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Cancer and Occupation in Massachusetts: A Death Certificate Study

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This study examines cancer mortality patterns by occupation for white males in Massachusetts using 1971–1973 death records. Its purpose is to identify occupation-cancer associations that, when interpreted in conjunction with results from other studies and hypotheses about potential occupational carcinogens, can serve as leads for more definitive etiological investigations.

Sixty-two malignancy categories (including grouped categories) were investigated for each of 397 occupational categories (including grouped categories) using an age-standardized mortality odds ratio approach.

An important finding was the association between lung cancer and a large number of occupations for which there is support from other epidemiologic studies and/or for which there are reasonable hypotheses as to possible carcinogenic exposures. These occupations include truck drivers, painters, machinists, automobile mechanics, plumbers, cooks, fishermen, heated metal workers, sheet metal workers, and brickmasons/stonemasons/tile setters.

Key words: occupational cancer, cancer surveillance, occupational cancer surveillance, surveillance, death certificates, mortality odds ratio

INTRODUCTION

This study examines cancer mortality patterns by occupation for white males in the state of Massachusetts using death records for the years 1971–1973. Its purpose is to identify occupation-cancer associations which, when interpreted in conjunction with results from other studies and hypotheses about potential occupational carcinogens, can serve as leads for more definitive etiological investigations.

A number of similar studies, which provide information on occupation-cancer associations, based on either vital records data or cancer registry data, have been performed over the past 20 years [Decoufle et al, 1977b; Guralnick, 1963; Gute, 1981; Howe and Lindsay, 1983; Milham, 1976; Petersen and Milham, 1980; Registrar

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General, 1971, 1972, 1975, 1978; Williams et al, 1977]. The repetition of this type of study is important for a number of reasons:

1) Many of the associations seen in any one study will be chance associations. Any time a large number of statistical comparisons are made, a certain number will achieve statistical significance by chance alone. In addition, some of the associations will be artifacts resulting from problems in the particular method of analysis or data base used. However, if the same association is reproduced in several different studies, the probability that the association is not a statistical or methodological artifact is enhanced. Of course, further investigation is necessary to determine whether the association is causal or is due to a confounding factor—such as socioeconomic status, ethnicity, cigarette smoking, or consumption of alcoholic beverages.

2) For rare occupations, rare forms of cancer, or weak associations, the numbers in any one study may not be sufficient to show statistical significance. But if the same association is seen consistently from study to study, even if it is statistically significant in none of them, it may point to an occupational hazard.

3) Occupational cancer risks may change as a function of time. As old processes or materials are replaced by new ones, exposure patterns to occupational carcinogens may change. Thus an occupation-cancer association may be observed in a study using a 1970 data base, but not in a study using a 1950 data base.

4) Certain occupations and industries are found concentrated in some geographical areas, but not in others. For example, the Washington state study [Milham, 1976] has a large number of plywood workers and atomic energy workers, but very few textile workers and no shoe factory workers. The present study of Massachusetts complements the Washington state study in this respect, having a large number of textile workers, but no plywood workers or atomic energy workers.

5) Occupational cancer risk may be a function of geography. A given industry may have its older plants concentrated in one geographical region, and its more modern facilities in another. Differences between the processes or materials used in the older versus the newer plants may result in differences in exposure patterns to occupational carcinogens.

It was in the context of the need for ongoing occupational cancer surveillance that the present study of Massachusetts was undertaken. This report presents the major findings of this study. A more detailed account is also available [Dubrow and Wegman, 1983a].

METHODS

Death-Certificate Data

The initial data source for this study was the entire death file for Massachusetts residents (including residents who died out-of-state; excluding out-of-state residents who died in Massachusetts) for the years 1971 to 1973. All adult males (20 years of age or older) whose underlying cause of death was coded by the state nosologist as a malignant neoplasm (International Classification of Diseases, eighth revision [U.S. Department of Health, Education, and Welfare, 1967] codes 140–209) were chosen for the study. Because a number of industrial chemicals are potential liver toxins, adult males with cirrhosis of the liver (ICD code 571) as the underlying cause of

death were selected as well. The results for cirrhosis of the liver will for the most part not be presented in this report.

In addition, a sample of every fourth adult male death was chosen. The deaths other than malignant neoplasms and cirrhosis of the liver from this sample were used as the auxiliary (comparison) disease group in the age-standardized mortality odds ratio analysis (see Methods of Analysis section). The proportion of nonwhites was only 3%, and they were omitted from the analysis to avoid confounding by race. The total number of nonwhites was too few to permit separate analysis. Thus all results are for adult white males only. A total of 34,879 adult white males were in the final data base, including 16,629 who died from malignant neoplasms.

The items of information used from the death certificates to perform the analysis were: 1) age at death; 2) underlying cause of death as coded by the state nosologist according to the ICD (eighth revision) code; 3) usual occupation. The instruction on the death certificate reads, "Kind of work done during most of working life"; and 4) industry or business.

Cause of Death Categories

Sixty-two malignancy categories (including grouped and overlapping categories) were investigated. All other causes of death (with the exception of cirrhosis of the liver) were grouped together into the "auxiliary causes of death" category, to be used in the mortality odds ratio analysis (see Methods of Analysis section).

It was desirable to do as detailed an investigation as possible with respect to type and anatomic site of cancer. This is because many carcinogens are known to have a high degree of target specificity. Thus the classification system used in this study is a detailed one. At the same time, information would be lost by not collapsing the most specific categories into broader categories, so this was done as well. For example, reticulum cell sarcoma, lymphosarcoma, and Hodgkin's disease were investigated individually, and were also collapsed, along with unspecified and other lymphomas, into the broader category "lymphoma."

Occupational Code

In designing the occupational code, we attempted to make the occupational categories as homogeneous as possible, so as not to dilute or cancel out possible effects. At the same time, we created grouped codes of occupations that are likely to have similar exposures. These provide the advantage of larger numbers for analysis.

Every subject is classified into one of 321 individual occupational categories. (This includes industrial categories (eg, rubber workers, shoe factory workers, fabricated metal products workers not elsewhere classified [nec]), as well as strictly occupational categories such as machinists. For simplicity, we are including "industrial" within the term "occupational".) In addition, most of the individual occupational categories are collapsed into 70 grouped categories of similar occupations. An individual occupation can appear in more than one grouped category. (For example, the individual occupational category "blacksmiths" is classified into the grouped category "heated metal workers" as well as the broader grouped category "metal workers.") Finally, we coded six large employers who are named on the death certificates with sufficient frequency to permit analysis. Subjects classified into one of the large employer categories are also classified into an individual occupation

category. The complete occupational coding scheme is presented in Dubrow and Wegman [1983a].

