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Mortality Among Workers in the Metal Polishing and Plating Industry, 1951-1969

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workers in metal refining and metal-using industries are reported to experience high mortality for certain cancers, particularly those of the nasal passages and the lung.¹⁻⁵ The polishing, electroplating, and coating of metals may involve hazardous exposure to metals such as chromium, nickel, copper, iron, lead and zinc; to corrosive acid and caustic alkaline solutions; and to solvents such as trichloroethylene and tetrachloroethylene.⁷⁻⁸ However, the mortality experience of workers in this industry has not been well investigated. As an initial attempt to evaluate the cancer experience of metal polishers and platers (hereafter referred to as metal platers) in the United States, comparisons were made between deaths by cause in this occupational group and in the general population.

Materials and Methods

Deceased metal platers were identified from obituary listings in the *Journal of the Metal Polishers, Buffers, Platers, and Allied Workers International Union*. From these listings name, date of death, union status (working or retired), and the address and number of the union local to which they had belonged were abstracted for 1,709 members who died between 1951 and 1969. These decedents represent union members for whom death benefit claims were paid (i.e., those active or retired and in good standing at the time of death). For these decedents death certificates were requested from the vital statistics departments of 16 states. All states responded, providing a total of 1,445 death certificates (85% of those requested). The proportion of death certificates received was lower for the northeastern states (80%) than for other areas (88%). The underlying cause of death was coded by a trained nosologist according to the 7th Revision of the International Classification of Diseases (ICD).¹⁰ Since 89%

of the decedents were white males, analyses were restricted to this group.

The numbers of deaths by specific cause among the 1,292 white male metal platers were compared with expected numbers based on the cause-specific proportionate mortality (by five-year age and calendar period groups) among white males in the U.S.¹¹ Differences between observed and expected numbers of deaths were summarized in the form of a proportionate mortality ratio (PMR). The statistical significance of the difference between observed and expected numbers was assessed by a chi-square test with one degree of freedom.¹² Proportionate cancer mortality ratios (PCMRs) were also computed using cancer mortality patterns from Illinois (a state contributing many deaths to this study and with high rates for some cancers) and from the total U.S. Expected numbers for PCMRs are computed using the method for the PMRs, except that the total number of cancer deaths instead of the total number of deaths from all causes serves as the denominator.

Results

Table 1 shows the distribution of deaths by age and by calendar year for the 7,292 metal platers. Most decedents were active union members at the time of death and this accounts for the fact that about half (53%) of the deaths occurred before 66 years of age.

The proportionate mortality experience of the 1,292 metal platers in relation to that of the U.S. white male population is shown in Table 2. The proportion of deaths from all malignant neoplasms was only slightly higher than expected, but was significantly increased for esophageal cancer (85%) and primary liver cancer (178%). The excess mortality from these cancers was not limited to any particular geographic region. There were statistically nonsignificant increases for cancers of the buccal cavity and pharynx, rectum, pancreas, and larynx, and for non-Hodgkin's lymphoma and Hodgkin's disease.

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Table 1. — Distribution of Deaths by Age and by Calendar Year for White Male Metal Polishers and Platers, 1951-1969.

| Age at Death | Year of Death | | | Total | |
|--------------|---------------|------------|------------|------------|-------------|
| | 1950-54 | 1955-59 | 1960-64 | | |
| ≤24 | 0 | 5 | 9 | 6 | 20 |
| 25-34 | 1 | 21 | 2 | 9 | 39 |
| 35-44 | 0 | 40 | 24 | 18 | 82 |
| 45-54 | 3 | 97 | 58 | 44 | 202 |
| 55-64 | 4 | 137 | 109 | 95 | 345 |
| 65-74 | 3 | 93 | 113 | 137 | 346 |
| 75-84 | 1 | 51 | 63 | 101 | 216 |
| 85-94 | 0 | 12 | 11 | 19 | 42 |
| Total | 12 | 456 | 395 | 429 | 1292 |

