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Malignant Melanoma in the Printing Industry

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In an occupational mortality surveillance study, cause-specific mortality patterns by occupation and industry, among Rhode Island residents who died during the period 1968–78, were examined using the age-standardized proportionate mortality ratio (PMR) method. A noteworthy finding was an elevated PMR for malignant melanoma among white males in the printing industry (PMR = 460, observed deaths = 6, $p < .01$). When the results of other epidemiologic studies are reviewed in aggregate, they are consistent with this finding. A wide variety of chemicals, some of which are known or suspected human or animal carcinogens, are used in the printing industry. There is also potential exposure to ultraviolet radiation. The hypothesis of a relationship between malignant melanoma and occupational exposures in the printing industry should be investigated further.

Key words: malignant melanoma, printing industry, printers, occupational mortality surveillance, proportionate mortality ratio, death certificates, surveillance, occupational cancer

INTRODUCTION

Researchers from the National Institute for Occupational Safety and Health (NIOSH) have been engaged in cooperative activities with selected states to develop their occupational disease surveillance capabilities (Surveillance Cooperative Agreement between NIOSH and States [SCANS] program). As part of the SCANS program, the Rhode Island Department of Health (RIDH) has been coding the usual occupation and industry entries on death certificates of all adult Rhode Island residents. To generate leads for more definitive investigations, cause-specific mortality patterns by occupation and industry have been examined for the years 1968–78, using the proportionate mortality ratio (PMR) method. One such lead, described in this report, was an excess of malignant melanoma among white males in the printing industry.

Previous analyses of these data, which examined a limited number of occupation, industry, and cause of death categories, have been published [Gute, 1981; Kelley and Gute, 1986].

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METHODS

A computer tape of all 1968–78 Rhode Island death certificate records, including occupation and industry codes, was provided to NIOSH by the RIDH through the SCANS program. For the present study, death certificate records were selected from this computer tape for all Rhode Island residents 16 years of age or greater who died during the period 1968–78, with the exception of residents who died out of state in 1968. (These certificates, which accounted for five percent of the deaths in 1968, could not be found at the time that the occupation and industry coding was done.)

The RIDH mortality computer file includes information on the decedent's sex, race, age at death, underlying cause of death, usual occupation ("kind of work done during most of working life, even if retired"), and usual industry ("kind of business or industry"). For the period 1968–78, underlying cause of death was coded by state nosologists according to the Eighth Revision, International Classification of Diseases, Adapted for Use in the United States [U.S. Department of Health, Education, and Welfare, 1967]. Usual occupation and industry were coded by state coders according to the 1970 U.S. Bureau of the Census occupational and industrial classification system [U.S. Bureau of the Census, 1971], with minor additions. Occupation and industry coding procedures have been described [Gute, 1981; Kelley and Gute, 1986; Dubrow and Gute, Cause-specific mortality among Rhode Island jewelry workers (manuscript in preparation)].

Age-standardized PMRs were calculated by sex and race for an array of specific causes of death within specific occupations and industries. The standard proportions were derived from the total Rhode Island mortality experience for the combined years 1968–78. Age stratification was done by five-year age groups. Only whites and blacks were included in the PMR analysis. Meaningful analysis could not be performed on the small number of decedents of other and unknown races.

Significance testing (two tailed, $p < .05$ and $p < .01$) was done using the chi-square test, applying the Mantel-Haenszel procedure [Mantel and Haenszel, 1959] for results in which there were at least five expected deaths. For results in which there were fewer than five expected deaths, 95% and 99% significance factors for the ratio of an observed value of a Poisson variable to its expectation were applied to test for statistical significance [Bailar and Ederer, 1964]. PMRs are presented to two significant figures.

RESULTS

One of the notable findings which emerged from reviewing the results of this analysis for possible leads was an excess of malignant melanoma among white males within the printing industry. Of a total of 577 white male decedents whose usual industry was printing, six died from malignant melanoma. Only 1.3 deaths were expected (PMR = 460, $p < .01$).

Occupations that are directly involved in the printing process are much more likely to have printing-related hazardous exposures than are occupations that are not directly involved (editors and reporters, managers, clerical workers, sales workers, truck drivers, etc). PMRs were calculated for the grouped category of all occupations in the printing trades (compositors and typesetters, electrotypers and stereotypers, photoengravers and lithographers, and printing pressmen and plate printers). There

were 290 white males with a usual occupation in the printing trades (48 of these worked in industries other than printing). Four deaths were from malignant melanoma, with 0.70 expected (PMR = 570, $p < .05$). The usual industry of all four of these decedents was printing.