The individual occupation classification is based on the modification of the 1960 U.S. Bureau of the Census classification used in the Washington state study [Milham, 1976], with significant additional modifications. New categories added to the classification include our own additions, additions taken from the 1970 Bureau of the Census classification, and a number of industrial categories. The 1970 Bureau of the Census Alphabetical Index of Occupations and Industries [U.S. Bureau of the Census, 1971] was relied on extensively as an aid in assigning occupational codes (those from the 1960 classification as well as the additions).

Many death certificates list the name of the employer in the "industry or business" entry. The 1974–75 Massachusetts Industrial Directory [Bureau of Research and Statistics, Massachusetts Department of Commerce and Development, 1974], which classifies Massachusetts manufacturing firms by their Standard Industrial Clasasification (SIC) code [Office of Management and Budget, 1972], also proved to be invaluable in assigning codes. Not only are a number of our categories strictly industrial, but in the Bureau of the Census classification system the assignment of occupational codes is often dependent on both the occupation and the industry. There was enough information on the death certificates to classify 96.4% of the subjects into a category other than "not stated, unknown, none." The occupational coding was triple-checked, and we are confident in its accuracy.

Methods of Analysis

The age-standardized mortality ratio (SMR) is a reasonable index for measuring occupational mortality. The SMR is the ratio of the death rate for a specific cause in a given occupation to the death rate for that cause in the study group as a whole, obtained through indirect standardization. In practice it is very difficult to obtain accurate SMRs using death certificate data. In most of the studies in which this has been done [Guralnick, 1963; Gute, 1981; Registrar General, 1971, 1978], census data have been used to obtain age-specific number of persons at risk of death in each occupation (the denominator in the rates). However, the relatively poor correspondence between occupational statements on death certificates and census records [Guralnick, 1963; Registrar General, 1971, 1978] leads one to interpret the SMR results with a great degree of caution.

Because of the problems in obtaining accurate SMRs, we chose to use the age-standardized mortality odds ratio (sMOR) as the measure of relative mortality in this study [Miettinen and Wang, 1981]. The MOR is the ratio of mortality odds between the cancer of interest and other (auxiliary) diseases for the occupation of interest compared with a nonexposed comparison group. The MOR approach is essentially equivalent to a case-control approach, where the cases are all of the deaths from the cancer of interest, the controls are the auxiliary causes of death, and the exposure of interest is occupation. The exposure odds ratio—the ratio of the exposure odds between the occupation of interest and the nonexposed comparison group for the cancer of interest compared with the auxiliary diseases—is equal to the MOR.

The sMOR can be interpreted as the SMR on the assumption that the mortality rate for the auxiliary causes of death is the same in the occupation of interest and the comparison group [Miettinen and Wang, 1981]. We performed the sMOR analyses using all other individuals in the entire population as the comparison group. (A social

class adjusted analysis, using all other individuals within the same social class as the comparison group, was also performed. The social class classification scheme was based upon occupation. In general, the social class adjusted and unadjusted results were surprisingly similar. The results of the social class adjusted analysis are presented elsewhere [Dubrow and Wegman, 1983a].) Causes of death other than malignant neoplasms and cirrhosis of the liver were used as the auxiliary causes of death.

The sMOR approach is superior to the more commonly used proportionate mortality ratio (PMR) approach [Miettinen and Wang, 1981]. The sMOR has a clear quantitative interpretation as an SMR, with appropriate assumptions. The PMR can be interpreted as an SMR only when the number of deaths from the cause of interest is small in relation to the number of deaths from the auxiliary causes. Thus, for a given cause, the PMR is dependent on the size of the auxiliary cause of death group. The sMOR, in contrast, is independent of this factor. (This has important practical implications. In this study, we chose the auxiliary cases from a one in four sampling of male deaths for the period under study. Because of the restriction of the size of the auxiliary group, the interpretation of a PMR analysis on this data would have been seriously compromised. The PMR approach would have necessitated including all male deaths in the study, resulting in a considerable increase in costs.)

Age Standardization

An age-standardized MOR analysis was performed for the entire matrix of 397 $\times$ 62 occupation-cancer combinations. Age stratification was done by five-year age groups (20–24, 25–29, . . . 95–99). Summary sMORs [Miettinen and Wang, 1981] were calculated for the age groups 20–54, 20–64, 20–74, 55–74, and 75+, as well as for the total age range (20+). This was done in order to facilitate looking at occupation-cancer associations as a function of age. This could be valuable for several reasons:

1) Some occupational cancers may occur at an earlier than average age because of higher intensity exposure.

2) On the other hand, some occupational cancers may concentrate in the 55–74 age group, and not appear at younger ages, because of a long latent period or a long duration of exposure necessary for cancer induction.

3) Some occupational cancers may occur selectively among younger or older workers depending upon the changes in exposures owing to changes in work materials and processes.

4) The accuracy of the cause of death statement and the occupational statement on death certificates has been reported to decrease with increasing age past retirement [Registrar General, 1971]. Thus, including the older age groups (especially 75+) in the analysis could dilute the magnitude of real occupation-cancer associations. On the other hand, if the death certificates in the older age groups are not less accurate for many occupations and cancers, excluding them from the analysis would mean a loss of information.

One cannot predict a priori which age grouping would be optimal to examine for a given occupation-cancer combination based on the above considerations. Thus, we deemed it valuable to examine systematically the range of age groupings.

Significance Testing

Significance testing ($p \leqslant .05$) was done using the chi-square test, applying the Mantel-Haenszel principle [Mantel and Haenszel, 1959]. Significance testing was done for each age grouping studied, but only if four or more deaths were observed in the grouping.

RESULTS

The occupations with statistically significant ($p \leqslant .05$) sMOR elevations over the entire age range (20+) for selected cancer categories are presented in Table I. Table II presents selected occupation-cancer associations of interest that were statistically significant over at least one of the narrower age ranges examined, but not over the entire age range. Other associations of interest, which did not achieve statistical significance, are presented in Table III. Most of these are associations that are supported by other studies from the literature. References to supporting studies from the literature are provided in Tables I–III.

DISCUSSION

Occupational cancer surveillance studies based upon death certificates, such as the present study, are relatively crude. The information available for analysis is of limited scope and accuracy. There is no information available on potential confounding variables such as smoking, alcohol consumption, and diet. The occupational information is limited to the decedent's "usual" occupation and industry. The accuracy of the occupational statement has generally been found to be in the 60–80% range [Alderson, 1972; Buechley et al, 1956; Guralnick, 1963; Milham, 1976; Registrar General, 1971, 1978; Wegman and Peters, 1978; Wigle et al, 1980]. For most forms of cancer, the accuracy of the cause of death statement has been found to be in the 70–90% range when compared with hospital diagnoses [Gittelsohn and Senning, 1979; Percy et al, 1981] although it has been found to be somewhat lower when compared with autopsy findings [Engel et al, 1980].

