, $p = .01$; "other" RR = 2.73, $p = .003$) for 30 years of exposure. The association with reported asbestos exposure of 30 years was both substantive and significant (RR = 8.03, $p = .009$).

Other recommendations for further use of these data include a comparison of occupations reported by cases as the occupation held longest with the occupations reported on their death certificates. The data set will also serve as a basis for further exploration of some of the methodological issues encountered during this project, such as the sensitivity of the interview approach, the efficiency of matching on neighborhood of residence, and the determination of sample size required to show differences in occupational risk. This information can be used to guide further studies on the occupational contribution to respiratory cancer.

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Appendix A, Table 1. Unadjusted associations between respiratory cancer and different measures of cigarette smoking

SMOKING MEASURE	RELATIVE RISK PER UNIT	95% CONFIDENCE INTERVAL	SIGNIFICANCE PROBABILITY (p=)
Ever/never smoking	6.42	(3.96, 10.41)	< .001
Smoking duration[1] (unit = 30 years)	5.82	(3.96, 8.53)	< .001
Cigarette consumption[1] (unit = 40 pack years)	3.88	(2.83, 5.31)	< .001
Tar-adjusted cigarette consumption[1] (unit = 150 tar-adjusted pack years)	3.41	(2.51, 4.64)	< .001
Average amount smoked[1] (unit = one pack)	3.10	(2.34, 4.10)	< .001
Tar-adjusted average amount smoked[1] (unit = four tar-adjusted packs)	1.29	(1.19, 1.38)	< .001

[1]The unit values represent the average of each measure for smokers.

Appendix A, Table 2. Unadjusted associations between respiratory cancer and blue-collar occupational exposure factors

OCCUPATIONAL EXPOSURE CATEGORY (coded never=0, ever=1)	RELATIVE RISK PER UNIT	95% CONFIDENCE INTERVAL	SIGNIFICANCE PROBABILITY (p=)
Asbestos	1.82	(1.08, 3.06)	.02
Shipyard	0.93	(0.56, 1.56)	.79
Petrochemical	1.04	(0.59, 1.82)	.89
Metal	1.10	(0.75, 1.61)	.63
Construction	1.40	(0.88, 2.23)	.16
Other	1.20	(0.85, 1.69)	.30

Appendix A, Table 3. Associations between respiratory cancer and blue-collar occupational exposure factors adjusted for each other

OCCUPATIONAL EXPOSURE CATEGORY (coded never=0, ever=1)	RELATIVE RISK PER UNIT	95% CONFIDENCE INTERVAL	SIGNIFICANCE PROBABILITY (p=)
Asbestos	1.89	(1.08, 3.30)	.03
Shipyard	0.76	(0.44, 1.32)	.33
Petrochemical	0.98	(0.55, 1.75)	.95
Metal	1.11	(0.74, 1.65)	.61
Construction	1.53	(0.82, 2.17)	.25
Other	1.25	(0.88, 1.77)	.21

Appendix A, Table 4. Unadjusted associations between respiratory cancer and duration of blue-collar occupational exposure factors

OCCUPATIONAL EXPOSURE CATEGORY	RELATIVE RISK PER 30 YEARS OF EXPOSURE	95% CONFIDENCE INTERVAL	SIGNIFICANCE PROBABILITY (p=)
Asbestos	3.86	(1.40, 10.62)	.01
Shipyard	1.79	(0.37, 8.67)	.47
Petrochemical	1.10	(0.39, 3.11)	.86
Metal	1.52	(0.77, 2.98)	.22
Construction	1.86	(0.95, 3.74)	.08
Other	1.50	(1.00, 2.24)	.05

Appendix A, Table 5. Associations between respiratory cancer and duration of blue-collar occupational exposure factors adjusted for each other.

OCCUPATIONAL EXPOSURE CATEGORY	RELATIVE RISK PER 30 YEARS OF EXPOSURE	95% CONFIDENCE INTERVAL	SIGNIFICANCE PROBABILITY (p=)
Asbestos	4.13	(1.35, 12.68)	.01
Shipyard	1.23	(0.19, 7.78)	.83
Petrochemical	1.29	(0.42, 3.97)	.66
Metal	2.19	(1.05, 4.54)	.04
Construction	2.20	(1.03, 4.69)	.04
Other	2.04	(1.28, 3.24)	.003

Appendix A, Table 6. Associations between respiratory cancer and all risk factors adjusted for each other

RISK FACTOR	RELATIVE RISK	95% CONFIDENCE INTERVAL	SIGNIFICANCE PROBABILITY (p=)
Asbestos (30 years)	8.03	(1.69, 38.23)	.009
'Other' (30 years)	2.73	(1.41, 5.28)	.003
Metal (30 years)	3.37	(1.30, 8.72)	.01
Construction (30 years)	2.04	(0.72, 5.81)	.18
Petrochemical (30 years)	2.17	(0.47, 9.94)	.32
Shipyard (30 years)	1.47	(0.11, 19.54)	.77
Cigarette Smoking (30 yrs)	6.60	(3.56, 10.30)	<.001
Cigarette Smoking (1 pack)	1.25	(0.87, 1.81)	.23
Yellow Vegetables (4 servings/week)	.84	(0.58, 1.22)	.36
Green Vegetables (6 servings/week)	.68	(0.43, 1.07)	.10
Milk (8 servings/week)	1.44	(1.11, 1.86)	.006
Eggs (4 servings/week)	1.26	(0.92, 1.71)	.15
Cheese (4 servings/week)	1.00	(0.69, 1.45)	.99
Vitamin A (70,000 u/week)	.86	(0.65, 1.14)	.29
Alcohol (14 drinks/week)	1.40	(1.12, 1.74)	.003
Education (each level)	.78	(0.61, 0.98)	.03

All units inside the parentheses are based on the mean values for those subjects who are exposed to the risk factor.

Appendix A, Table 7. Distribution of occupation/industries[1] among cases and controls (in person years).