There was a significant deficit of deaths from infective and parasitic diseases. Mortality from lung cancer was not excessive and there were no deaths due to cancer of the nasal cavities (ICD 1601, although only 0.6 would be expected. The mortality from selected causes among metal platers was analyzed for two age groups (Table 3). The proportion of deaths from all cancers, and particularly from cancer of the esophagus, was significantly elevated among those 66 years or older, but not among those under 66 years. Primary liver cancer also appeared

excessive in the older age category, although the number of cases was small. Slight excesses were seen for non-Hodgkin's lymphoma, Hodgkin's disease and cancers of the buccal cavity and pharynx in the younger age group and for cancers of the colon, rectum, pancreas, prostate, and bladder in the older group. Mortality was low for infective and parasitic diseases among the younger metal platers, while a deficit of vascular lesions of the central nervous system was seen in the older group.

Metal polishing or plating was specifically mentioned on 66% of the death certificates as the usual occupation of the deceased and the excess mortality from cancers of the esophagus and the liver was limited to this group (Table 4). The PMRs for non-Hodgkin's lymphoma and for cancers of the buccal cavity and pharynx, rectum, pancreas, larynx, and bladder were moderately elevated among this group, but not among those in which the statement of occupation on the death certificate was unrelated to metal polishing or plating.

PCMRs for esophageal cancer were elevated when the expected number was based either on cancer mortality patterns from Illinois or from the total U.S. population, but they failed to reach statistical significance (Table 5). For primary cancer of the liver (ICD 155), the observed number of deaths was significantly greater than expected

Table 2. — Observed and Expected Numbers of Deaths and Proportionate Mortality Ratios Among White Male Metal Polishers and Platers by Underlying Cause, 1951-1969.

| Cause (ICD, 7th Revision) | Observed Deaths | Expected Deaths | Chi-Square | |
|--|-----------------|-----------------|------------|--------|
| | | | PMR | Values |
| All deaths | 1292 | 1292 | | |
| All infectious & parasitic diseases (001-138) | 9 | 18.9 | 48 | 5.19 |
| All cancer (140-205) | 244 | 223.7 | 109 | 2.24 |
| Buccal cavity and pharynx (140-148) | 11 | 7.6 | 145 | 1.59 |
| Digestive organs & peritoneum (150-159) | 86 | 72.6 | 118 | 2.64 |
| Esophagus (150) | 10 | 5.4 | 185 | 3.96 |
| Stomach (151) | 14 | 16.6 | 84 | 0.43 |
| Colon (152) | 23 | 20.8 | 111 | 0.23 |
| Rectum (154) | 11 | 9.1 | 121 | 0.38 |
| Liver (155.156) | 10 | 6.1 | 164 | 2.52 |
| (Liver, primary [155]) | 5 | 1.8 | 278 | 4.05 |
| Pancreas (157) | 17 | 12.8 | 133 | 1.36 |
| Larynx (161) | 5 | 3.5 | 143 | 0.65 |
| Lung (162.163) | 62 | 58.7 | 106 | 0.20 |
| Prostate (177) | 19 | 17.1 | 111 | 0.21 |
| Kidney (180) | 6 | 5.4 | 111 | 0.08 |
| Bladder (181) | 8 | 7.7 | 104 | 0.01 |
| Brain (193) | 7 | 6.5 | 108 | 0.04 |
| Non-Hodgkin's lymphoma (200) | 8 | 5.8 | 138 | 0.80 |
| Hodgkin's disease (201) | 5 | 3.5 | 143 | 0.64 |
| Leukemia (204) | 5 | 10.0 | 60 | 1.59 |
| Other cancer | 21 | 25.3 | 83 | 0.75 |
| Diabetes mellitus (250) | 26 | 17.9 | 145 | 3.78 |
| Vascular lesions of CNS (330-334) | 91 | 106.6 | 85 | 2.56 |
| Arteriosclerotic heart disease (420-422) | 470 | 472.1 | 100 | 0.02 |
| Pneumonia (490-493) | 23 | 28.7 | 80 | 1.18 |
| Emphysema (518) | 25 | 19.7 | 127 | 1.47 |
| All diseases of digestive system (530-587) | 63 | 59.6 | 106 | 0.20 |
| Cirrhosis of the liver (581) | 20 | 25.6 | 78 | 1.28 |
| Diseases of the genitourinary system (590-637) | 26 | 21.6 | 120 | 0.94 |
| All accidents (800-962) | 88 | 90.6 | 97 | 0.10 |
| Motor vehicle accidents (810-835) | 45 | 44.9 | 100 | 0.00 |
| Suicide (963.970-979) | 32 | 27.5 | 116 | 0.76 |
| All other causes | 195 | 205.2 | 95 | 0.60 |