Random errors in occupation and cause of death assignments will result in dilution of results. However, if some occupations or forms of cancer are selectively misassigned into others, or if the accuracy of the cause of death statement is occupation-dependent, biases will result. Such biases have been demonstrated to occur [Registrar General, 1978].

The assumption that the mortality rate for the auxiliary causes of death is independent of occupation should be kept in mind when interpreting the results of this analysis. A number of studies have consistently revealed an inverse relationship between mortality for causes other than cancer and cirrhosis of the liver (the grouped auxiliary causes) and occupational level (or social class) [Kitagawa and Hauser, 1973]. Generally, there tend to be relatively small differences among the upper and middle occupational levels (or social classes), and a wider gap between the upper and middle versus the lower levels. Professional, technical, and kindred workers; managers, officials, and proprietors (except farm); and farmers and farm laborers consistently have the lowest mortality rates, while laborers (except farm) consistently have the highest mortality rates. Differences in mortality among occupational levels decrease with increasing age and seem to be narrowing over time. To the extent that these

TABLE I. Significant ($p \leq .05$) Occupation-Cancer Associations by Cancer Type, Age 20+[†]

Occupation by cancer type[a]	sMOR[b]
Buccal cavity and pharynx (ICD 140-149)	
Inspectors, railroad	924(4)***
Railroad workers (off train) (grouped)	260(17)***
Printing trades (grouped) [Decoufle et al, 1977b; Lloyd et al, 1977; Nicholson et al, 1981; Williams et al, 1977]	252(15)***
Bar workers (grouped) [Guralnick, 1963; Howe and Lindsay, 1983; Milham, 1976; Petersen and Milham, 1980]	304(10)***
Pressmen and plate printers, printing [Lloyd et al, 1977; Nicholson et al, 1981]	257(9)**
Artists and art teachers	364(4)**
Cooks, chefs (except private household) [Buell et al, 1960; Milham, 1976]	206(12)*
Foundry workers (grouped)	257(6)*
Restaurant workers (grouped) [Guralnick, 1963; Williams et al, 1977]	161(25)*
Mechanics and repairmen (grouped)	156(26)*
Brickmasons, stonemasons, tile setters	211(8)*
Mechanics and repairmen, vehicle (grouped)	187(12)*
Esophagus (ICD 150)	
Longshoremen and stevedores [Buell et al, 1960]	685(7)***
Chemical workers [Englund, 1980]	552(5)***
Truck and tractor drivers	234(21)***
Steamfitters	493(5)***
Engineers, mechanical	316(5)*
Warehousemen nec	340(4)*
Plumbers (grouped) [Kaminski et al, 1980]	197(10)*
Stationary engineers (grouped)	204(8)*
Stomach (ICD 151)	
Plastic workers	337(7)**
Plasterers and lathers [Milham, 1976]	423(4)**
Stomach (ICD 151) (Cont.)	
Dispatchers and starters, vehicle	302(6)**
Carpenters (grouped) [Guralnick, 1963; Milham, 1976, 1978]	156(37)*
Slaughterhouse butchers	245(6)*
Painters, construction and maintenance [Decoufle et al, 1977b]	158(23)*
Musicians and music teachers	252(5)*
Machinists and related occupations (grouped) [Buell et al, 1960; Decoufle, 1978; Järvholm et al, 1981]	131(62)*
Large intestine, except rectum (ICD 153.0-153.8)	
Officers-pilots-pursers-engineers, ship	1,396(4)***
Teachers and administrators, college and university (grouped) [Registrar General, 1978]	347(11)***
Managers, administrators, officials, and proprietors nec; supervisors nec [Guralnick, 1963; Milham, 1976; Petersen and Milham, 1980; Registrar General, 1972, 1975, 1978]	140(116)**
Chemists (grouped)	306(10)**
Large employer B—abrasives products [Wegman and Eisen, 1981[c]]	273(12)**
Engineers, chemical	565(4)**
Physicians and surgeons [Milham, 1976; Registrar General, 1972]	202(16)**
School professions (grouped)	165(28)*
Tool and die makers [Decoufle, 1978]	190(17)*
Locomotive engineers (railroad) [Milham, 1978]	290(6)*
Adjustors, examiners, investigators, estimators	314(5)*
Metal workers (grouped)	120(172)*
Foundry workers nec	249(7)*

TABLE I. Significant ($p \leq .05$) Occupation-Cancer Associations by Cancer Type, Age 20+[†] (continued)

Occupation by cancer type[a]	sMOR[b]
Large intestine, except rectum (ICD) 153.0–153.8) (Cont.)	
Physicians, dentists, and related practitioners (grouped)	151(31)*
Heated metal workers (grouped)	150(31)*
Managers and superintendents, building	271(5)*
Tinsmiths, coppersmiths, and sheet metal workers	191(11)*
Large intestine and rectum[d] (ICD 153–154)	
Plasterers and lathers [Milham, 1976]	289(7)*
Foundry workers (grouped)	183(18)*
Railroad workers (grouped)	140(50)*
Manufacturers and sales representatives [Howe and Lindsay, 1983; Registrar General, 1978]	194(13)*
Boilermakers	253(6)*
Rectum and rectosigmoid junction (ICD 154)	
Large employer B—abrasives products [Wegman and Eisen, 1981[c]]	498(8)***
Railroad clerks	527(4)***
Postal clerks [Petersen and Milham, 1980]	264(9)**
Public utility supervisors, officials, managers, etc	314(6)**
Slaughterhouse butchers [Howe and Lindsay, 1983]	316(5)*
Postal workers (grouped)	185(18)*
Assemblers (grouped)	312((5)*
Railroad workers (off train) (grouped)	193(14)*
Heated metal workers (grouped) [Registrar General, 1971]	179(14)*
Liver (ICD 155.0)	
Shoe factory workers	321(6)**
Carpenters (grouped) [Registrar General, 1972]	265(8)**
Cooks, chefs (except private household) [Petersen and Milham, 1980]	350(4)**
Liver (ICD 155.0) (Cont.)	
Physicians, dentists, and related practitioners (grouped)	279(4)*
Gallbladder, ducts, ampulla of Vater (ICD 156)	
Bar workers (grouped)	579(4)***
Restaurant workers (grouped)	258(9)**
Construction workers (grouped)	306(6)**
Policemen, detectives, marshalls, constables, sheriffs, court officers	330(5)**
Architects, draftsmen, and engineers (grouped)	235(8)*
Construction trades (grouped)	159(21)*
Pancreas (ICD 157)	
School administrators, elementary and secondary school	503(7)***
Managers and superintendents, building	554(5)***
Precision machine operatives	276(8)**
Lawyers and judges [Registrar General, 1978]	228(11)**
Chemists [Li et al, 1969]	362(4)*
Teachers and administrators, college and university (grouped)	300(5)*
Building contractors, construction contractors	186(12)*
Peritoneum and retroperitoneal tissue (ICD 158)	
Construction trades (grouped) [McDonald and McDonald, 1980]	296(5)*
Nose and nasopharynx (ICD 147, 160.0)	
Truck and tractor drivers	539(5)***
Larynx (ICD 161)	
Bar workers (grouped) [Milham, 1976; Petersen and Milham, 1980]	493(7)***
Cranemen, derrickmen, and hoistmen	613(4)***