OCCUPATIONAL CATEGORY	INDUSTRY	CASES	CONTROLS	TOTAL
	Total	10602	10255	20857
WHITE COLLAR	Agriculture	5 71.4%	2 28.6%	7
	Mining	55 75.3%	18 24.7%	73
	Construction Mfg.	92 59.0%	64 41.0%	156
	Food and Tobacco	164 55.0%	134 45.0%	298
	Textile, Apparel Mfg.	68 88.3%	9 11.7%	77
	Paper, Printing Mfg.	181 41.0%	260 59.0%	441
	Petrochemical Mfg.	72 33.2%	145 66.8%	271
	Leather Mfg.	29 82.9%	6 17.1%	35
	Lumber, Wood, Furniture Mfg.	13 44.8%	16 55.2%	29
	Stone, Glass, Clay Mfg.	1 33.3%	2 66.7%	3
	Metal Mfg.	37 14.5%	218 85.5%	255
	Machinery Mfg.	14 25.0%	42 75.0%	56

[1]No person years reported in the following industrial categories:

a) 'Other' transportation equipment manufacturing for blue-collar workers
b) Barber shops for white-collar workers
c) Shoe repair for white-collar or blue-collar workers

Continued

Appendix A, Table 7. Distribution of occupation/industries[1] among cases and controls (in person years).

OCCUPATIONAL CATEGORY	INDUSTRY	CASES	CONTROLS	TOTAL
	Total	10602	10255	20857
WHITE COLLAR	Electrical Mfg.	137 52.3%	125 47.7%	262
	Motor Vehicles Mfg.	90 75.6%	29 24.4%	119
	Aircraft, Space Vehicles Mfg.	6 33.3%	12 66.7%	18
	Ship, Boat Repairs Mfg.	54 77.1%	16 22.9%	70
	Other Mfg.	70 89.7%	8 10.3%	78
	Transportation	336 50.2%	334 49.8%	670
	Communications	35 12.9%	237 87.1%	272
	Utilities	7 3.1%	218 96.9%	225
	Wholesale Trade	358 51.7%	335 48.3%	693
	Retail Trade	694 45.1%	845 54.9%	1539
	Finance	418 53.4%	365 46.6%	783
	Business Service	169 60.1%	112 39.9%	281

[1]No person years reported in the following industrial categories:

a) 'Other' transportation equipment manufacturing for blue-collar workers
b) Barber shops for white-collar workers
c) Shoe repair for white-collar or blue-collar workers

Continued

Appendix A, Table 7. Distribution of occupation/industries[1] among cases and controls (in person years).

OCCUPATIONAL CATEGORY	INDUSTRY	CASES	CONTROLS	TOTAL
	Total	10602	10255	20857
WHITE COLLAR	Automotive Services	43 60.6%	28 39.4%	71
	Repair Services	12 20.0%	48 80.0%	60
	Personal Service	46 79.3%	12 20.7%	58
	Laundry Cleaning	59 92.2%	5 7.8%	64
	Beauty Shops	0 0.0%	13 100.0%	13
	Funeral and Other	0 0.0%	47 100.0%	47
	Entertainment	93 60.0%	62 40.0%	155
	Professional and Related Services	634 37.8%	1044 62.2%	1678
	Public Administration	265 49.3%	273 50.7%	538
	Armed Forces	192 62.1%	117 37.9%	309
BLUE COLLAR	Forest, Fisheries Agriculture	320 47.1%	360 52.9%	680
	Mining	41 66.1%	21 33.9%	62

[1]No person years reported in the following industrial categories:

a) 'Other' transportation equipment manufacturing for blue-collar workers
b) Barber shops for white-collar workers
c) Shoe repair for white-collar or blue-collar workers

Continued

Appendix A, Table 7. Distribution of occupation/industries[1] among cases and controls (in person years).

OCCUPATIONAL CATEGORY	INDUSTRY	CASES	CONTROLS	TOTAL
	Total	10602	10255	20857
BLUE COLLAR	Construction	821 62.2%	499 37.8%	1320
	Food and Tobacco Mfg.	318 62.9%	188 37.1%	506
	Textiles, Apparel Mfg.	39 51.3%	37 48.7%	76
	Paper, Printing Mfg.	105 46.5%	121 53.5%	226
	Petrochemical Mfg.	319 50.5%	313 49.5%	632
	Leather Mfg.	33 100.0%	0 0.0%	33
	Lumber, Wood, Furniture Mfg.	118 32.8%	242 67.2%	360
	Stone, Glass, Clay Mfg.	75 38.9%	118 61.1%	193
	Metal Industries Mfg.	420 57.2%	314 42.8%	734
	Machinery Mfg.	155 61.3%	98 38.7%	253
	Electrical Mfg.	94 48.2%	101 51.8%	195
	Motor Vehicles Mfg.	119 69.6%	52 30.4%	171

[1]No person years reported in the following industrial categories:

a) 'Other' transportation equipment manufacturing for blue-collar workers
b) Barber shops for white-collar workers
c) Shoe repair for white-collar or blue-collar workers

Continued

Appendix A, Table 7. Distribution of occupation/industries[1] among cases and controls (in person years).

OCCUPATIONAL CATEGORY	INDUSTRY	CASES	CONTROLS	TOTAL
	Total	10602	10255	20857
BLUE COLLAR	Aircraft, Space Vehicles Mfg.	25 43.1%	33 56.9%	58
	Ship, Boat Repairs, Mfg.	233 58.3%	167 41.7%	400
	Other Transport Mfg.	0 0.0%	1 100.0%	1
	Other Mfg.	11 36.7%	19 63.3%	30
	Transportation	793 65.2%	423 34.8%	1216
	Communications	28 57.1%	21 42.9%	49
	Utilities	40 44.4%	40 55.6%	90
	Wholesale Trade	261 63.2%	152 36.8%	413
	Retail Trade	703 58.2%	506 41.8%	1209
	Finance	5 27.8%	13 72.2%	18
	Business Service	47 42.0%	65 58.0%	112
	Automotive Service	173 62.5%	104 37.5%	277

[1]No person years reported in the following industrial categories:

a) 'Other' transportation equipment manufacturing for blue-collar workers
b) Barber shops for white-collar workers
c) Shoe repair for white-collar or blue-collar workers

Continued

Appendix A, Table 7. Distribution of occupation/industries[1] among cases and controls (in person years).

