Patterns of Mortality Among Commercial Pressmen[1]

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ABSTRACT—A proportionate analysis of cause of death in 1,401 commercial pressmen was initiated following a report of a cancer cluster in this group. The study found a significant elevated risk of all cancers [proportionate mortality ratio (PMR)=127] and cancers of the lymphatic and hematopoietic system (PMR=122), with non-Hodgkin's lymphomas responsible for much of the excess. Three deaths in the cohort were attributed to myelofibrosis, a rare disease associated with benzene exposure. A significantly elevated PMR was also detected for colorectal cancer (PMR=171) and, among those employed 20 years or more, for cancers of the liver (PMR=216) and pancreas (PMR=162). No excess risk of bladder or lung cancer or leukemia was seen. Proportionate mortality analyses rarely show excess risk of both cancer and heart disease in a working population. Surprisingly, a significantly elevated risk of arteriosclerotic heart disease (PMR=113) was found in this group. These findings indicate that solvent exposure may be associated with excess mortality risk in Commercial pressmen.—JNCI 1986; 76:1047-1051.

Printing is one of the oldest and largest manufacturing industries in the United States, employing more than 500,000 production workers in 1977. Over 275,000 are employed in the commercial printing sector; printing publications, advertisements, and financial or legal documents. Commercial pressmen are generally found in small establishments; more than 80% of the 22,000 commercial presses in the United States employ no more than 20 workers. Newspaper publishing, the second largest sector of the printing industry, employs 165,000 individuals in the production of more than 10,000 daily, weekly, and Sunday newspapers. (NIOSH: Unpublished data).

There have been several reports of excess lung cancer mortality among newspaper pressmen in England (*1,* 2) and the United States (Nicholson WJ, Seidman H, Hoos D, et al.: Unpublished data). Increased, although not significantly, risk of lung cancer mortality was detected in two other studies, and significant excess mortality from leukemia and cancers of the oropharyngeal cavity, larynx, and kidney has also been reported among newspaper pressmen [*3, 4)* and Nicholson WJ, Seidman H, Hoos D: Unpublished data]. In contrast, however, there has been only a single study on mortality within the other sector of the industry, commercial pressmen. Lloyd et al. found increased mortality in commercial Printers due to heart disease and, in several age subgroups, pancreatic and rectal cancer *(4).*

The present study was requested by Local 51, GCIU, following the report by a business agent of a bladder cancer cluster among the commercial pressmen represented by this union. Commercial pressmen may work with benzidine-based color inks and other suspect bladder carcinogens. To explore the relationship between workplace exposures and health in this industry, we conducted an analysis of proportionate mortality among members of Local 51.

METHODS

Local 51 has been in existence for more than 120 years. All members of the local are journeymen commercial printers, having served a minimum 5-year apprenticeship. Currently, the local represents approximately 2,500 members in more than 150 establishments in New York City, Long Island, and New Jersey.

Local 51 provides a death benefit to the survivors of deceased members if the decedent had been a union member for at least 5 years. At the time of this study the union files contained 1,427 death certificates, which included all certificates of members who died between January 1, 1958 and December 31, 1981. Relevant information from the certificates, including age, race, sex, year of death, and all listed causes of death, was abstracted and coded. The coding sheets, including the transcription of the causes of death, were sent to a trained nosologist for classification according to the underlying cause of death with the use of the ICD. The New York City Department of Health, Department of Vital Statistics, provided the underlying causes of death and ICD classifications for those printers who died in

ABBREVIATIONS USED: CI=confidence interval(s); CNS=central nervous system; GCIU=Graphic Communications International Union; ICD=International Classification of Diseases (Eighth Revision); IPPAU=International Printing Pressmen and Assistants Union; NIOSH=National Institute of Occupational Safety and Health; PMR=proportionate mortality ratio(s).

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New York City. Similar information for printers who died in New Jersey was supplied by the health department of that state. Of the 1,427 certificates, 16 were deemed illegible, incomplete, or in other ways deficient. We did not include in the final analysis either the deficient certificates or the 10 certificates belonging to women or black men, because there were too few persons in either category for statistical consideration. This left 1,401 white male commercial pressmen on whom we conducted the proportionate mortality analysis.