*PMR = Observed/expected x 100

Table 3. — Observed and Expected Numbers of Deaths and Proportionate Mortality Ratios for White Male Metal Polishers and Platers by Underlying Cause and Age at Death, 1951-1969.

| Cause (ICD) | Age at Death ≤ 65 | | | | Age at Death > 66 | | | |
|--|-------------------|-----------------|-------|-------|-------------------|-----------------|-----|--------|
| | Observed Deaths | Expected Deaths | PMR*† | χ² | Observed Deaths | Expected Deaths | PMR | χ² |
| All deaths | 723 | 723 | | | 569 | 569 | | |
| All infectious & parasitic diseases (001-138) | 6 | 13.4 | 45 | 4.16‡ | 3 | 5.4 | 56 | 1.08 |
| All cancer (140-205) | 133 | 131.2 | 101 | 0.03 | 111 | 92.6 | 120 | 4.41‡ |
| Buccal cavity and pharynx (140-148) | 7 | 4.9 | 143 | 0.90 | 4 | 2.6 | | |
| Digestive organs & peritoneum (150-159) | 39 | 38.9 | 100 | 0.00 | 47 | 33.7 | 139 | 5.58‡ |
| Esophagus (150) | 3 | 3.2 | | | 7 | 2.2 | 318 | 10.86‡ |
| Stomach (151) | 6 | 8.5 | 71 | 0.73 | 2 | 8.2 | 98 | 0.00 |
| Colon (152) | 10 | 10.5 | 95 | 0.03 | 13 | 10.3 | 126 | 0.74 |
| Rectum (154) | 5 | 4.9 | 102 | 0.00 | 6 | 4.2 | 143 | 0.74 |
| Liver (155,156) | 6 | 3.4 | 176 | 2.09 | 4 | 2.7 | | |
| (Liver, primary [155]) | 2 | 1.0 | | | 3 | 0.7 | | |
| Pancreas (157) | 8 | 7.3 | 110 | 0.06 | 9 | 5.5 | 164 | 2.22 |
| Larynx (161) | 2 | 2.2 | | | 3 | 1.3 | | |
| Lung (162,163) | 40 | 38.5 | 104 | 0.06 | 22 | 20.2 | 109 | 0.18 |
| Prostate (177) | 3 | 4.1 | | | 16 | 13.0 | 123 | 0.69 |
| Bladder (181) | 2 | 3.3 | | | 6 | 4.4 | 136 | 0.57 |
| Brain (193) | 6 | 5.6 | 107 | 0.02 | 1 | 0.9 | | |
| Non-Hodgkin's lymphoma (200) | 5 | 4.1 | 122 | 0.22 | 3 | 1.8 | | |
| Hodgkin's disease (201) | 5 | 3.0 | 167 | 1.44 | 0 | 0.6 | | |
| Leukemia (204) | 4 | 6.1 | 66 | 0.71 | 2 | 3.9 | | |
| Other cancer | 20 | 20.5 | 98 | 0.05 | 7 | 10.2 | 69 | 1.36 |
| Diabetes mellitus (260) | 15 | 9.4 | 160 | 3.43 | 11 | 8.5 | 129 | 0.75 |
| Vascular lesions of CNS (330-334) | 43 | 37.4 | 115 | 0.89 | 48 | 69.2 | 69 | 7.48‡ |
| Arteriosclerotic heart disease (420-422) | 246 | 252.8 | 97 | 0.29 | 224 | 219.3 | 102 | 0.16 |
| Pneumonia (490-493) | 9 | 12.5 | 72 | 0.98 | 14 | 16.3 | 86 | 0.33 |
| Emphysema (518) | 10 | 9.3 | 108 | 0.06 | 15 | 10.4 | 144 | 2.06 |
| All diseases of digestive system (530-587) | 41 | 40.7 | 101 | 0.00 | 22 | 19.0 | 116 | 0.51 |
| Cirrhosis of the liver (581) | 15 | 20.9 | 72 | 1.73 | 5 | 4.2 | 106 | 0.02 |
| Diseases of the genitourinary system (590-637) | 10 | 10.5 | 95 | 0.03 | 16 | 11.0 | 145 | 2.29 |
| All accidents (800-962) | 73 | 76.6 | 95 | 0.23 | 15 | 14.0 | 107 | 0.07 |
| Motor vehicle accidents (810-835) | 44 | 40.2 | 109 | 0.44 | 1 | 4.7 | | |
| Suicide (936,970-979) | 29 | 23.7 | 122 | 1.23 | 3 | 3.8 | | |
| All other causes | 108 | 105.5 | 102 | 0.04 | 87 | 99.5 | 87 | 1.75 |