TABLE I. Significant ($p \leq .05$) Occupation-Cancer Associations by Cancer Type, Age 20+[†](continued)

Occupation by cancer type[a]	sMOR[b]
Larynx (ICD 161) (Cont.)	
Plumbers (grouped) [Englund, 1980]	290(9)**
Truck and tractor drivers [Howe and Lindsay, 1983]	229(14)**
Meat cutters, except slaughterhouse and packing house	359(5)**
Mechanics and repairmen nec	285(7)**
Linemen, servicemen, and installers—telegraph, telephone, power (utility and gas)	369(4)**
Vehicle drivers (grouped)	178(22)*
Painters (grouped) [Englund, 1980; Guralnick, 1963]	205(10)*
Construction trades (grouped)	145(38)*
Trachea, bronchus, and lung (ICD 162)	
Truck and tractor drivers [Ahlberg et al, 1981; Guralnick, 1963; Luepker and Smith, 1978; Menck and Henderson, 1976; Milham, 1976; Milne et al, 1983; Petersen and Milham, 1980; Registrar General, 1972, 1975, 1978; Williams et al, 1977]	173(176)***
Vehicle drivers [Guralnick, 1963; Gute, 1981; Menck and Henderson, 1976; Wegman and Peters, 1978; Williams et al, 1977]	145(305)***
Agricultural scientists	929(8)***
Adjustors, examiners, investigators, estimators	312(17)***
Shipyards (grouped)[c] [Blot and Fraumeni, 1981; Guralnick, 1963]	151(108)***
Forgemen and hammermen [Guralnick, 1963]	613(9)**
Machinists, shipyard	270(18)**
Mechanics and repairmen, air conditioning, heating, refrigeration appliances	412(13)**
Trachea, bronchus, and lung (ICD 162) (Cont.)	
Heavy equipment, construction equipment operators [Breslow et al, 1954; Decoufle et al, 1977a; Milham, 1976; Petersen and Milham, 1980; Tsuchiya, 1965]	295(18)**
Managers and superintendents, building	284(14)**
Cashiers	448(8)**
Clothing pressers [Menck and Henderson, 1976]	223(14)*
Tailors [Guralnick, 1963]	192(20)*
Painters (grouped) [Breslow et al, 1954; Decoufle et al, 1977b; Englund, 1980; Guralnick, 1963; Menck and Henderson, 1976; Milham, 1976; Milne et al, 1983; Morrison, 1957; Petersen and Milham, 1980; Registrar General, 1971, 1972, 1975, 1978; Williams et al, 1977; Wynder and Graham, 1951]	131(110)*
Sailors (grouped) [Milne et al, 1983]	143(62)*
Window cleaners [Registrar General, 1972, 1975, 1978]	632(4)*
Painters, shipyard	261(9)*
Foresters and conservationists	455(4)*
Railroad foremen	219(13)*
Steamfitters	176(18)*
Steelworkers, wire workers[c] [Guralnick, 1963; Menck and Henderson, 1976; Milne et al, 1983; Redmond et al, 1981]	173(25)*
Mechanics and repairmen, vehicle (grouped) [Guralnick, 1963; Menck and Henderson, 1976; Milham, 1976; Milne et al, 1983; Registrar General, 1972, 1975, 1978]	136(69)*

TABLE I. Significant ($p \leq .05$) Occupation-Cancer Associations by Cancer Type, Age 20+[†](continued)

Occupation by cancer type[a]	sMOR[b]
Trachea, bronchus, and lung (ICD 162) (Cont.)	
Conductors, bus and street railway [Registrar General, 1972, 1975]	259(10)*
Mechanics and repairmen nec [Guralnick, 1963; Menck and Henderson, 1976; Milham, 1976; Petersen and Milham, 1980; Registrar General, 1972, 1975]	142(59)*
Brickmasons, stonemasons, tile setters [Breslow et al, 1954; Howe and Lindsay, 1983; Milham, 1976; Morrison, 1957; Petersen and Milham, 1980; Registrar General, 1972, 1975, 1978]	143(41)*
Boilermakers [Beaumont and Weiss, 1980; Milham, 1976]	215(10)*
Officers and enlisted men, Navy [Milham, 1976]	180(18)*
Compositors and typesetters	216(12)*
Respiratory system[f] (ICD 160–163)	
Brewery workers	314(9)*
Bar workers (grouped) [Howe and Lindsay, 1983; Menck and Henderson, 1976; Registrar General, 1972, 1975]	156(41)*
Apparel workers (grouped) [Guralnick, 1963]	146(46)*
Plumbers (grouped) [Buell et al, 1960; Guralnick, 1963; Howe and Lindsay, 1983; Kaminski et al, 1980; Menck and Henderson, 1976; Milham, 1976; Petersen and Milham, 1980; Registrar General, 1972, 1975, 1978]	135(77)*
Mechanics and repairmen, airplane [Milne et al, 1983]	432(6)*
Respiratory system[f] (ICD 160–163) (Cont.)	
Heated metal workers (grouped) [Milham, 1976; Registrar General, 1971, 1972, 1975, 1978; Wynder and Graham, 1951]	132(88)*
Sewers and stitchers, manufacturing; cutters	211(11)*
Asbestos and insulation workers[e] [Menck and Henderson, 1976; Milham, 1976; Selikoff et al, 1964]	201(12)*
Pleura and mediastinum (ICD 163.0, 163.1)	
Asbestos exposure (grouped)[e] [McDonald and McDonald, 1980]	565(5)***
Construction trades (grouped) [McDonald and McDonald, 1980]	272(8)**
Bone (ICD 170)	
Truck and tractor drivers	292(5)*
Malignant melanoma of skin (ICD 172)	
Teachers and administrators, college and university (grouped)	1,265(4)***
Clergymen	653(4)***
Teachers and administrators, elementary and secondary school (grouped)	286(4)*
Clerical and kindred workers nec [Registrar General, 1972, 1975]	258(5)*
Skin, other malignant neoplasms (ICD 173)	
Painters (grouped)	492(4)***
Prostate (ICD 185)	
Chemical workers	364((9)***
Motion picture projectionists	801(4)***
Compositors and typesetters [Ernster et al, 1979]	376(6)**
Welders (grouped) [Kolonel and Winkelstein, 1977]	256(14)**

TABLE I. Significant ($p \leq .05$) Occupation-Cancer Associations by Cancer Type, Age 20+[†](continued)

