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Cancer Mortality Among Shoe and Leather Workers in Massachusetts

David H. Garabrant, MD, MPH, and David H.Wegman, MD, MS

A proportional mortality analysis of death certificates of 2,798 shoe and leather workers demonstrated a statistically significant excess of bladder cancer among female shoe workers (PMR = 2.51, 95% confidence interval 1.23 to 5.12). A case-referent analysis of 289 leather workers, on whom detailed occupational information was available, demonstrated an association of lung cancer with work in leather-tanning jobs (odds ratio = 4.2, 95% confidence interval 1.09 to 16.2).

Key words: shoe manufacturing, leather manufacturing, bladder cancer, lung cancer

INTRODUCTION

Work in the shoe and leather industries has been associated with an increased risk of cancer of a number of specific sites [Acheson et al, 1970b; Aksoy et al, 1974; Cecchi et al, 1980; Cole et al, 1972; Decoufle, 1979; Henry et al, 1931; IARC, 1981]

The shoe and leather industries have been major employers in Massachusetts. In 1954, there were over 44,000 individuals employed in shoe manufacturing and over 9,600 employed in leather manufacturing. These industries declined over the next 20 years, and in 1974 only 14,900 shoe workers and 3,200 leather workers remained [Massachusetts Industrial Directory, 1974–75]. We undertook this study to determine the mortality experience of Massachusetts shoe and leather workers and to contribute further understanding to the risks described among other groups in these industries.

Occupational Health Program, Harvard School of Public Health, Boston (D.H.W.).
Department of Family and Preventive Medicine, Division of Occupational Health, University of Southern California School of Medicine, Los Angeles (D.H.G.).
Address reprint requests to Dr. David Wegman, Department of Environmental Sciences and Physiology, Harvard School of Public Health, 665 Huntington Avenue, Boston, MA 02115.
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METHODS

Proportional Mortality Study

All death certificates for the state of Massachusetts are filed according to the town of death. We chose to study three towns in which the shoe and leather industries were major employers. Brockton, which is located about 20 miles south of Boston, and Haverhill, which is 30 miles north of Boston, were chosen because of shoe manufacturing; Peabody, which is 20 miles north of Boston, was chosen because of leather manufacturing. For the purposes of this study, we defined leather workers as individuals who were employed in the manufacturing of leather from animal hides (see Table I), and we defined shoe workers as individuals who were employed in the manufacturing of shoes or boots. Death certificates in Massachusetts indicate the usual occupation and industry of the deceased. Using this information, we selected for study all individuals who died in one of the three towns of interest between 1954 and 1974 and whose death certificate indicated either an occupation in leather or shoe manufacturing or an employer in these industries; 2,798 individuals were selected. Because of the strict criteria we used for inclusion in the study, it is unlikely that individuals who never worked in these industries could have been included. It is possible that some individuals could have been misclassified as to whether they were shoe or leather workers. We believe this may have occurred in cases where the death certificates listed "leather workers" as the usual occupation, because, in our experience this term has been applied to both shoe and leather workers. However, knowledge of the employer made it possible to classify correctly almost all subjects who listed ill-defined occupations.

It is likely that individuals who worked for many years in these industries were included in the study, while individuals who worked for only short periods of time or who worked in these industries early in life were less likely to be included, because their death certificates were less likely to reflect shoe and leather work. The decline of the shoe and leather industries may also have led to the exclusion from this study of workers who left the industries and whose death certificates reflected only their most recent work.

Causes of death were selected according to the seventh revision of the International Classification of Diseases (ICD) [World Health Organization, 1957] but coded according to the eighth revision of the ICD [National Center for Health Statistics, 1975] for deaths before 1968, or were coded directly according to the eight revision of the ICD for deaths during or after 1968. Only the underlying cause of death was considered for each subject. A proportional mortality (PMR) analysis was performed using the computer program developed by Monson [1974] in which the age- time-sex-, cause-specific proportional mortality based on the United States population is multiplied by the number of observed deaths in the 5-year age-, time-specific group to obtain the stratum specific expected number of deaths.