OCCUPATIONAL CATEGORY	INDUSTRY	CASES	CONTROLS	TOTAL
	Total	10602	10255	20857
BLUE COLLAR	Repair Services	19 21.8%	68 78.2%	87
	Personal Services	161 41.2%	230 58.8%	391
	Laundry, Cleaning	34 38.2%	55 61.8%	89
	Beauty Shops	44 71.0%	18 29.0%	62
	Barber Shops	2 1.6%	120 98.4%	122
	Funeral and Other	1 100.0%	0 0.0%	1
	Entertainment	116 73.9%	41 26.1%	157
	Professional and Related Services	342 56.6%	262 43.4%	604
	Public Administration	173 66.3%	88 33.7%	261
	Armed Forces	476 33.5%	946 66.5%	1422

[1]No person years reported in the following industrial categories:

a) 'Other' transportation equipment manufacturing for blue-collar workers
b) Barber shops for white-collar workers
c) Shoe repair for white-collar or blue-collar workers

Appendix A, Table 8. Distribution of occupations[1] among cases and controls (in person years).

OCCUPATION	CASES	CONTROLS	TOTAL
Total	10633	10258	20891
Executive Managerial	968 48.9%	1010 51.1%	1978
Professional Speciality	731 34.9%	1363 65.1%	2094
Technicians and Related	286 50.4%	282 49.6%	568
Sales	886 47.0%	1000 53.0%	1886
Administrative Support	1632 51.3%	1551 48.7%	3183
Private Household Protective	132 39.9%	199 60.1%	331
Fire Fighting	34 50.0%	34 50.0%	68
Food Preparation and Services	523 63.5%	301 36.5%	824
Health and Building Services	341 55.8%	270 44.2%	611
Pest Control	0 0.0%	1 100.0%	1
Personal Services	86 57.3%	64 42.7%	150
Barber, Hair Dresser	46 25.3%	136 74.7%	182

[1] No person years reported in the following occupational categories:

a) Electrical precision production or electronic assemblers
b) Insulation workers

Occupations in the Armed Forces are shown in industrial classifications.

Continued

Appendix A, Table 8. Distribution of occupations[1] among cases and controls (in person years).

OCCUPATION	CASES	CONTROLS	TOTAL
Total	10633	10258	20891
Farming, Forestry	328 42.2%	397 54.8%	725
Supervisors, Mechanics	3 6.8%	41 93.2%	44
Vehicle, Mobile Mechanics	252 52.9%	224 47.1%	476
Electric, Electrical Epquiment	66 44.0%	84 56.0%	150
Miscellaneous Mechanics	243 76.9%	73 23.1%	316
Construction Trades Supervisors	156 68.7%	71 31.3%	227
Carpenters	175 46.5%	201 53.5%	376
Electricians, Etc.	118 86.8%	18 13.2%	136
Painters	87 34.0%	169 66.0%	256
Plasterers Drywall Installers	63 67.0%	31 33.0%	94
Plumbers	129 93.5%	9 6.5%	138
Paving Operators, Roofers	0 0.0%	20 100.0%	20

[1] No person years reported in the following occupational categories:

a) Electrical precision production or electronic assemblers
b) Insulation workers

Occupations in the Armed Forces are shown in industrial classifications.

Continued

Appendix A, Table 8. Distribution of occupations[1] among cases and controls (in person years).

OCCUPATION	CASES	CONTROLS	TOTAL
Total	10633	10258	20891
Sheet Metal Workers	36 72.0%	14 28.0%	50
Other Construction Trades	193 60.7%	125 39.3%	318
Extractive Occupations	16 51.6%	15 48.4%	31
Precision Production Supervisors	118 34.7%	222 65.3%	340
Metal Working	316 51.1%	303 48.9%	619
Wood Working	27 20.8%	103 79.2%	130
Textile including Shoe	158 50.5%	155 49.5%	313
Assorted Other Precision Production	425 56.4%	328 43.6%	753
Dental Lab and Appliance	0 0.0%	2 100.0%	2
Butcher, Baker	129 60.6%	84 39.4%	213
Testers, Graders	3 100.0%	0 0.0%	3
Plant, System Operators	100 71.9%	39 28.1%	139

[1] No person years reported in the following occupational categories:

a) Electrical precision production or electronic assemblers
b) Insulation workers

Occupations in the Armed Forces are shown in industrial classifications.

Continued

Appendix A, Table 8. Distribution of occupations[1] among cases and controls (in person years).

OCCUPATION	CASES	CONTROLS	TOTAL
Total	10633	10258	20891
Hand Printing	42 32.3%	88 67.7%	130
Welders	138 61.9%	85 38.1%	223
Other Hand Workers	88 52.4%	80 47.6%	168
Motor Vehicle Operators	141 63.5%	81 36.5%	222
Truck Drivers	508 65.0%	274 35.0%	782
Mail Transport Operators	104 71.2%	42 28.8%	146
Water Transport	17 23.0%	57 77.0%	74
Material Moving	157 63.0%	96 37.0%	253
Handlers, Laborers	650 57.0%	491 43.0%	1141
Service Station	36 50.0%	36 50.0%	72

[1] No person years reported in the following occupational categories:

a) Electrical precision production or electronic assemblers
b) Insulation workers

Occupations in the Armed Forces are shown in industrial classifications.