Using the age and year of death of each of the 1,401 printers, we determined PMR for several causes of death using a computer program designed for this purpose *(5)*. Mortality data from comparable age, sex, race, and year of death subgroups of the U.S. population were employed to generate the expected number of deaths. For the purpose of analysis, data were aggregated into 5-year age and year-of-death strata.

Local 51's records contain data on the amount of money paid to the beneficiary of the deceased member, which reflects the length of the union membership (including the apprenticeship). The maximum amount was paid to beneficiaries of members employed for at least 20 years. Utilizing these data, we were able to identify the length of membership for 1,264 members of the study population (90% of the entire cohort). Of the 1,264, 1,100 were members for 20 years or more, and 164 were members for less than 20 years. This enabled us to conduct a separate analysis of the mortality patterns based on number of years in the trade. However, since only a small number of the decedents in this study were known to be employed for less than 20 years, data related to length of union membership should be interpreted cautiously. Proportionate mortality analyses were also performed on subgroups of the cohort based on age and year of death.

The data presented in this study are not wholly independent from that of Lloyd et al. *(4)*. These investigators analyzed proportionate mortality of deceased members of a nation-wide union, the IPPAU, who died during the 3-year period of 1966–68. The IPPAU. to which Local 51 belonged, was a predecessor union to the GCIU. Of the 1,401 deceased pressmen in our study, 199 died in either 1966, 1967, or 1968. Therefore, at most, 14% of our study population potentially overlaps with that of Lloyd.

RESULTS

Table 1 shows PMR and 95% CI for selected malignant and nonmalignant causes of death for the entire study population. Relevant findings from analyses of the data classified according to length of union membership, age at death, and year of death are presented in the text.

Mortality due to all cancer sites was significantly greater than expected in the entire cohort (PMR = 127). A major area of increased cancer mortality was the lym-

TABLE 1.—*Proportionate mortality among commercial pressmen*

ICD	Cause of death	Obs	Exp	PMR[b]	95% CI
140-209	All cancer	315	247.8	127[c]	112-144
140-149	All buccal cavity and pharynx	9	7.3	123	64-238
150-159	All digestive system	108	77.0	140[c]	115-170
150	Esophagus	3	5.7	53	17-162
151	Stomach	16	15.7	102	62-167
153	Large intestine	40	25.3	158[c]	116-216
154	Rectum	19	9.2	206[c]	132-321
155	Liver	9	5.4	167	87-320
157	Pancreas	18	14.2	127	80-202
160-163	All respiratory	87	72.0	120	98-151
161	Larynx	4	3.5	114	43-304
162	Lung	79	67.7	116	94-147
	All genitourinary				
188	Bladder	11	10.2	108	60-196
189	Kidney	8	5.4	146	74-293
191-192	Brain and other CNS tissue	6	4.4	137	62-305
200-209	All lymphatic and hematopoietic	27	22.2	122	83-178
202-203	Other lymphatic cancer	11	5.2	209[c]	117-375
204-207	Leukemia and aleukemia	9	10.0	89	47-173
390-458	Diseases of circulatory system	842	842.7	99	92-109
393-398	Chronic rheumatic heart disease	16	8.8	182[c]	112-298
410-414	Arteriosclerotic heart disease	627	554.0	113[c]	103-125
430-438	Vascular lesions of CNS	111	145.3	76[c]	63-93
460-519	All respiratory diseases	80	96.1	83	66-104
492	Emphysema	9	24.4	36[c]	20-69
520-577	All diseases of digestive system	43	51.9	82	61-112
571	Cirrhosis of liver	12	19.8	60	35-107

[a] Obs = observed deaths; Exp = expected deaths.
[b] Obs/exp X 100.
[c] $P<.05$.

phatic system. Non-Hodgkin's lymphomas were significantly increased, with 11 cases observed and 5 expected (PMR = 209). Seven of the cases were seen in the younger population, those who died before age 65 (PMR = 388). No excess of leukemia was detected either in the overall group (PMR = 89) or in printers who worked 20 years or more (PMR = 102). Three deaths among cohort members were attributed to myelofibrosis, classified as a cancer in ICD.