Case-Referent Study

A second phase of investigation was initiated to look for associations between specific jobs in the leather industry and cancer deaths, for those sites that have been previously reported to be associated with work in the leather and leather products industries (cancer of the buccal cavity and pharynx, stomach, digestive tract, nose and paranasal sinuses, larynx, lung, bladder, lymphoma, and leukemia). We felt that

TABLE I. Suspected and Established Carcinogens Present in Leather Manufacturing*

Job	Materials used or present	IARC carcinogenicity evaluation
Hide preparation		
Trim, side, sort	Sodium arsenate, arsenious anhydride,	Arsenic compounds are
soak, wash	arsenious oxide	carcinogenic in humans
	Ethylene oxide	Probably carcinogenic in humans
Flesh	Mineral oil	Carcinogenic in humans
Unhair	Arsenic sulfide	Arsenic compounds are carcinogenic in humans
	N-Nitrosodimethylamine and N-Nitrosomorpholine, produced from dimethylamine sulfate	Carcinogenic in animals
Bate, pickle		
Tanning		
Tan	Potassium dichromate, sodium dichromate, chromic oxide	Chromium (VI) salts are carcinogenic in humans
Wring, split, shave, neutralize, retan		
color	Dyes	
	Acid violet 49 (benzyl violet 4B)	Carcinogenic in animals
	Direct black 38	Carcinogenic in humans
	Direct blue 14 (trypan blue)	Carcinogenic in animals
	Food Red 5 (Ponceau MX)	Carcinogenic in animals
	Solvent yellow 34 (auramine)	Carcinogenic in humans
Fat liquor	Mineral oil	Carcinogenic in humans
Setting out		
Leather finishing		
Toggle, paste, stake,		
mill, buff finish	Cadmium sulfide	Probably carcinogenic in humans
	Lead chromate	Carcinogenic in animals
	1,4 Dioxane	Carcinogenic in animals
Maintenance and support		
Carpenter		
Chemist	Dyes, chromium (VI) compounds	Carcinogenic in humans
Truck driver		
Engineer		
Stationary fireman		
Foreman		
Inspector		
Mechanic		
Millwright		
Shipper		
Measurer		
Steamfitter	Asbestos	Carcinogenic in humans
Supervisor		
Watchman		
Elevator operator		
Stock clerk		
Janitor		
Maintenance worker		

* Adapted from IARC Monographs [1981].

workers in certain processes in leather manufacturing had a high potential for exposure to carcinogens and that examination of the subjects above might reveal excess cancer risks that were not apparent in the PMR study, which examined mortality in all leather workers together. The death certificates of 178 leather workers abstracted for the PMR analysis contained detailed job titles. The principal jobs of an additional 111 deceased leather workers were obtained from the records of a leather workers' union pension fund located in Peabody. The principal job was taken as the longest job held. These 111 workers included all members of the pension fund who died between 1975 and 1979. Their death records were obtained from the State files, and the underlying cause of death was coded according to the eighth revision of the ICD.

The subjects were grouped into four exposure categories that reflected the major processes in leather manufacturing: hide preparation, tanning, leather finishing, and maintenance and support. The job titles and likely exposures to carcinogens in each category are presented in Table I. Subjects who died from cancer of each site listed above were compared to subjects who died from causes other than cancer. Each of the three production groups (hide preparation, tanning, leather finishing) was compared to the maintenance and support workers. Odds ratios, P values, and confidence intervals were calculated using the methods given by Rothman and Boice [1979]. The cases were not matched to controls, because the number of controls available was limited and did not permit adequate matching.

RESULTS

Proportional Mortality Study

The frequencies of observed and expected deaths among leather workers are shown in Table II. Slight deficits of deaths due to malignant neoplasms were present among both males and females. A statistically significant excess of stomach cancer ($P=0.03$) was present among male leather workers, and a nonsignificant numerical excess of stomach cancer was present among females. There were no deaths due to cancer of the nose or paranasal sinuses among leather workers. Statistically significant excesses of deaths due to diseases of the circulatory system were present among male and female leather workers ($P=0.002$ and $P=0.01$, respectively), and a statistically significant deficit of deaths due to infective and parasitic diseases was present among male leather workers.