Appendix A, Table 9. Distribution of substance exposures among cases and controls (in person years)

EXPOSURE	PERSON YEARS OF EXPOSURE	
	Cases	Controls
Asbestos	540.3	264.3
Shipyard	229.4	233.1
Arsenic	36.2	7.0
Nickel	0.0	3.0
Vinyl chloride	0.0	8.0
Tar, carbon black	236.2	163.8
Beryllium	0.0	12.0
Lead	143.9	197.3
Herbicides	20.8	0.0
Paints	362.6	403.3
Metal dusts	162.6	333.8
Cutting oil	202.4	490.5
Petroleum, benzene	413.5	260.7
Organic solvents or chemicals	344.3	286.2
Chemicals unspec.	191.1	142.2
Insecticides	36.0	101.2
Sawdust	277.2	91.8
Leather dust	4.0	0.0
Fiberglass	59.5	6.9
Formaldehyde	4.0	30.4
Radiation	62.1	80.1
Dust unspec.	1111.1	1441.3
Dyes	1.8	0.0
Gases, vapors	308.8	627.8
Unspecified	51.3	5.9

Appendix A, Table 10. Process of obtaining cases for study

CASE POPULATION STATUS	NUMBER AVAILABLE	LOST TO STUDY
Total Incident Cases Ascertained	1,036	
M.D. Contact		
1) Deceased or too ill		266
2) Recommendation not to contact		70
Attempted patient contact		
1) Deceased or too ill		136
2) Unavailable or language barrier		72
Patients Eligible for Interview	492	
Refusals		48
No control found		79
Incomplete smoking history for one member of the pair		19
Cases Analyzed in Case-Control Pairs	346	

Appendix A, Table 11. Proportion of study cases to total cases for lung and larynx cancer by sex and age

AGE	LUNG (N_1 = 946, N_2 = 308)		LARYNX (N_1 = 71, N_2 = 32)	
	Males	Females	Males	Females
TOTAL	.31	.35	.46	.42
20-29	-0-	-0-	-0-	1.00
30-39	.22	.25	-0-	-0-
40-49	.46	.39	.25	1.00
50-59	.40	.45	.69	.50
60-69	.34	.43	.43	.57
70-79	.22	.22	.40	-0-
80+	.05	.04	.33	-0-

N_1= Total cases in category

N_2= Study cases

Appendix A, Table 12. Lung cancer cases: percent distribution of cell type in interviewed and non-interviewed cases

CELL TYPE	INTERVIEWED	NON-INTERVIEWED
TOTAL	100	100
Squamous cell	30	22
Small cell	15	18
Adenocarcinoma	28	26
Large cell	17	17
Other cell type	10	17

Appendix A, Table 13. Proportion of study cases to total cases by sex and age

AGE	TOTAL MALES (N_1=644, N_2=208)	TOTAL FEMALES (N_1=392, N_2=138)
TOTAL	.32	.35
20-29	-0-	1.00
30-39	.20	.25
40-49	.46	.41
50-59	.42	.46
60-69	.34	.42
70-79	.24	.21
80+	.06	.04

N_1= Total cases in category

N_2= Study cases

Appendix A, Table 14. Distribution of study cases by sex, age and site

SEX AND AGE	TOTAL	SITE			
		Lung	Larynx	Mesothelioma of pleura	Nasal Cavity
TOTAL	346	308	32	5	1
Male	208	180	24	4	0
35-39	2	2	0	0	0
40-44	9	9	0	0	0
45-49	15	13	1	1	0
50-54	27	24	3	0	0
55-59	40	34	6	0	0
60-64	27	23	4	0	0
65-69	45	40	5	0	0
70-74	26	24	1	1	0
75-79	14	9	3	2	0
80-84	1	1	0	0	0
85+	2	1	1	0	0
Female	138	128	8	1	1
20-24	1	0	1	0	0
35-39	1	1	1	0	0
40-44	7	6	1	0	0
45-49	6	6	0	0	0
50-54	18	16	1	1	0
55-59	25	24	1	0	0
60-64	34	32	2	0	0
65-69	25	23	2	0	0
70-74	15	14	0	0	1
75-79	5	5	0	0	0
80-84	1	1	0	0	0

Appendix A, Table 15. Distribution of lung cancer study cases by cell type, race and sex

CELL TYPE	TOTAL	TOTAL MALES AND FEMALES		RACE							
				White		Black		Asian		American Indian	
		M	F	M	F	M	F	M	F	M	F
TOTAL	308	180	128	150	114	27	12	2	1	1	1
Squamous cell	82	58	24	45	21	11	3	1	0	1	0
Small cell anaplastic	48	24	24	22	24	2	0	0	0	0	0
Adeno-carcinoma	81	46	35	36	29	10	5	0	1	0	0
Large cell anaplastic	49	23	26	21	23	1	2	1	0	0	1
Other	48	29	19	26	17	3	2	0	0	0	0

Appendix A, Table 16. Distribution of exposure to occupational/industrial categories[1] reported by cases and controls

EXPOSURE	OBSERVATIONS				
	Total Resp.	Male Cases	Male Controls	Female Cases	Female Controls
Asbestos	86	48	33	4	1
Construction	88	49	37	1	1
Metal	147	59	60	17	11
Petrochemical	59	27	25	3	4
Shipyard	80	34	37	5	4
Other blue-collar	370	148	148	43	31

[1] Exposure is defined as ever having worked for six months or longer in a blue-collar production occupation in the specified industry category. Respondents with multiple exposures were assigned to as many categories as applicable.

Appendix A, Table 17. Duration of exposure to occupational/industrial categories reported by cases and controls (in person years)

EXPOSURE	PERSON YEARS			
	Male Cases	Male Controls	Female Cases	Female Controls
Asbestos	678.4	277.0	3.5	3.3
Shipyard	251.3	257.8	15.7	15.2
Petrochemical	308.5	305.0	7.0	19.0
Metal	646.7	548.7	141.7	30.4
Construction	717.8	452.9	34.0	0.0
Other blue-collar	2919.4	2344.8	426.6	238.8

Appendix A, Table 18. Distribution of blue-collar occupations reported by cases and controls as the longest held

OCCUPATION	OBSERVATIONS					
	Total Respondents		Cases		Controls	
	No.	%	No.	%	No.	%
Total Blue-Collar	326	100.0	180	100.0	146	100.0
Service	65	19.9	30	16.7	35	24.0
Firefighting	2	0.6	1	0.5	1	0.7
Bartenders	5	1.5	3	1.7	2	1.4
Cooks, etc.	13	4.0	7	3.9	6	4.1
Other Service	45	13.8	19	10.6	26	17.8
Farming, forestry	7	2.2	4	2.2	3	2.1
Production	254	77.9	146	81.1	108	73.9
Mechanics, machine operations, etc.	138	42.3	74	41.4	64	43.8
Insulation	1	0.3	1	0.5	0	0.0
Other construction	36	11.0	19	10.6	17	11.6
Transportation	38	11.7	25	13.9	13	8.9
Laborer, etc.	41	12.6	27	15.0	14	9.6