A significantly elevated PMR was found for all cancers of the digestive organs and peritoneum (PMR = 140); this was primarily due to excess cancer of the colon (PMR = 158) and rectum (PMR = 206). Cancer of the liver was also in excess in the overall population (PMR = 167), but it was not statistically significant. However, all 9 cases of liver cancer were among those who worked for 20 years or more, resulting in a significantly increased PMR of 216. Similarly, elevated mortality observed for pancreatic cancer was statistically significant among the longer working population (PMR = 162; 18 observed, 11.1 expected).

Of the cancers of the respiratory system, lung cancer was only slightly elevated in the total group. This elevation was found in both the shorter and longer period pressmen. A nonsignificant excess of oropharyngeal cancer was also observed (PMR = 123), as were small but not statistically significant elevations in brain cancer (PMR = 137) and kidney cancer (PMR = 146).

With regard to nonmalignant diseases, mortality for several diseases of the circulatory system was also elevated. There was a statistically significant excess PMR (PMR = 113) for arteriosclerotic heart disease, the largest single cause of death. This significant excess mortality was seen in pressmen who worked for less than 20 years (PMR = 129; 79 observed, 60.8 expected), as well as in both younger and older age-at-death categories. Deaths attributable to vascular lesions of the CNS (stroke) were significantly less than expected. Mortality from rheumatic heart disease was significantly increased (PMR = 182) in the entire population.

Finally, we observed no excess mortality for nonmalignant respiratory disease (PMR = 83), including emphysema (PMR = 36) as well as cirrhosis of the liver.

DISCUSSION

The results of this study suggest that commercial pressmen may be at risk for cancer at several sites, particularly those of the digestive tract and of the lymphatic system. Further, the data also suggest that excess mortality due to arteriosclerotic heart disease may occur in this population.

Limitations of proportionate mortality analyses are well known and must be considered in the interpretation of these data. Potential sources of bias include incomplete data sources, the interdependent nature of the data, and the potential for underestimating the population at risk (*6, 7*). The strength of the present study is that it is based on the financial records of a long established pension plan; beneficiaries had a strong monetary incentive to report the death of a union member. Beaumont et al. (8) noted that PMR analyses based on insurance plans of this type provide the closest estimate of true relative risks. In addition, PMR analyses may overestimate the risk of cancer mortality if other major causes of death, particularly heart disease, are low ***(9)***. Since we report excess mortality due to heart disease, this effect is likely to be minimal.

Earlier studies of commercial and newspaper printers have found a significant risk of hematopoietic system cancer, particularly leukemia (3, ***10)***, and have, in general, attributed this excess to the historic widespread use of benzene as a solvent in the printing industry. Considerable exposure to solvents still occurs in pressrooms, often in concentrations exceeding NIOSH recommended standards (NIOSH: Unpublished data).

In the present study, we did not observe any elevation of leukemia mortality. However, all lymphatic and hematopoietic system cancers (ICD 200-209) were elevated, and non-Hodgkin's lymphomas were found to be significantly in excess. In addition, we have found three deaths due to myelofibrosis (ICD 209), a relatively rare myeloproliferative disease (crude incidence 2/100,000) that is known to be associated with benzene exposure (*11,* 12). This disease may terminate in acute myeloid leukemia, also known to be caused by benzene exposure *(13)*. Interestingly, Paganini-Hill et al. found one case of myelofibrosis in their study of newspaper pressmen (3). Benzene may not be the only solvent in the industry capable of causing hematopoietic system cancers. Checkoway et al. suggested that carbon tetrachloride and carbon disulfide exposure is associated with leukemia ***(14)***. Both of these solvents are used extensively in the printing industry (NIOSH: Unpublished data).