The frequencies of observed and expected deaths among shoe workers are shown in Table III. Slight deficits of deaths due to malignant neoplasms were present among both males and females. A statistically significant excess of cancer of the digestive tract ($P=0.02$) was present among male shoe workers. When this was analyzed by anatomic site, nonsignificant numerical excesses of cancer of the esophagus, stomach, pancreas, and large intestine were apparent. There were slight deficits of cancer of the rectum and liver. Female shoe workers had a statistically significant ($P=0.01$) excess of bladder cancer. There were no deaths due to cancer of the nose or paranasal sinuses among shoe workers.

Case-referent Study

The leather workers in the case-referent study were compared to the leather workers in the PMR study to demonstrate that the two groups are comparable (Table

TABLE II. Observed and Expected* Deaths by Cause Among Leather Workers (1954–1974)

	Males			Females		
Cause of death and ICD number[a]	Obs	Exp	Obs/Exp	Obs	Exp	Obs/Exp
All causes	758	758		78	78	
Infective and parasitic diseases (000–136)	1	7.7	0.13[b]	1	0.5	2.00
Malignant neoplasms (140–209)	120	131.9	0.91	12	16.3	0.74
Buccal cavity and pharynx (140–149)	5	4.1	1.23	0	0.2	0
Digestive (150–159)	47	42.9	1.09	5	5.0	1.00
Stomach (151)	16	9.5	1.69[c]	2	0.7	2.80
Larynx (161)	2	1.9	1.04	0	0.04	0
Lung (162)	27	34.4	0.79	1	1.28	0.78
Bladder (188)	3	5.3	0.56	0	0.3	0
Lymphatic and hematopoietic (200–209)	9	11.8	0.76	0	1.4	0
Lymphoma (200–202)	3	3.9	0.77	0	0.5	0
Leukemia (204)	3	5.4	0.56	0	0.6	0
Diseases of circulatory system (390–458)	496	455.0	1.09[d]	56	45.8	1.22[e]
Diseases of respiratory system (460–519)	36	47.9	0.75	1	3.3	0.30
Diseases of digestive system (520–577)	27	29.5	0.92	0	2.7	0
Accidents, poisoning, and violence (800–999)	45	39.8	1.13	3	3.1	0.98
Residual	33	46.2	0.71	5	6.3	0.80

*Expected deaths based on 5-year age-, time-, cause-, and sex-specific proportional mortality for the United States 1954–1974.
[a]International Classification of Diseases, 8th Revision:
[b]95% confidence interval 0.03–0.68; p = 0.02;
[c]95% confidence interval 1.04–2.73; p = 0.03;
[d]95% confidence interval 1.03–1.15; p = 0.002;
[e]95% confidence interval 1.04–1.43; p = 0.01.

TABLE III. Observed and Expected* Deaths by Cause Among Shoe Workers (1954–1974)

Cause of death and ICD number[a]	Males			Females		
	Obs	Exp	Obs/Exp	Obs	Exp	Obs/Exp
All causes	1195	1195		767	767	
Infective and parasitic diseases (000–136)	8	7.5	1.07	4	4.2	0.95
Malignant neoplasms (140–209)	217	200.2	1.08	131	138.3	0.95
Buccal cavity and pharynx (140–149)	5	5.4	0.93	0	1.9	0
Digestive (150–159)	84	60.6	1.39[b]	44	44.6	0.99
Stomach (151)	17	11.4	1.49	5	6.1	0.82
Larynx (161)	3	2.6	1.16	0	0.3	0
Lung (162)	55	52.9	1.04	13	12.1	1.07
Bladder (188)	5	8.9	0.56	7	2.8	2.51[c]
Lymphatic and hematopoietic (200–209)	16	18.0	0.89	6	12.8	0.47
Lymphoma (200–202)	4	4.6	0.87	2	3.6	0.56
Leukemia (204)	8	8.4	0.95	2	3.8	0.52
Diseases of circulatory system (390–458)	736	740.8	0.99	499	483.2	1.03
Diseases of respiratory system (460–519)	85	90.1	0.94	42	35.5	1.18
Diseases of digestive system (520–577)	46	38.2	1.20	33	23.9	1.38
Accidents, poisoning, and violence (800–999)	38	46.4	0.82	19	24.1	0.79
Residual	65	71.8	0.90	39	57.8	0.67

*Expected deaths based on 5 year age-, time-, cause-, and sex-specific proportional mortality for the United States 1954–1974.