Appendix A, Table 19. Distribution of duration of cigarette smoking among cases and controls

SMOKING DURATION IN YEARS	OBSERVATIONS									
	Total Respondents		Male Cases		Male Controls		Female Cases		Female Controls	
	No.	%	No.	%	No.	%	No.	%	No.	%
Total	692	100.0	208	100.0	208	100.0	138	100.0	138	100.0
Nonsmokers	157	22.7	11	5.3	59	28.4	16	11.6	71	51.4
< 9	25	3.6	3	1.5	12	5.8	3	2.2	7	5.1
10 - 19	34	4.9	8	3.8	16	7.7	3	2.2	7	5.1
20 - 29	97	14.0	32	15.4	33	15.8	15	10.9	17	12.3
30 - 39	162	23.4	50	24.0	47	22.6	42	30.4	23	16.7
40 - 49	145	21.0	59	28.4	34	16.3	42	30.4	10	7.2
50 - 59	61	8.8	37	17.8	6	2.9	15	10.9	3	2.2
60+	11	1.6	8	3.8	1	0.5	2	1.4	0	0.0

Appendix A, Table 20. Distribution of cigarette consumption (in pack years) among cases and controls

TOTAL PACK YEARS	OBSERVATIONS									
	Total Respondents		Male Cases		Male Controls		Female Cases		Female Controls	
	No.	%	No.	%	No.	%	No.	%	No.	%
Total	692	100.0	208	100.0	208	100.0	138	100.0	138	100.0
Nonsmokers	157	22.7	11	5.3	59	28.4	16	11.6	71	51.5
< 29	208	30.1	43	20.7	73	35.1	43	31.2	49	35.5
30 - 59	219	31.6	90	43.3	54	25.9	58	42.0	17	12.3
60 - 89	81	11.7	46	22.1	17	8.2	17	12.3	1	0.7
90+	27	3.9	18	8.6	5	2.4	4	2.9	0	0.0

Appendix A, Table 21. Distribution of cigarette consumption (in pack years adjusted for tar content) among cases and controls

TAR-ADJUSTED PACK YEARS	OBSERVATIONS									
	Total Respondents		Male Cases		Male Controls		Female Cases		Female Controls	
	No.	%	No.	%	No.	%	No.	%	No.	%
Total	692	100.0	208	100.0	208	100.0	138	100.0	138	100.0
Nonsmokers	157	22.7	11	5.3	59	28.4	16	11.6	71	51.4
< 99	211	30.5	43	20.7	62	29.8	54	39.1	52	37.7
100 - 199	202	29.2	80	38.5	62	29.8	49	35.5	11	8.0
200 - 299	76	11.0	45	21.6	14	6.7	13	9.4	4	2.9
300 - 399	28	4.0	18	8.6	7	3.4	3	2.2	0	0.0
400	18	2.6	11	5.3	4	1.9	3	2.2	0	0.0

Appendix A, Table 22. Distribution of occupations reported by cases and controls as the longest held, by sex and ever smoking regularly

OCCUPATIONAL/ SMOKING CATEGORY	OBSERVATIONS				
	Total Resp.	Male Cases	Male Controls	Female Cases	Female Controls
Total	692	208	208	138	138
Blue-collar	326	139	109	41	37
Smokers	269	129	84	35	21
Nonsmokers	57	10	25	6	16
White-collar	366	69	99	97	101
Smokers	266	68	65	87	46
Nonsmokers	100	1	34	10	55

Appendix A, Table 23. Distribution of asbestos exposure and ever smoking regularly among cases and controls

ASBESTOS AND CIGARETTE SMOKING	OBSERVATIONS				
	Total Resp.	Male Cases	Male Controls	Female Cases	Female Controls
Asbestos exposures	86	48	33	4	1
Smokers	73	45	23	4	1
Nonsmokers	13	3	10	0	0
No asbestos exposure	606	160	175	134	137
Smokers	462	152	126	118	66
Nonsmokers	144	8	49	16	71

Appendix A, Table 24. Distribution of alcohol consumption among cases and controls

NUMBER OF ALCOHOL SERVINGS PER WEEK	OBSERVATIONS									
	Total Respondents		Male Cases		Male Controls		Female Cases		Female Controls	
	No.	%	No.	%	No.	%	No.	%	No.	%
Total	692	100.0	208	100.0	208	100.0	138	100.0	138	100.0
None	243	35.1	48	23.0	63	30.3	58	42.0	74	53.6
< 5	130	18.8	38	18.3	41	19.7	21	15.2	30	21.7
6 - 10	90	13.0	25	12.0	32	15.5	21	15.2	12	8.7
11 - 15	75	10.8	25	12.0	24	11.5	16	11.6	10	7.3
16 - 20	31	4.5	13	6.3	10	4.8	5	3.6	3	2.2
21 - 30	69	10.0	28	13.5	24	11.5	10	7.3	7	5.1
31 - 40	19	2.7	8	3.8	6	2.9	4	2.9	1	0.7
41 - 50	11	1.6	5	2.4	3	1.4	2	1.5	1	0.7
51+	24	3.5	18	8.7	5	2.4	1	0.7	0	0.0

Appendix A, Table 25. Distribution of education level among cases and controls

EDUCATION	OBSERVATIONS									
	Total Respondents		Male Cases		Male Controls		Female Cases		Female Controls	
	No.	%	No.	%	No.	%	No.	%	No.	%
Total	692	100.0	208	100.0	208	100.0	138	100.0	138	100.0
No/or some school	231	33.4	86	41.3	60	28.8	47	34.1	38	27.5
High school	238	34.4	70	33.7	60	28.8	56	40.6	52	37.7
Some college	118	17.1	26	12.5	37	17.8	29	21.0	26	18.9
College graduate	57	8.2	14	6.7	28	13.5	2	1.4	13	9.4
Any post graduate	47	6.8	12	5.8	23	11.1	4	2.9	8	5.8
Refused	1	0.1	0	0.0	0	0.0	0	0.0	1	0.7