*PMR = Observed/expected x 100

†PMRs and χ²s are not shown when both observed and expected deaths are < 5

‡p ≤ 0.05

Table 4. — Observed and Expected Numbers of Deaths and Proportionate Mortality Ratios Among White Male Metal Polishers and Platers by Selected Underlying Causes, 1951-1969.

| | Occupation Recorded on the Death Certificate | | | |
|--|--|----------|----------|----------|
| | Metal Polisher or Plater | | Other | |
| | Observed | Expected | Observed | Expected |
| | | | | |

Table 5. — Observed and Expected Numbers of Esophageal and Liver Cancer Deaths and Proportionate Cancer Mortality Ratios for White Male Metal Polishers, 1951-1969.

| Cause of Death | Comparison Population (White Male) | | | | | | | |
|-------------------|------------------------------------|-----------------|-------|----------|-----------------|-----------------|------|----------|
| | Total U.S. | | | | Illinois | | | |
| | Observed Deaths | Expected Deaths | PCMR* | χ^2 | Observed Deaths | Expected Deaths | PCMR | χ^2 |
| Esophageal cancer | 10 | 6.0 | 167 | 2.15 | 10 | 7.2 | 139 | 0.72 |
| Liver cancer† | 5 | 1.5 | 333 | 6.19‡ | 10 | 7.6 | 132 | 0.48 |

*PCMR = Observed/expected x 100

†When the comparison population is that of the total U.S., liver cancer refers to the 7th Rev. ICD = 155, but is (155.156) for Illinois

‡p ≤ 0.05

based on the U.S. cancer experience. Unfortunately, expected numbers for primary cancer of the liver based on the Illinois mortality experience could not be calculated.

Discussion

The present study has certain limitations that make it difficult to draw definite conclusions. First, risk estimates obtained from PMR analyses only approximate the results from studies of cause-specific disease rates. Although PMRs are often similar to risk estimates developed when it is possible to study the population-at-risk,¹¹ they may be inflated for certain causes when the overall mortality of the study group is lower than that of the comparison population, as is usually the case with working populations.¹² Second, the specific kinds and amounts of exposures were not available, making it impossible to characterize each subject's work experience. Third, this study included only deaths reported to the union (consisting of actively working or retired union members participating in the insurance program), thereby excluding persons who worked in the industry but later dropped their union membership. Mortality is reportedly higher among workers leaving an industry than among those remaining until retirement, particularly for lung cancer and respiratory disease.¹³ In addition, the failure to obtain death certificates for 15% of the decedents could introduce a further, but unspecified, bias. It seems unlikely, however, that the likelihood of obtaining or of not obtaining a death certificate was influenced by the cause of death. The data do show that the PMRs for cancers of the esophagus and the liver were not correlated with level of death certificate ascertainment (i.e., the PMRs were high in all geographic regions). Fourth, multiple comparisons were made; therefore, some statistically significant differences entirely due to chance would be expected. Finally, individual information on potentially confounding factors, such as tobacco usage or alcohol consumption, was not available. Despite these limitations, this method is a useful first attempt to evaluate the mortality experience of metal platers.