Occupation by cancer type[a]	sMOR[b]
Prostate (ICD 185) (Cont.)	
Housekeepers and stewards, except private household	445(4)**
Garage, gas station owners, foremen, managers	234(9)*
Mechanics and repairmen nec	174(17)*
Buyers and shippers, farm products; produce brokers	196(10)*
Painters (grouped)	146(36)*
Bladder (ICD 188)	
Engineers, chemical	1,805(4)***
Hairdressers and cosmetologists [Anthony and Thomas, 1970; Dunham et al, 1968; Howe et al, 1980; Wynder et al, 1963]	1,156(4)***
Blacksmiths	737(5)***
Chemical workers [Cole et al, 1972; Howe et al, 1980; Hueper, 1969]	460(5)***
Gas station, garage workers (grouped) [Howe and Lindsay, 1983; Milham, 1976]	330(8)***
Conductors, railroad	458(4)**
Heated metal workers (grouped)	196(14)*
Physicians and surgeons	252(7)*
Engineers (grouped)	172(21)*
Meat processing workers (grouped)	200(9)*
Slaughterhouse butchers	276(4)*
Kidney (ICD 189.0, 189.1)	
Laundry and drycleaning operatives, owners, managers [Katz and Jowett, 1981[g]]	446(5)***
Slaughterhouse butchers	432(4)**
Financial workers (grouped)	195(15)*
Treasurers, financial managers, bank officers	278(6)*
Hospital workers (grouped)	296(4)*
Grocers and market managers	240(6)*
Medical workers (grouped)	193(11)*
Engineers, electrical	277(4)*
Brain (ICD 191)	
Lawyers and judges [Milham, 1976]	556(7)***
Brain (ICD 191) (Cont.)	
Checkers, examiners and inspectors, manufacturing [Petersen and Milham, 1980]	557(4)***
Teachers, elementary and secondary school [Petersen and Milham, 1980]	371(7)***
Financial workers (grouped)	229(13)**
School professions (grouped)	254(10)**
Treasurers, financial managers, bank officers [Milham, 1976]	347(5)**
Operatives and kindred workers nec	326(4)*
Postal clerks [Petersen and Milham, 1980]	286(5)*
Brickmasons, stonemasons, tile setters	314(4)*
Lymphomas (ICD 200–202)	
Teachers and administrators, college and university (grouped) [Milham, 1976]	577(6)***
Engineers, electrical	300(8)**
Life and physical scientists (grouped)	389(5)**
Treasurers, financial managers, bank officers	252(9)**
Physicians and surgeons	278(7)**
Managers, administrators, officials and proprietors nec; supervisors nec [Petersen and Milham, 1980; Registrar General, 1978]	149(41)*
Mail carriers [Milham, 1976]	240(6)*
Railroad workers (on train) (grouped)	291(4)*
Lymphosarcoma (ICD 200.1)	
Electricians (grouped)	331(6)**
Fabricated metal products workers nec	269(5)*
Hodgkin's disease (ICD 201)	
Treasurers, financial managers, bank officers	505(4)***
Railroad workers (grouped)	265(4)*

TABLE I. Significant ($p \leq .05$) Occupation-Cancer Associations by Cancer Type, Age 20+[†](continued)

Occupation by cancer type[a]	*sMOR*[b]	*Occupation by cancer type*[a]	*sMOR*[b]
Multiple mycloma (ICD 203)		Leukemia and aleukemia (ICD 204–207) (Cont.)	
Carpenters (grouped) [Agu et al, 1980; Milham, 1978]	286(12)***	Architects, draftsmen, and engineers (grouped)	171(23)*
Stock clerks and storekeepers	491(4)***	Shoe factory workers [Aksoy et al, 1974]	178(14)*
Farmers (grouped) [Agu et al, 1980; Burmeister, 1981; Milham, 1971]	313(7)**	Lymphatic leukemia, chronic (ICD 204.1)	
School professions (grouped)	297(5)*	Material handlers (grouped)	720(4)***
Plant and tree workers (grouped)	231(8)*	Carpenters (grouped)	317(7)**
Leukemia and aleukemia (ICD 204–207)		Myeloid leukemia (ICD 205)	
Stationary engineers	383(8)***	Car salesmen, dealers, managers	365(4)**
Large employer B—abrasives products	395(5)**	Large employer A—electrical equipment; engines and turbines	239(9)*
Carpenters (grouped) [Milham, 1978; Petersen and Milham, 1980]	169(23)*	Architects, draftsmen, and engineers (grouped)	203(12)*
		Rubber workers [McMichael et al, 1975]	289(4)*

[†]Significant ($p \leq .05$) occupation-cancer associations are presented by cancer type, in descending order of the chi-square value. For the sake of brevity, under a given cancer type, occupational category entries that were largely redundant were omitted from the table. For example, under larynx, the individual occupational category plumbers and pipefitters and the grouped category plumbers (grouped) (which includes plumbers and pipefitters; steamfitters; and plumbers, shipyard) were both significantly elevated. Plumbers (grouped) had an sMOR = 290, with nine observed deaths, and plumbers and pipefitters had an sMOR = 313, with seven observed deaths. Plumbers and pipefitters were omitted from the table.

[a]References indicate studies in the literature that support the association found in this study. The abbreviatiion "nec" in an occupational title stands for "not elsewhere classified." The definitions of the grouped occupational categories in terms of their individual components are presented in Dubrow and Wegman [1983a].

[b]sMOR = age-standardized mortality odds ratio. The number in parentheses indicates the observed number of deaths.

[c]The death certificate data used in this reference and the present report overlap.

[d]Most of the occupational categories that were significantly elevated for this cancer category were also significantly elevated for cancer of the large intestine, except rectum. These occupational categories were listed only once, under large intestine, except rectum. Listed here are only those occupational categories that were significantly elevated for the cancer category large intestine and rectum, but that were not significantly elevated for large intestine, except rectum.

[e]This association has been observed in numerous studies. A representative reference is listed in addition to surveillance-type studies.

[f]Most of the occupational categories that were significantly elevated for this cancer category were also significantly elevated for cancer of the trachea, bronchus, and lung. These occupational categories were listed only once, under trachea, bronchus, and lung. Listed here are only those occupational categories that were significantly elevated for the cancer category respiratory system, but which were not significantly elevated for trachea, bronchus, and lung.

[g]This reference was a study of females.

*$p \leq .05$.

**$p \leq .01$.

***$p \leq .001$.

relationships between mortality for the grouped auxiliary causes and occupational level exist in the Massachusetts study population, the results will be biased toward systematically overestimating cancer mortality in the higher occupational levels and farmers, and systematically underestimating it in the lower occupational levels, especially in the younger age groups.

Aside from the general relationships between mortality and occupational level, the possibility must be considered that a specific occupation has a high mortality rate from the auxiliary causes of death due primarily to hazards associated with the occupation. For example, asbestos workers die from asbestosis. For such occupations, cancer mortality will be systematically underestimated in this study.