Appendix A, Table 26. Distribution of income among cases and controls

INCOME	OBSERVATIONS									
	Total Respondents		Male Cases		Male Controls		Female Cases		Female Controls	
	No.	%	No.	%	No.	%	No.	%	No.	%
Total	692	100.0	208	100.0	208	100.0	138	100.0	138	100.0
<$ 4,999	48	6.9	9	4.3	9	4.3	16	11.6	14	10.2
$ 5,000 - $ 9,999	88	12.7	31	14.9	21	10.1	24	17.4	12	8.7
$10,000 - $19,999	162	23.4	44	21.2	53	25.5	29	21.0	36	26.1
$20,000 - $29,999	109	15.8	33	15.9	42	20.2	16	11.6	18	13.0
$30,000 - $39,999	62	9.0	26	12.5	22	10.6	6	4.4	8	5.8
$40,000 - $49,999	38	5.5	14	6.7	15	7.2	4	2.9	5	3.6
>$50,000	34	4.9	10	4.8	15	7.2	4	2.9	5	3.6
Refused	78	11.3	26	12.5	18	8.7	17	12.3	17	12.3
Unknown	73	10.5	15	7.2	13	6.2	22	15.9	23	16.7

Appendix B. Classification of Industries[1]

Agriculture		010-031
Mining		040-050
Construction		060
Manufacturing:		
	Food & Tobacco	100-130
	Textile & Apparel	132-152
	Paper & Printing	160-172
	Petrochemical & plastics	180-212
	Leather	220-222
	Lumber, wood furniture	230-242
	Stone, glass, clay	250-262
	Metal	270-301
	Machinery	310-332
	Electrical machinery & supplies	340-350
	Motor vehicles	351
	Aircraft & space vehicles	352,362
	Ship & boat	360
	Other transportation equipment	361,370
	Other manufacturing industries	371-392
Transportation		400-432
Communication		440-442
Utilities		460-472
Wholesale trade		500-571
Retail trade		580-691
Finance, etc.		700-712
Business services		721-742
Automotive		750-751
Repair services		752-760
Personal services		761-770
Cleaning & laundry		771
Beauty shops		772
Barber shops		780

[1]1980 Census of Population, Alphabetical Index of Industries and Occupations

Appendix B. Classification of Industries[1]

Shoe repair	782
Funeral and other	781,790,791
Entertainment, etc.	800-802
Professional & related	812-892
Public administration	900-931
Armed forces, etc.	932,942

[1]1980 Census of Population, Alphabetical Index of Industries and Occupations

Appendix C. Classification of Occupations[1]

Executive, managerial	003-037
Professional speciality	043-199
Technicians & related	203-235
Sales	243-285
Administration support	303-389
Service, private household & protective	404-407,414,415, 418-427
Fire fighting	413,416,417
Food preparation and service	433-444
Service, health & building	445-454
Pest control	455
Service personal	456,459-469
Barber, hair dressers	457,458
Farmers & forestry	473-499
Mechanics & repairers, supervisors	503
Vehicle, mobile machinery	505-519
Electrical & electronic equipment	523-534
Miscellaneous	535-549,864
Construction trades, supervisors	553-558
Carpenters	567,569
Electricians, etc.	575-577
Painters, paperhangers	579,583,759,789
Drywall installers, plasterers	573,584
Plumbers, pipefitters & steamfitters	585,587
Insulation workers	593
Paving, surfacing operators, etc., roofers	594,595
Sheetmetal & structural metal workers	596,597
Other construction trades	563-566,588,589,598, 599,865,869
Extractive occupations	613-617,867
Precision production occupations, supervisors	633
Precision metal working	634-655,703-725

[1]1980 Census of Population, Alphabetical Index of Industries and Occupations

Appendix C. Classification of Occupations[1]

Precision wood working	656-659,726-733
Precision textile, etc., includes shoe	666-674,738-749
Precision assorted & other	675-677,679,684, 753-758,763-779
Dental lab includes appliance	678
Electric & electronic assemblers	683
Precision food	686-688
Precision inspectors & graders	689,693,796-799
Plant & system (includes stationary engineers)	694-699
Machine operators - printing, hand	734-737,793
Welders, cutters, solderers, brazers	783-784
Other hand workers	785-787,794-795
Motor vehicle operators	803,806-814
Truck drivers	804,805
Rail transporation operators	823-826
Water	828-834
Material moving	843-859
Handlers, equipment cleaners & laborers, etc.	863,866,875-883, 887-889
Garage, service station	885

[1]1980 Census of Population, Alphabetical Index of Industries and Occupations

Appendix D. Industrial and Occupational Codes for the Five Industrial Groups[1]

INDUSTRY	INDUSTRIAL CODES	OCCUPATIONAL CODES
Shipyard	360	503-799; 803-859; 863-889
Petrochemical	041-042; 180-192; 200-201; 210-212	503-799; 803-859; 863-889
Metal	040; 270-359; 361-370	503-799; 803-859; 863-889
Construction	043-049; 051-099; 131; 153-159; 173-179; 193-199; 202-209; 213-219; 223-229; 243-249; 263-269	503-799; 803-859; 863-889
Other	010-031; 050; 100-130; 132-152; 160-172; 220-222; 230-242; 250-262; 371-392; 400-472; 500-691; 750-802; 812-932	503-799; 803-859; 863-889

[1]1980 Census of Population, Alphabetical Index of Industries and Occupations

Appendix E. Estimation of Cigarette Smoking Measures

Concern about hazardous ingredients in cigarettes arose in the fifties when the relationship between cigarette smoking and lung cancer became accepted. This resulted in analyses of the total particulate matter (TPM) or "tar" and of the nicotine content of different cigarette brands by the Consumers Union (CU) (124), Foster D. Snell Inc. for the Reader's Digest (125), and from 1967 onward, the Federal Trade Commission (FTC) (126). The tar fraction of cigarettes is a mixture of many chemicals. It contains most of the known carcinogens in cigarette smoke and is commonly used as an indicator of carcinogenic potency.