The overall mortality rates in working populations are usually lower than those of the general population because of selective entry into the work force and of the inability of those who are in poor health to continue working. This differential, however, tends to diminish after age 65, particularly among retired workers.¹⁴ The high proportional mortality from cancers of the esophagus and the liver among the older metal platers may, therefore, reflect underlying risks. PCMRs may also be used to obviate the "healthy worker" problem by

removing the causes of death that contribute to this phenomenon (i.e., infectious, respiratory, and circulatory diseases) from the denominator. The elevated PCMRs for cancers of the esophagus and the liver further suggest that the high PMRs for these tumors are not fortuitous findings. The limitation of excess deaths for these two tumors to cases in which the death certificate recorded the usual occupation as metal polisher or plater (i.e., those workers likely to have worked longer in the industry), additionally implies the importance of occupationally related exposures.

The particular exposures that might increase the risk of cancer among metal platers are unclear; however, several potentially hazardous exposures may occur. These workers are likely to experience contact with several metals, including chromium and nickel, both of which are known to cause occupational cancers of the respiratory tract.¹⁵ Mortality from cancers of the nasal cavities and the lung, however, was not unusual. The literature also contains scattered reports of excesses of cancer of the esophagus,¹⁶ as well as of the larynx¹⁷ and the stomach,¹⁸ among occupational groups having contact with these metals. A recent study in the U.K. also suggested an excess of gastrointestinal cancer among chrome platers.¹⁹ The use of strong acid and alkaline solutions in the cleaning of metals prior to plating²⁰ may also be related to the development of esophageal cancer in light of reports of tumor development associated with esophageal strictures resulting from ingestion of lye.²¹

The use of trichloroethylene and tetrachloroethylene to degrease metals²²⁻²⁴ may lead to significant worker exposures. Epidemiologic studies of workers exposed to these chemicals are inconclusive.¹⁹⁻²⁰ However, the high proportionate mortality from liver cancer in this study is interesting in view of the capability of both solvents to induce liver cancer in rodents.²¹⁻²²

The lack of unusual mortality from lung cancer or cirrhosis of the liver among metal platers suggests that the excesses for esophageal and liver cancers are not attributable to smoking habits or alcohol consumption, two known risk factors for these tumors.²³⁻²⁴ The reason for the low mortality from infective and parasitic disease and from vascular lesions of the central nervous system, although unclear, may reflect the movement of individuals from the work force to the general population because of illness.

The present study was intended as an exploratory investigation of the mortality patterns of an occupational group (metal polishers and platers) with exposure to potentially hazardous solvents and metals. Despite the

study limitations, the excess mortality from cancers of the esophagus and the liver suggests the involvement of occupational exposures that require further investigation.

Summary

The numbers of deaths by cause among 1,292 white male metal polishers and platers identified from obituary listings in the *Journal of the Metal Polishers, Buffers, Platers, and Allied Workers International Union* were compared to an expected distribution based on the white male population of Illinois and the U.S. The proportions of deaths due to cancers of the esophagus and the liver were high, particularly among those over 65 and those listed as metal polishers or platers on the death certificate. The PCMRs for these two tumors were also moderately elevated. Despite methodologic limitations, these findings, along with the known use in this industry of chromium and nickel, strong acid and alkaline solutions, and the solvents trichloroethylene and tetrachloroethylene, suggest that metal polishers and platers may be subject to exposures capable of inducing cancer.

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In times of stress, management must be there. The presence of authority figures who are available both to answer questions and to lead is essential. Great assurance and reassurance can be drawn from the simple presence of those in command. Dependency needs in times of stress are heightened and a demonstration that one's superior cares and recognizes the impact of stress on the employee under his or her supervision will reap incalculable rewards.

— From *Work Stress* by Alan A. McLean Addison-Wesley Publishing Company, Reading, Massachusetts, 1979