[a]International Classification of Diseases, 8th Revision.

[b]95% confidence interval 1.13–1.70; p = 0.002.

[c]95% confidence interval 1.23–5.13; p = 0.01.

TABLE IV. Comparison of Leather Workers in PMR Study With Leather Workers in Case-referent Study

	PMR study		Case-referent study	
	Males	Females	Males	Females
Number of subjects (%)	758(91)	78(9)	258(89)	31(11)
Mean age at death	70.2	71.3	69.6	69.9

TABLE V. Comparison of Leather Worker Cases and Referents

	Number of subjects	Males N(%)	Females N(%)	Age at death Mean SD
Referents	227	201(89)	26(11)	68.6 ± 20.0
Cases	62	57(92)	5(8)	72.6 ± 10.8
Buccal cavity + pharynx	1	1(100)		63
Stomach	8	7(88)	1(12)	68.6 ± 12.3
Digestive tract except stomach	17	17(100)		75.6 ± 5.7
Nose and sinuses	0			
Larynx	2	2(100)		81.5 ± 0.7
Lung	18	16(89)	2(11)	71.7 ± 10.6
Bladder	2	2(100)		73.5 ± 2.1
Lymphoma	5	5(100)		71.6 ± 11.8
Leukemia	0			
All other cancer	9	7(78)	2(22)	71.8 ± 17.6

IV). In both studies, males made up approximately 90% of the subjects, and females 10%. The mean age at death for males was 70 in both studies, while the mean age at death for females was 71 in the PMR study and 70 in the case-referent study. The subjects selected for the case-referent study appear to be comparable to the PMR study subjects, except that the majority of the PMR subjects are unlabeled as to specific job.

The mean age at death of cases and referents are comparable (Table V) as is the sex distribution of the cases and referents. Sixty-two deaths due to cancer occurred among the subjects, of which 18 were lung cancer, 7 were stomach cancer, and 17 were cancer of the digestive tract except stomach. Small numbers of cases of cancer of the buccal cavity and pharynx, larynx, bladder, and lymphomas occurred. There were 9 cases of cancer of other sites, composed of prostate cancer (4 cases), cancer of undetermined origin (3 cases), malignant melanoma (1 case), and breast cancer (1 case). These are presented as one group in Table V because of the small number of cases and because none of them was found to be associated with specific jobs or job groups. There were no cases of cancer of the nose and paranasal sinuses or of leukemia.

The distribution of deaths over exposure groups was examined for associations between specific cancer sites and exposures (Tables VI). Maintenance workers and supportive personnel were grouped together and were used as the exposure group to which other groups were compared, since their exposure to materials used in production areas was believed to be significantly less than that of production workers. An observed association between cancer and work in a production area, using this

TABLE VI. Case-Referent Study of Leather Workers: Distribution of Deaths by Exposure Group

	Referents	Cancer deaths								
	Noncancer	Buccal cavity and pharynx	Stomach	Digestive tract except stomach	Larynx	Lung	Bladder	Lymphoma	All other cancer	Row total
Hide preparation	36			2	1	3		1	1	44
Tanning	30		1	3	1	7[a]	1		2	45
Finishing	107	1	5	7		5	1	3	2	131
Maintenance	54		2	5		3		1	4	69
Total	227	1	8	17	2	18	2	5	9	289

[a]Odds ratio for employment in tanning: OR = 4.20; $\chi^2 = 4.35$; p = 0.04; 95% confidence interval = 1.09–16.2.

comparison group, would underestimate the true association, because work in the comparison group would have a stronger association with cancer than work in a truly nonexposed job. In each of the production groups (hide preparation, tanning, and finishing) cases and referents were compared to the maintenance workers in a series of two-by-two contingency tables. For cases of lung cancer, the odds ratio for employment in tanning was 4.2 ($P=0.04$, 95% confidence interval, 1.09 to 16.2). Cancer of the stomach and cancer of the digestive tract, except stomach, were not statistically significantly associated with any exposure group. For the other cancer sites, small numbers of deaths were present, and analysis did not reveal any statistically significant associations with exposure groups.