Even when the assumption that the mortality rate for the auxiliary diseases is independent of occupation is valid, there are still numerous confounding variables that can result in an occupation having an elevated sMOR for reasons other than an occupational exposure.

The value of this and similar studies lies in the relatively simple and inexpensive screening of a large number of occupations and cancer types for the purpose of generating leads for further planned investigations. Because of the large number of statistical comparisons made in this study, many of the associations discovered will be chance associations. Other associations will be the result of confounding or biases. The credibility of an association is strengthened if it is supported by other epidemiologic studies and if a reasonable hypothesis can be made as to potential carcinogenic exposures.

The fact that a number of associations were observed in this study that would have been expected based upon prior knowledge (eg, asbestos and insulation workers, shipyard workers and lung cancer; construction workers and cancer of the pleura and peritoneum; bar workers and cancer of the buccal cavity and pharynx) provides confidence in the validity of the method.

Comments on Selected Associations

Lung cancer. An important result of this study is the association between cancer of the trachea, bronchus, and lung and a large number of occupations for which there is support from other epidemiologic studies and/or for which there are reasonable hypotheses as to possible occupational carcinogens. These include the well-established lung cancer excesses among asbestos and insulation workers, shipyard workers, and steel workers. In addition, support for the lung cancer elevations found among vehicle drivers (especially truck drivers); painters; heated metal workers; brickmasons, stonemasons, and tilesetters; tinsmiths, coppersmiths, and sheet metal workers; automobile mechanics and repairmen; cooks; machinists; fishermen; and plumbers was particularly strong. Occupations found to be at excess risk of lung cancer that have potential exposures, but that, to our knowledge, have not been previously implicated include agricultural scientists; mechanics and repairmen, air conditioning, heating, refrigeration appliances; managers and superintendents, building; and compositors and typesetters.

Noteworthy is the large number of occupations with excess lung cancer that have known or suspected exposure to asbestos (eg, various shipyard categories; various construction trades; mechanics and repairmen, vehicle; various sailor categories; custodial, maintenance, and cleaning workers; boilermakers; clothing pressers; mechanics and repairmen, air conditioning, heating, refrigeration appliances) or

to polycyclic aromatic hydrocarbons (eg, various motor vehicle driver categories, various metal worker categories, cooks, bakers). A similar conclusion was reached in a study of lung cancer in Los Angeles County [Menck and Henderson, 1976].

The critical question that must be answered with regard to occupational excesses in lung cancer mortality is whether the excesses are the result of occupational exposures, or whether they can be explained by differences in cigarette smoking habits among occupations. This question has not yet been adequately addressed. The scanty evidence that does exist indicates that many of the excesses can not be explained by cigarette smoking. For example, adjusting the results from the present study for differences in smoking habits among major occupational groupings (eg, professional, technical, and kindred workers; craftsmen, foremen, and kindred workers), using independent data on smoking rates by occupation and on lung cancer risk ratios for smokers and ex-smokers, did not explain most of the differences in lung cancer sMORs among these groupings [Dubrow and Wegman, 1983a]. In addition, in two occupational cancer surveillance studies based on cancer registries [Decoufle et al, 1977b; Williams et al, 1977], which had smoking histories for each subject, most associations between occupation and lung cancer remained unchanged upon controlling for cigarette smoking.

Doll and Peto have estimated that roughly 15% of the cases of lung cancer in the United States can be attributed to occupational factors, although they think that this estimate might be on the high side [Doll and Peto, 1981]. They propose a large-scale national case-control study of lung cancer to address this issue. A study of this type can control carefully for cigarette smoking as well as for other potential confounding variables. We strongly support this proposal.

Furthermore, occupations that are consistently demonstrated to be at elevated risk of lung cancer in surveillance-type studies need to be systematically followed up by in-depth epidemiologic and industrial hygiene investigations, especially when there are reasonable hypotheses about potential occupational carcinogens or when there is other supporting evidence.

In addition to the wide range of findings for lung cancer, several specific findings, for lung cancer as well as for other cancers, when interpreted in conjunction with other information, suggest further research needs.

Truck and tractor drivers. Truck and tractor drivers exhibited cancer excesses over the entire respiratory system and upper alimentary tract—buccal cavity and pharynx; esophagus; nose and nasopharynx; larynx; and trachea, bronchus, and lung. An excess of bladder cancer was observed as well. The chi-square value for respiratory cancers was the highest for any occupation-cancer combination in the study with five or more observed deaths. The lung cancer excess is supported by a large number of other studies of various types (Table I). The excesses of cancer of the larynx and bladder also have support from the literature (Tables I, III). The generalized lung cancer excesses in this report among other vehicle drivers, although not as extreme, provide additional support for the association.

The cancer excesses among truck drivers can be due to life-style (cigarette smoking and alcohol consumption), occupational exposure to gasoline and diesel engine exhaust, or a combination of the two. Cigarette smoking is causally related to all of the above cancers, and truck drivers have been reported to be heavy cigarette smokers [Sterling and Weinkam, 1976]. Alcohol consumption is causally related to cancers of the buccal cavity and pharynx and esophagus. An excess of cirrhosis of

TABLE II. Selected Occupation-Cancer Associations Significant ($p \leq .05$) Over at Least One of the Age Groups 20–54, 20–64, 20–74, or 55–74, but not Over the Entire Age Range (20+), by Cancer Type†

Occupation by cancer type[a]	Age group	sMOR[b]	sMOR for entire age range (20+)[b]
Buccal cavity and pharynx (ICD 140–149)			
Painters (grouped) [Howe and Lindsay, 1983]	55–74	222(14)**	149(16)
Esophagus (ICD 150)			
Large employer A—electrical equipment; engines and turbines	20–54	645(4)***	139(11)
Stomach (ICD 151)			
Large employer A—electrical equipment; engines and turbines	20–54	317(5)*	110(17)
Large intestine, except rectum (ICD 153.0–153.8)			
Large employer A—electrical equipment; engines and turbines	20–54	437(9)***	125(34)
Machinists [Decoufle, 1978; Guralnick, 1963; Williams et al, 1977]	20–54	311(11)***	108(62)
Electrical and electronic machinery, equipment, and supplies workers nec [Guralnick, 1963]	20–54	418(5)**	140(9)
Rectum and rectosigmoid junction (ICD 154)			
Rubber workers	20–74	271(7)*	189((8)
Machinists	20–54	305(4)*	91(20)
Pancreas (ICD 157)			
Carpenters (grouped)	20–64	210(13)*	103(22)
Custodial, maintenance, cleaning workers (grouped)	20–64	159(25)*	125(49)
Larynx (ICD 161)			
Custodial, maintenance, cleaning workers (grouped)	20–54	370(5)**	129(17)
Trachea, bronchus, and lung (ICD 162)			
Machinists [Breslow et al, 1954; Buell et al, 1960; Howe and Lindsay, 1983; Menck and Henderson, 1976; Petersen and Milham, 1980; Registrar General, 1972, 1975, 1978; Waldron, 1975]	20–54	184(27)**	95(155)
Heated metal workers (grouped) [Milham, 1976; Registrar General, 1971, 1972, 1975, 1978; Wynder and Graham, 1951]	20–64	150(48)*	129(80)
Heat treaters, annealers [Menck and Henderson, 1976]	20–64	385(6)*	133(6)
Rubber workers[c] [Monson and Fine, 1978]	20–74	155(37)*	131(42)

TABLE II. Selected Occupation-Cancer Associations Significant ($p \leq .05$) Over at Least One of the Age Groups 20–54, 20–64, 20–74, or 55–74, but not Over the Entire Age Range (20+), by Cancer Type† (Cont.)