Initial efforts to reduce both the tar and nicotine content of cigarettes were hampered by lack of agreement as to testing methods and criteria, and by FTC rules on cigarette advertising. There were substantial changes in the tar content of individual brands within short time periods (127). Overall, between 1955 and 1980 there was a sharp decrease in the tar content of most cigarettes. It is worth noting that filter cigarettes did not uniformly have lower tar values than non-filter cigarettes.

From the three sources listed above, we generated a list of 227 cigarettes, specific for brand name, size (regular, king, long, etc.), presence or absence of filter, and presence or absence of menthol. The number of brands listed increased over time from 23 in the 1955 CU listing, to 59 in the 1967 first FTC listing, to 187 in the 1980 FTC listing. Perusal of the listings of tar content indicated that in spite of the overall decrease and some individual variations, there was a general tendency for low, medium and high tar cigarettes to remain in the same relative categories throughout. Accordingly, we used these relative categories to classify our listing of 227 brands as high, medium or low tar.

With the aim of estimating decade specific tar exposures delivered by the low, medium and high tar cigarette categories, we defined the ranges for the three categories from 1955 to 1980 at several points in time. As there were no data to suggest otherwise, we assumed 1955 tar values to be representative of all pre-1955 tar values. For the central 1965 values we used the ranges defined by Hammond et al., low = 4-18 mg., medium = 19-25 mg., high = 26-37 mg. (128). Corresponding values for 1955 were set at low = 27-35 mg., medium = 36-45 mg., high = 46-59 mg., and for 1975 low = 2-12 mg., medium = 13-21 mg., high = 22-31 mg. For each range we calculated a mean tar value for the cigarettes available at the time. As there was no listing for 1965, we combined 1961 and 1968 listings, using a mean tar value for the cigarettes common to both listings.

The 227 cigarette brands were given a three digit code, the first digit indicating high, medium or low tar value as defined by the relative categories, the remaining two digits identifying the brand, size etc. The majority fell into the medium range. The recorded smoking history included a maximum of five smoking experiences as defined by brand and amount smoked, dating from the

start of regular smoking (defined as smoking one or more cigarettes a day for at least twelve months). Thus it was possible to obtain the brand and amount of that brand smoked by calendar periods, and to separate these into calendar decades. From this we calculated a tar adjusted smoking amount for each decade for each respondent.

For every decade, beginning with 1900 and ending in the decade of the 1980's, three measures of cigarette smoking were calculated: duration of smoking, pack years of experience, and tar adjusted pack years. Duration of smoking (D) was defined as the number of years smoked for each decade. Pack years of experience was defined as packs smoked per day times the number of years during which the respondent smoked that amount, summed over all smoking experiences for each decade.

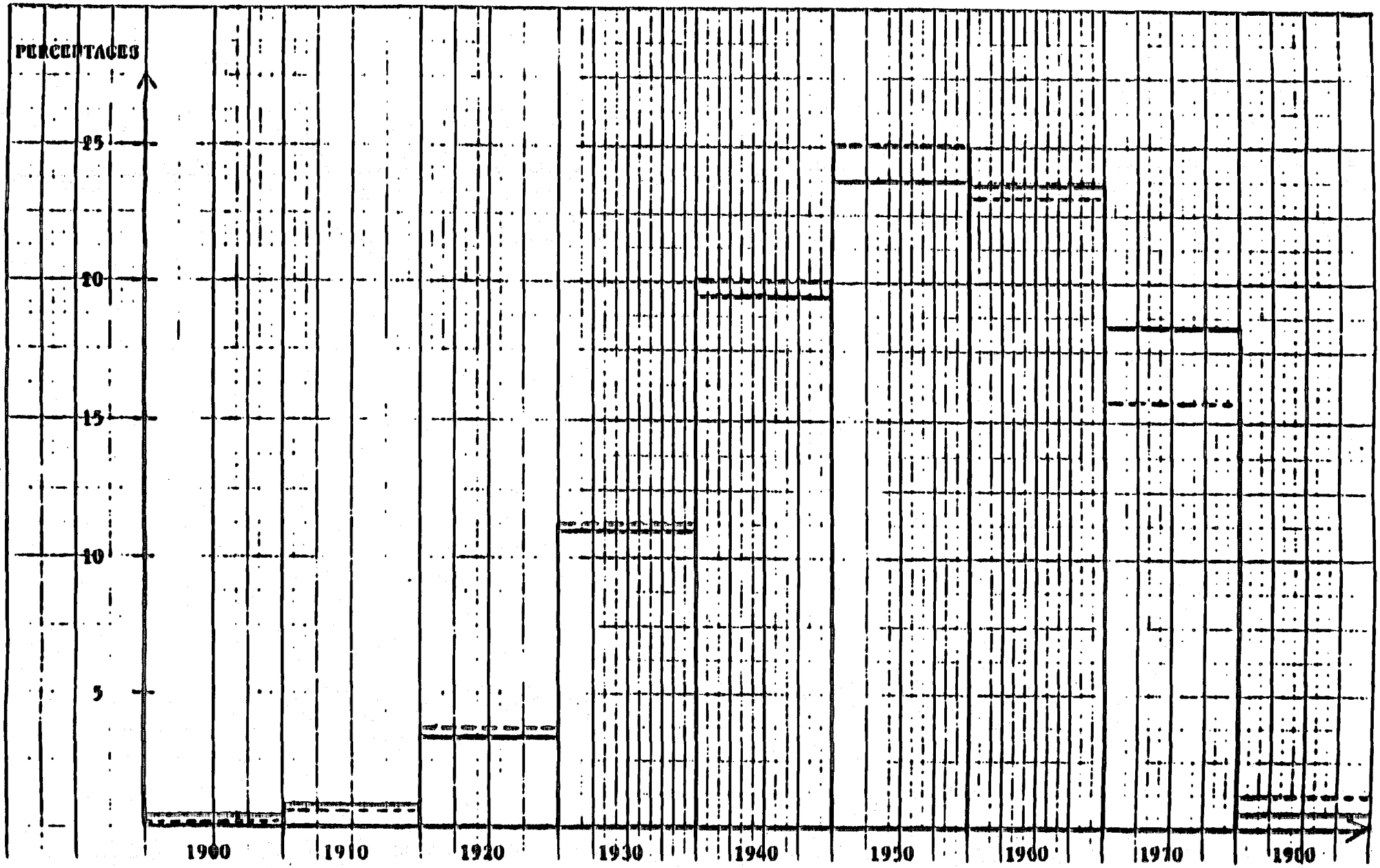
$$(PY_j = \sum_{i=1}^{N_j} P_{ij}\ /\text{day} \times D_{ij}$$, where N equals the