DISCUSSION

This study confirmed a previously established association between bladder cancer and work in the leather products industry. In our study, this association was apparent among female, but not among male, shoe workers. Excess mortality due to bladder cancer has not previously been reported among female shoe workers specifically, although excess incidence of bladder cancer has been reported among females employed in the leather and leather products industry [Decoufle, 1979]. Excess mortality due to bladder cancer among male shoemakers and shoehands was reported by Versluys [1949] in the Netherlands in a study of death certificates between 1931 and 1935, in which the PMR for bladder cancer was 1.7. This is consistent with the risk among females found in our study (PMR=2.51, 95% confidence interval 1.2–5.1). Excess deaths due to bladder cancer among males in the leather industry were reported in Great Britain, based on death certificates from 1921 to 1928, in which the ratio of observed to expected deaths was 1.7 [Henry et al, 1931]. More recent case control studies of bladder cancer incidence have shown an increased risk among shoemakers and leather workers [Wynder et al, 1963] and leather and leather products workers [Cole et al, 1972; Decoufle, 1979]. These three studies were conducted using cases diagnosed between 1956 and 1968, and were limited to males. In the study by Cole [1972] the highest risk of bladder cancer was observed among male workers whose occupations involved cutting and assembling leather pieces, and related activities such as buffing. The risk among workers in leather tanning was lower. Thus, it appears from our results that females in the leather products industry also share the increased risk of bladder cancer previously described among other groups of workers.

An excess risk of bladder cancer among males was not demonstrated in our study, contrary to our expectations. From our observations in the shoe industry, we believe that males tend to hold jobs different from those of females, and may have different exposures. Our PMR analysis, which considered all male shoe workers together, would not be expected to reflect an excess bladder cancer risk, which was present only among the subgroup of males whose jobs were comparable to those of the females.

Our PMR analysis used the United States population rates to derive the expected numbers of deaths, which may have given us results different from those we would have obtained had we used Massachusetts population rates. Monson [1980], in a comparison of the Massachusetts white population to the United States white population, found the PMR for genitourinary cancer to be 69 for males and 88 for females

in Massachusetts. Had we used a Massachusetts population for comparison, it is likely that the PMRs for bladder cancer in both males and females would have been higher than we observed.

It is possible that the smoking habits of our study group were different from those of the general population, and that a proportion of the excess risk of bladder cancer was due to the difference in smoking habits. However, the magnitude of the risk of bladder cancer seen in our study exceeds that which is seen in relation to smoking [Cole et al, 1972], and information from other sources [Sterling and Weinkam, 1976] indicates that the smoking habits of female industry operatives, such as shoe workers, are almost identical to those of the United States female population. Thus, we feel that smoking habits are unlikely to be responsible for the pattern of bladder cancer risk that we attribute to shoe making.

Our study demonstrated a statistically significant excess of stomach cancer among male leather workers and a nonsignificant excess of stomach cancer among male shoe workers. Male shoe workers had a statistically significant excess of cancer of the digestive tract, but there was not one site that achieved statistical significance. Similar results have been reported from Great Britain [The Registrar General, 1971] in which an excess of stomach cancer was found among boot and shoe manufacturers and repairers in 1961 (SMR = 1.23, P = 0.03). Our case-referent analysis did not show an association between stomach cancer and any single exposure group.

We believe that a major part of this excess may have been due to the use of the United States population rates for the calculation of expected deaths. Monson [1980] demonstrated the PMR for digestive tract cancer to be 134 for white male and 114 for white female Massachusetts residents, using expected deaths based on the white United States population rates. In addition, elevated stomach cancer mortality has been reported for a number of Massachusetts counties, including the counties in which our study population is located [Mason et al, 1975]. Thus, it appears that factors other than work in the shoe and leather industry may be responsible for the excess risk of digestive tract cancer seen in our study. Further analyses using Massachusetts mortality rates are necessary to assess the effect these factors may have on our results.