Occupation by cancer type[a]	Age group	sMOR[b]	sMOR for entire age range (20+)[b]
Trachea, bronchus, and lung (ICD 162) (Cont.)			
Tool and die makers [Milham, 1976; Petersen and Milham, 1980]	20–54	269(8)*	120(31)
Custodial, maintenance, cleaning workers (grouped) [Gute, 1981; Menck and Henderson, 1976; Milne et al, 1983; Registrar General, 1978; Williams et al, 1977]	20–54	152(32)*	109(247)
Prostate (ICD 185)			
Oil and gasoline exposure (grouped)	55–74	228(16)**	137(23)
Bladder (ICD 188)			
Leather workers, tanners [Cole et al, 1972; Decoufle et al, 1977b]	55–74	398(5)**	191(7)
Filers, grinders, polishers, metal; metal cutters	55–74	379(4)**	206(4)
Tool and die makers			
Bladder (ICD 188) (Cont.)			
[Petersen and Milham, 1980; Williams et al, 1977]	55–74	283(4)*	187(6)
Brain and nervous system (ICD 191–192)			
Carpenters (grouped) [Guralnick, 1963]	20–54	274(7)*	149(11)
Brain (ICD 191)			
Machinists	20–54	312(5)*	134(10)
Lymphatic and hematopoietic tissue (ICD 200–209)			
Plumbers (grouped) [Kaminski et al, 1980]	20–54	262(5)*	125
Lymphomas (ICD 200–202)			
Plumbers (grouped)	20–54	403(4)**	134(8)
Hodgkin's disease (ICD 201)			
Custodial, maintenance, cleaning workers (grouped)	20–54	284(4)*	129(7)
Leukemia and aleukemia (ICD 204–207)			
Machinists [Decoufle et al, 1977b; Howe and Lindsay, 1983]	20–64	210(11)*	129(23)

†These associations are presented by cancer type, in descending order of the chi-square value.
[a]See Table I, footnote a.
[b]See Table I, footnote b.
[c]See Table I, footnote e.
*$p \leq .05$.
**$p \leq 0.01$.
***$p \leq .001$.

TABLE III. Selected Nonsignificant Occupation-Cancer Associations of Interest, by Cancer Type

Occupation by cancer type[a]	Age group	sMOR[b]	sMOR for entire age range (20+)[b]
Buccal cavity and pharynx (ICD 140–149)			
Truck and tractor drivers			142(19)
Rectum and rectosigmoid junction (ICD 154)			
Large employer A—electrical equipment; engines and turbines	20–54	264(2)	96(10)
Pancreas (ICD 157)			
Jewelers, watchmakers, silversmiths [Sparks and Wegman, 1980[c]]	20–64	269(4)	147(6)
Trachea, bronchus, and lung (ICD 162)			
Bakers [Menck and Henderson, 1976]	20–64	187(17)	123(32)
Boatbuilders, carpenters, shipyard			201(6)
Precision machine operatives			128(22)
Shoemakers and repairers [Menck and Henderson, 1976; Registrar General, 1972, 1975]			159(11)
Tinsmiths, coppersmiths, sheet metal workers [Guralnick, 1963; Milham, 1976; Registrar General, 1972, 1975, 1978]	55–74	172(15)	122(21)
Chemical workers			140(14)
Bus drivers [Milham, 1976; Milne et al, 1983; Petersen and Milham, 1980; Registrar General, 1972, 1975]	20–64	183(15)	132(24)
Meat cutters, except slaughterhouse and packing house [Fox et al, 1982]	20–64	175(16)	126(30)
Cooks, chefs (except private household) [Breslow et al, 1954; Menck and Henderson, 1976; Milham, 1976; Registrar General, 1972, 1975]	55–74	129(39)	111(51)
Fishermen and oystermen [Buell et al, 1960; Frazier and Wegman, 1979; Gute, 1981; Milham, 1976; Petersen and Milham, 1980]	20–64	196(10)	137(26)
Longshoremen and stevedores [Menck and Henderson, 1976; Morrison, 1957; Registrar General, 1972, 1975, 1978]	55–74	165(15)	137(16)
Road construction and maintenance workers			137(21)
Carpenters (grouped) [Buell et al, 1960; Guralnick, 1963; Milham, 1978; Registrar General, 1972, 1975, 1978]	20–64	124(48)	113(127)
Foundry workers			

TABLE III. Selected Nonsignificant Occupation-Cancer Associations of Interest, by Cancer Type (Cont.)

Occupation by cancer type[a]	Age group	sMOR[b]	sMOR for entire age range (20+)[b]
Trachea, bronchus, and lung (ICD 162) (Cont.)			
(grouped)[d] [Morrison, 1957; Palmer and Scott, 1981]	20–64	189(14)	132(23)
Bladder (ICD 188)			
Machinists [Anthony and Thomas, 1980; Dunham et al, 1968; Howe et al, 1980]	20–64	183(7)	96(20)
Truck and tractor drivers			
Bladder (ICD 188) (Cont.)			
[Milham, 1976; Silverman et al, 1983]	20–64	207(7)	150(14)
Medical workers [Anthony and Thomas, 1970; Howe et al, 1980]			165(16)
Lymphomas (ICD 200–202)			
Painters (grouped)	20–64	192(8)	128(12)

[a]See Table I, footnote a.
[b]See Table I, footnote b.
[c]See Table I, footnote c.
[d]See Table I, footnote c.

the liver was seen in this study [Dubrow and Wegman, 1983a], suggesting excessive alcohol consumption among truck drivers. On the other hand, diesel exhaust has been reported to contain carcinogenic substances [Schenker, 1980]. Furthermore, the excess of lung cancer among truck drivers seen in the Third National Cancer Survey study [Williams et al, 1977] remained unchanged after controlling for cigarette smoking based upon smoking histories for each subject. After adjusting the data from the present study for the effects of cigarette smoking, using independent data on smoking rates by occupation and on lung cancer risk ratios for smokers and ex-smokers, the truck drivers-lung cancer association was weakened but remained highly significant ($p \leqslant .01$) (Dubrow and Wegman, unpublished results [see Dubrow and Wegman, 1983a, for details of method]). Finally, a recent case-control study found a significantly increased risk of bladder cancer among truck drivers after controlling for cigarette smoking [Silverman et al, 1983]. Further in-depth investigation of truck drivers is clearly needed.