number of smoking experiences in decade j, (j=1,2,...9). P_{ij} equals the number of packs smoked in the i^{th} experience of the j^{th} decade and D_{ij} equals the number of years smoked in the i^{th} experience of the j^{th} decade). Tar adjusted packyears was based on the information obtained from the brand and amount of that brand smoked by calendar periods. Tar adjusted packyears (TPY) was defined as the number of packyears of experience times the adjusted tar concentration summed over all smoking experiences in each decade.

$$(TPY_j = \sum_{i=1}^{N_j} PY_{ij} \times AT_{ij}$$, where N equals the number of smoking

experiences in decade j,(j=1,2,...,9). PY_{ij} equals the pack years for the i^{th}experience of the j^{th} decade and AT_{ij} equals the adjusted tar concentration for the i^{th} experience in the j^{th} decade).

Appendix F. Figure 1. Case-control distribution of duration of smoking during the decades 1900-80[1]

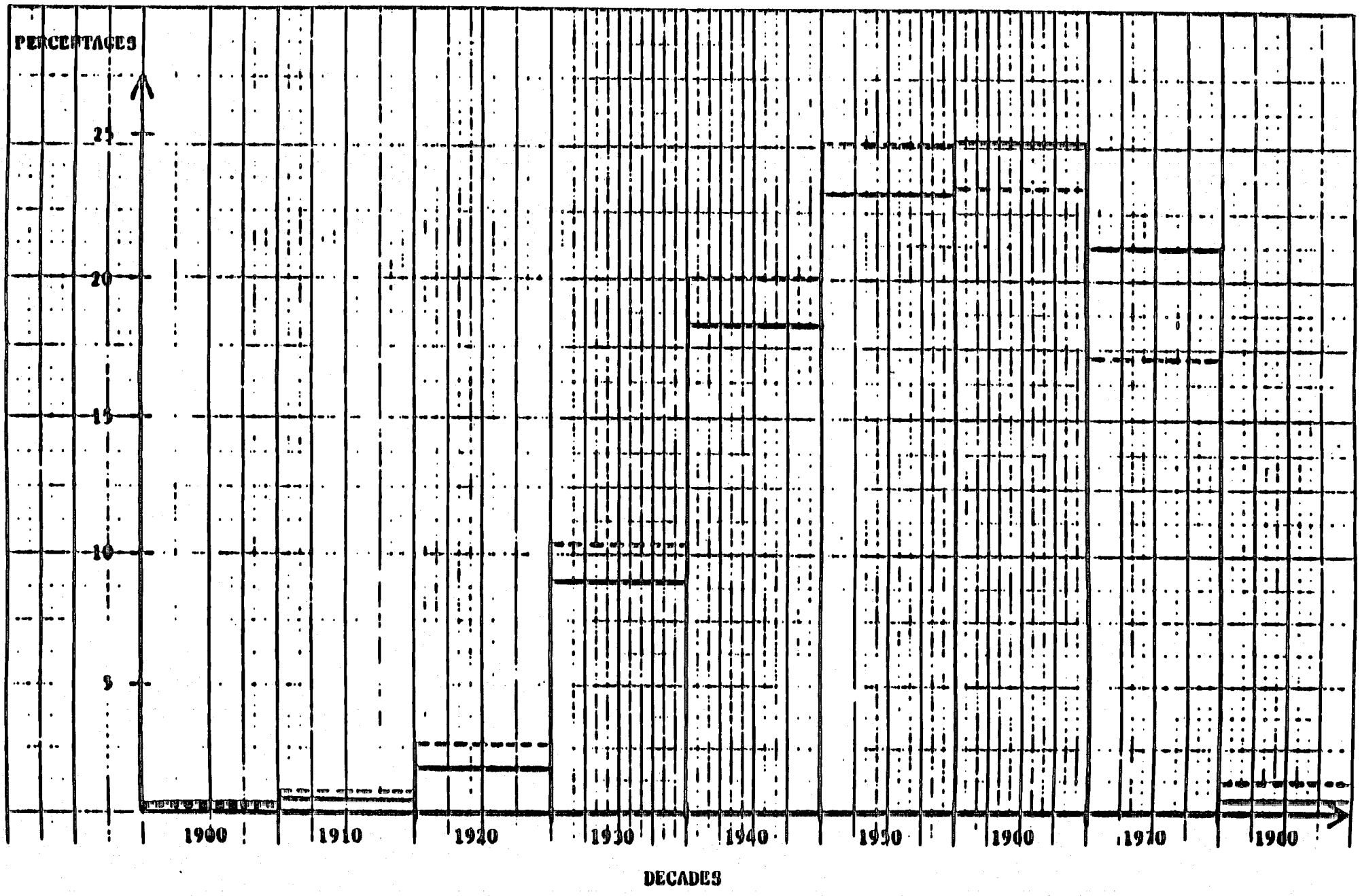


[1]The duration in each decade is expressed as the percentage of the total amount smoked by cases and control respectively over the whole time period.

——— = cases

- - - - - - - - = controls

Appendix F. Figure 2. Case-control distribution of packyears of smoking during the decades 1900-80[1]



[1] The packyears of smoking in each decade is expressed as the percentage of the total amount smoked by cases and controls respectively over the whole time period.

——— = cases

- - - - - = controls