Our case-referent study found an excess risk of lung cancer among male leather workers involved in tanning, although the PMR study did not demonstrate this. It is possible that an excess risk among tanners could have been obscured in the PMR analysis, because tanners were examined among a large group of workers who did not share their excess risk. We believe that these results provide new information that identifies a subgroup of leather workers who are at increased risk of lung cancer. However, because it is based on a small number of cases, this finding should be interpreted with caution.

Information from other sources also indicates that leather workers are at increased risk of lung cancer. Hexavalent chromium compounds, used in the tanning process, have been linked to lung cancer in humans [IARC Monographs, 1973]. A description of health hazards in the leather industry [McConnell et al, 1942] describes the handling of wet hides saturated with chromic acid and the risk of chrome ulcers in this process. A Massachusetts leather trade publication [New England Tanners Club, 1975], written in 1965, describes the use of hexavalent chromium compounds in the tanning process, and it is believed that workers' exposure to these materials was common even at that time. Exposure to hexavalent chromium was likely among

the subjects of this study and is the prime material suspected to be responsible for the excess of lung cancer among tanners. Exposure to arsenicals used in hide preparation and still present in the wet skins may also have contributed to excess of lung cancer.

Kennaway and Kennaway [1947], reported an SMR of 141 for lung cancer among male tanners, leather dressers, and curriers, based on death certificates from England and Wales for the years 1921 to 1938. The Registrar General's Decennial Supplement for England and Wales in 1951 [The Registrar General, 1958], showed 30 deaths due to lung cancer, while 23 were expected among male tanners, leather dressers, and curriers. No significant excess was found in 1961 [The Registrar General, 1971] or in 1970 [The Registrar General, 1978]. A cross-sectional study of lung cancer cases in Los Angeles County in 1968 to 1970 demonstrated an SMR of 1.7 for leather manufacturing and sales workers [Menck and Henderson, 1976].

Other site-specific cancer excesses have been reported in the literature, but were not evident in this study. An increased risk of cancer of the nasal cavity and paranasal sinuses has been found among boot and shoe workers in England and Wales [Acheson, 1976; Acheson et al, 1970a, 1972, 1981] and in male shoemakers and repairers in Italy [Cecchi et al, 1980]. Excess risks of cancer of the buccal cavity and pharynx and larynx have been reported among male leather industry and shoe workers in New York State [Decoufle, 1979]. An excess of cancer of the mouth has been reported among male shoemakers in the Netherlands [Versluys, 1949]. An excess of renal cancer has been noted among leather workers and employees in the leather industry in England and Wales and in the United States [IARC Monographs, 1981]. Leukemia has been observed among shoe workers exposed to benzene in Italy [Vigliani, 1976] and Turkey [Aksoy et al, 1974a; Aksoy and Erdem, 1978] but has not been observed among shoe workers without this exposure. An elevated risk of malignant lymphoma has been noted among male and female leather industry workers in New York State [Decoufle, 1979].

CONCLUSIONS

This study provides additional evidence of an excess risk of bladder cancer among female workers in the shoe manufacturing industry, and it provides evidence that lung cancer is associated more strongly with leather tanning than with other processes in leather manufacturing.

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REFERENCES

Acheson ED (1976): Nasal cancer in the furniture and boot and shoe manufacturing industries. Prev Med 5:295–315.

Acheson ED, Cowdell RH, Jolles B (1970a): Nasal cancer in the Northamptonshire boot and shoe industry. Br Med J 1:385–393.

Acheson ED, Cowdell RH, Jolles B (1970b): Nasal cancer in the shoe industry. Br Med J 1:791.

Acheson ED, Cowdell RH, Rang E (1972): Adenocarcinoma of the nasal cavity and sinuses in England and Wales. Br J Ind Med 29:21–30.

Acheson ED, Cowdell RH, Rang EH (1981): Nasal cancer in England and Wales: An occupational survey. Br J Ind Med 38:218–224.