Machinists and related occupations. Table IV summarizes cancer excesses seen among machinists and related occupations. The excesses of cancers of the stomach; large intestine, except rectum; trachea, bronchus and lung; and bladder; as well as leukemia and aleukemia, are supported by other epidemiologic studies (Tables I–III). Possible etiologic agents include cutting fluids and synthetic abrasives.

Of special interest are the results in the younger age groups. Six different cancer sites were elevated among machinists in the 20–54 or 20–64 age groups. These excesses cannot be explained by a systematic bias owing to a low auxiliary causes of death rate in these age groups, because the sMORs for a number of other sites were

TABLE IV. Cancer Excesses in Machinists and Related Occupations*

Cancer	Occupation	Age range
Stomach (ICD 151)	Machinists and related occupations (grouped)[a]	20+
Large intestine, except rectum (ICD 153.0-153.8)	Tool and die makers	20+
	Machinists	20–54
Rectum and rectosigmoid junction (ICD 154)	Machinists	20–54
Pancreas (ICD 157)	Precision machine operatives	20+
Trachea, bronchus, and lung (ICD 162)	Precision machine operatives	20+
	Machinists	20–54
	Tool and die makers	20–54
	Machinists, shipyard	20+
Bladder (ICD 188)	Machinists	20–64
	Tool and die makers	55–74
	Filers, grinders, and polishers, metal; metal cutters	55–74
Brain (ICD 191)	Machinists	20–54
Leukemia and aleukemia (ICD 204–207)	Machinists	20–64

*See Tables I–III for sMOR values and the number of observed deaths.

[a]The individual categories in this grouped category are machinists; tool and die makers; filers, grinders, and polishers, metal—metal cutters; precision machine operatives; machinists, shipyard; jobsetters and die setters, metal; millwrights; pattern and model makers, metal.

low, as was the sMOR for cirrhosis of the liver [Dubrow and Wegman, 1983a]. It is intriguing that lung cancer was also elevated among tool and die makers in the 20–54 age group. In addition, cancer of the large intestine, except rectum, was elevated in the 20–54 age group among electrical and electronic machinery, equipment, and supplies workers nec, and cancers of the large intestine and rectum were elevated among workers employed by large employer A—electrical equipment; engines and turbines. The manufacturing facilities of large employer A include a large proportion of machining operations.

The excess of colorectal cancer among workers employed by large employer A was largely independent of the excesses among machinists and electrical and elec-

tronic machinery, equipment, and supplies workers nec. Only four of the workers employed by large employer A who died from colorectal cancer were also classified into one of these two occupational categories.

Printing trades and cancers of the buccal cavity and pharynx. The highly significant excess of cancers of the buccal cavity and pharynx found in the printing trades was supported by other epidemiologic studies (Table I). Printing workers have a variety of exposures, including oil and ink mists and solvents. The highly significant excess of cancers of the buccal cavity and pharynx in this study among artists and art teachers, who also have exposure to inks, lends added weight to this association.

Prostate cancer and exposure to cadmium. Three of the occupational categories with highly significant excesses of cancer of the prostate—compositors and typesetters, painters (grouped), and welders (grouped)—have potential exposure to cadmium. Cadmium exposure has been linked to prostate cancer [Lemen et al, 1976]. Studies from the literature support the prostatic cancer excesses for compositors and typesetters and welders (Table I).

Custodial, maintenance, and cleaning workers. Cancer of the larynx; cancer of the trachea, bronchus, and lung; and Hodgkin's disease were elevated among custodial, maintenance, and cleaning workers in the 20–54 age group. Cancer of the pancreas was elevated in the 20–64 age group. As with machinists, these elevations are not due to a systematic bias owing to a low auxiliary causes of the death rate, the sMORs for a number of other sites being low [Dubrow and Wegman, 1983a]. Elevations in the younger age groups suggest relatively new carcinogenic exposures. Potential exposures include asbestos and a wide variety of chemicals used in cleaning.

Alcohol-related cancers. Cancers of the buccal cavity and pharynx, esophagus, larynx, and biliary passages and liver are known to be associated with an excessive use of alcohol [Rothman, 1975]. Alcohol is thought to act synergistically with cigarette smoke in causing cancers of the buccal cavity and pharynx, esophagus, and larynx. Bar workers have excesses of cancers of the buccal cavity and pharynx; larynx; and gallbladder, ducts, and ampulla of Vater. Cooks and chefs have excesses of cancers of the buccal cavity and pharynx and liver. Bar workers and cooks and chefs all have ready access to alcoholic beverages and have been reported to be heavy smokers [Sterling and Weinkam, 1976]. Cooks, however, are also exposed to combustion products of cooking, a possible etiologic agent for cancers of the buccal cavity and pharynx, as well as for the excess lung cancer found among cooks. Finally, the use of alcohol in these types of work settings should be considered an occupational exposure which warrants intervention.

CONCLUSIONS

As with all studies in cancer epidemiology, any real associations found here for the most part reflect exposures 20 to 40 years ago. Massachusetts industry has undergone a great deal of transition during the decades following World War II. There has been a dramatic decline in the textile and leather industries, along with a dramatic rise in the high technology and health services industries. The results of this study for the most part do not reflect these changes. In addition, this study did not effectively cover the health services industry because 75% of health services workers are women [U.S. Bureau of the Census, 1973].

Occupational cancer surveillance studies have an ongoing role to play in cancer epidemiology and control. A systematic approach is needed to ensure broad coverage with respect to occupations and industries, as well as minority groups and women. The utilization of cancer registries for occupational surveillance is probably the best avenue for the development of more sophisticated surveillance techniques [Siemiatycki et al, 1981]. Surveillance studies are most valuable when analyzed in conjunction with each other, with other epidemiologic studies, and with exposure information. In a separate paper, we have performed such an analysis [Dubrow and Wegman, 1983b].

Leads that are firmly established with the aid of surveillance need to be followed up vigorously. Thus, with nine surveillance-type studies [Guralnick, 1963; Menck and Henderson, 1976; Milham, 1976; Milne et al, 1983; Petersen and Milham, 1980; Registrar General, 1972, 1975, 1978; Williams et al, 1977] and two preliminary cohort studies [Ahlberg et al, 1981; Luepker and Smith, 1978] demonstrating an excess risk of lung cancer among truck drivers, in-depth epidemiologic and industrial hygiene studies are clearly indicated. Additional surveillance studies are not needed to confirm leads such as this. The long delay in acceptance of asbestos as an occupational cancer hazard should not be repeated.

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