We also observed significantly elevated mortality from liver and pancreatic cancer among individuals who were members of the printers union for more than 20 years. Excess liver cancer among pressmen has not been observed in any of the previous printer mortality studies. Several of the chemicals known to cause liver cancer in experimental studies have been constituents of printing inks. These include several dyes, polychlorinated biphenyls, and 2-nitropropane (NIOSH: Unpublished data). Alcohol, a risk factor for liver cancer (*11, 15*), is also a possible causal agent. However, no excess mortality due to cirrhosis of the liver was observed. While several authors have reported an excess risk of pancreatic cancer associated with exposure to chemicals (*11, 16*), the known difficulties in diagnosing pancreatic cancer require that the observed excess of cancer at this site should be interpreted cautiously.

There was no excess mortality due to bladder cancer, the original reason for the union's concern over a cancer hazard in the industry. A recent study of British pressmen also initiated by union concern over bladder cancer did not find any excess mortality from this disease in its preliminary analysis (Leon D: Unpublished data). However, small excess risk of bladder cancer may not be apparent in a mortality study, since the disease has a relatively high 5-year survival rate (*17, 18*).

We observed significant elevations in cancers of the colon and rectum. Excess colon, although not rectal, cancer was reported in a study of the printers employed by the U.S. Government Printing Office (*10*) and, as well, in the preliminary analysis of mortality among the membership of the British printers' union (Leon D: Unpublished data). Lloyd et al. found, in commercial pressmen over age **65** at death, significant excess mortality from rectal cancer (*4*). Neither excess colon nor rectal cancer is seen in any of the studies of the newspaper printing industry. [(*3*, ***19***) and Nicholson WJ, Seidman H, Hoos D: Unpublished **data**].

Some of the exposures specific to commercial pressrooms may have caused the observed increase in mortality from digestive system cancers. Potential candidates are the abundantly used printing inks, several of which contain known or suspected carcinogens (20–22) or the hydrocarbon oils in inks, oils that have been suggested to be carcinogenic to the gastrointestinal tract (23). Alternatively, the observed excess of colorectal cancer may be a result of diet or other factors related to the ethnic background of the pressmen (*11*).

This investigation, confirming Lloyd's earlier observation (*4*), found an increase in arteriosclerotic heart disease among all pressmen. These findings are supported by the recently published analysis of mortality among U.S. veterans. In that study, the age and smoking standardized mortality ratios among printing pressmen for all cardiovascular diseases and coronary heart disease were 114 and 135, respectively ***(24).***

It is quite unusual for proportionate mortality analyses *to* detect elevated PMR both for deaths attributed to heart disease and all malignant neoplasms. Most epidemiologic investigations of mortality in employed populations find heart disease mortality rates far lower than in the general population, a result of the selection bias known as the "healthy worker effect" ***(25,*** 26). Further, the proportionate approach tends to "dampen" or underestimate PMR for common causes of death, such as heart disease, in those cases where real excesses exist.

The absence of significant excess mortality from many of the common smoking-related causes of death (emphysema, lung cancer, bladder cancer, and oropharyngeal cancer) in the present study suggests that the observed excess heart disease mortality is not likely to be smoking related. It is also unlikely that the excess heart disease mortality found in our study is a result of geographical differences in heart disease rates since Lloyd found similar elevated PMR for pressmen in several regions of the United States ***(4).*** One hypothesis is that the high level of solvent exposure in this industry acts as a causal agent for heart disease. Several solvents, including methylene chloride and carbon disulfide, both used in the printing industry, have been suggested to cause heart arrhythmias and myocardial hypoxia, as well as coronary artery disease (27, 28).

This study strongly suggests the presence of significant occupationally related mortality in this cohort. These data, taken in conjunction with the existing literature, suggest that exposure to solvents in the past has resulted in an increase in lymphatic system neoplasms, as well as in myeloproliferative disease. Possibly related to solvent exposure as well is the observed increase in heart disease mortality. While the printing industry has gone through rapid technologic change during the recent past, significant exposure to ink mists, solvents, and cutting oils is still a feature of modern pressrooms. In fact, there is new concern over the introduction of glycol ethers into the industry as replacements for benzene and toluene. Cullen et al. (29) suggest that exposure to glycol ethers may give rise to a new set of problems, including bone marrow injury among commercial printers.

We believe these data suggest that prudence should be exercised in the handling of these chemicals and additional engineering controls should be developed to limit pressroom exposures.

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