Aksoy M, Erdem S (1978): Follow-up study on the mortality and the development of leukemia in 44 pancytopenia patients with chronic exposure to benzene. Blood 52:285–292.

Aksoy M, Erdem S, Dincol G (1974a): Leukemia in shoe workers exposed chronically to benzene. Blood 44:837–841.

Aksoy M, Erdem S, Ergodan G, Dincol G (1974b): Acute leukemia in two generations following chronic exposure to benzene. Hum Hered 24:70–74.

Cecchi F, Buiotti E, Kriebel D, Nostasi L, Santucci M (1980): Adenocarcinoma of the nose and paranasal sinuses in shoemakers and woodworkers in the providence of Florence, Italy (1963–77). Br J Ind Med 37:222–225.

Cole P, Hoover R, Friedell GH (1972): Occupation and cancer of the lower urinary tract. Cancer 29:1250–1260.

Cole P, Monson RR, Haning H, Friedell G (1971): Smoking and cancer of the lower urinary tract. N Engl J Med 284:129–134.

Decoufle P (1979): Cancer risks associated with employment in the leather and leather products industry. Arch Environ Health 34:33–37.

Henry SA, Kennaway NM, Kennaway EL (1931): The incidence of cancer of the bladder and prostate in certain occupations. J Hyg (London) 31:125–137.

IARC Monographs (1981): Evaluation of the carcinogenic risk of chemicals to humans—wood, leather and some associated industries. Vol 25. IARC Lyon 25:243.

IARC Monographs (1973): Some inorganic and organometallic compounds. In: IARC Monographs of the Evaluation of the Carcinogenic Risk of Chemicals to Man. Vol. 2. Lyon, France.

Kennaway EL, Kennaway NM (1947): A further study of the incidence of cancer of the lung and larynx. Br J Cancer 1:260–298.

Massachusetts Industrial Directory 1974–75. Bureau of Research and Statistics Department of Commerce and Development. Commonwealth of Massachusetts.

Mason TJ, McKay FW, Hoover R, Blot WJ, Fraumeni JF (1975): Atlas of cancer mortality for U.S. counties: 1950–69. DHEW Publication No. (NIH) 75–780. Washington, D.C., U.S. Government Printing Office.

McConnell WJ, Fehnel W, Ferry JJ (1942): Potential health hazards of the leather industry. J Ind Hyg Toxicol 24:93–108.

Menck HR, Henderson BE (1976): Occupational differences in rates of lung cancer. J Occup Med 18:797–801.

Monson RR (1974): Analysis of relative survival and proportional mortality. Comput Biomed Res 7:325–332.

Monson RR (1980): Mortality in a Massachusetts general population. J Chronic Dis 33:29–35.

National Center for Health Statistics, Eight Revision (1975): International classification of diseases. Adapted for use in the United States, USPHS Publication 1693. Washington, D.C. U.S. Government Printing Office.

New England Tanners Club (1975): Leather facts. New England Tanners Club. Peabody, Massachusetts.

The Registrar General's Decennial Supplement, England and Wales 1951 (1958): Occupational mortality part II. Her Majesty's Stationery Office, London.

The Registrar General's Decennial Supplement, England and Wales 1961 (1971): Occupational mortality tables. Her Majesty's Stationery Office, London.

The Registrar General's Decennial Supplement, England and Wales 1970–72 (1978): Occupational mortality. Her Majesty's Stationery Office, London.

Rothman KJ, Boice JD (1979): Epidemiologic analyses with a programmable calculator. U.S. Department of Health, Education, and Welfare. NIH Publication Number 79–1649. Washington, D.C.

Sterling TD, Weinkam JJ (1976): Smoking characteristics by type of employment. J Occup Med 18:743–754.

Versluys JJ (1949): Cancer and occupation in the Netherlands. Br J Cancer 3:161–185.

Vigliani EC (1976): Leukemia associated with benzene exposure. Ann NY Acad Sci 271:143–151.

World Health Organization (1957): International classification of diseases, 7th Revision. Geneva.

Wynder EL, Onderdonk J, Mantel N (1963): An epidemiologic investigation of cancer of the bladder. Cancer 16:1308–1407.