Examination of death certificates of the printing industry decedents who died from malignant melanoma revealed that three of the four decedents who worked in the printing trades either were lithographers or worked at companies where lithography was performed.

There were no malignant melanoma deaths in the printing industry or printing trades among blacks, other and unknown races, or women. Only nine non-white male decedents had a usual industry of printing, and only two worked in printing trade occupations. There were 154 women (all white) in the printing industry but only 14 in the printing trades.

DISCUSSION

Although based on small numbers, these results are consistent with a malignant melanoma risk in the printing industry. The magnitude of the PMR was large, and the risk was concentrated in the printing trades, as would be expected if the excess malignant melanoma were due to printing-specific occupational exposures.

Other Epidemiological Studies of Printing Workers

Because of the multiple comparisons made in this study, many of the observed associations could be due to chance. However, the credibility of an association is strengthened if it is supported by other epidemiological studies and if it is biologically plausible. Table I presents the results of all other studies in which, to the author's knowledge, observed and expected values for malignant melanoma in the printing industry or in printing trades have been reported or can be calculated from the data presented. While the results of each individual study taken separately are not particularly noteworthy because of the small numbers, taken together these results provide substantial support for the hypothesis of a malignant melanoma risk in the printing industry.

In eight of these nine studies, the observed-to-expected ratio (x100) for malignant melanoma was reported to be greater than 100. (The one exception was a small study [Bertazzi and Zocchetti, 1980] in which only 0.10 deaths from malignant melanoma were expected.) Summing the observed and expected values, respectively, across the nine studies produced an aggregate observed-to-expected ratio of 198 ($p < .01$ [Bailar and Ederer, 1964]), with a total of 23 observed cases.

In a study of male newspaper plant workers not listed in Table I, 3 of 204 deaths were reported to be from malignant neoplasms of the skin, with no indication as to how many of these were malignant melanomas [Pasternack and Ehrlich, 1972]. An expected number was not presented. Using data presented in the paper on number of deaths by year and age group in conjunction with year-, sex-, age-, cause-specific mortality tables from the National Center for Health Statistics [Public Health Service, 1960–1974], the expected number of deaths for skin neoplasms based on the age-standardized PMR method can be calculated to be 0.64 (PMR = 470).

The last two decennial occupational mortality studies of England and Wales [Registrar General, 1971, 1978] reported results for malignant melanoma in the

TABLE I. Reports of Malignant Melanoma in the Printing Industry[a]

Study	Study period	Mortality or incidence index[b]	Observed	Expected	(Observed/expected) × 100
Utah[c] [Dubrow and Burnett, 1985]	1959–78	PMR	3	1.30	231
Massachusetts[d] [Dubrow and Wegman, 1984]	1971–73	MOR	3	1.65	182
Washington State[d] [Milham, 1983]	1950–79	PMR	4	2.67	150
California[d] [Petersen and Milham, 1980]	1959–61	PMR	2	1.85	108
Roswell Park[d] [Decouflé et al, 1977]	1956–65	IOR	2	0.13	1,502*
Third National Cancer Survey[c] [Williams et al, 1977]	1969–71	IOR	2	0.67	300
U.S. Government Printing Office employees [Greene et al, 1979]	1948–77	PCMR	5	2.81	178
London newspaper workers [Greenberg, 1972]	1954–66	PMR[e]	2	0.39	517
Milan newspaper workers [Bertazzi and Zocchetti, 1980]	1956–75	PMR[f]	0	0.14	0
Total			23	11.61	198**

[a]All of these studies were of males.

[b]PMR, proportionate mortality ratio; MOR, mortality odds ratio; PCMR, proportionate cancer mortality ratio; IOR, incidence odds ratio.

[c]Printing industry.

[d]Printing trades.

[e]In this study, 2 of 670 deaths were reported to be from malignant melanoma. However, a PMR for malignant melanoma was not presented. The expected number of deaths and PMR were calculated for this table using data presented in the paper on the number of deaths by year and age group in conjunction with year-, sex-, age-, cause-specific mortality tables for England and Wales [World Health Organization, 1957–1964, 1965–1968, 1970; Registrar General, 1967].

[f]In this study, the expected number of malignant melanoma deaths was not reported. It was calculated for this table using data presented in the paper on the number of deaths by age group in conjunction with year-, sex-, age-, cause-specific mortality tables for Italy [World Health Organization, 1959–1964, 1965–1978, 1970; tabulations from the Italian Central Isntitute of Statistics, provided by Dr. Pietro Comba and Dr. Rosella Senior Costantini].

*$p < .05$, significance test according to Bailar and Ederer [1964].

**$p < .01$, significance test according to Bailar and Ederer [1964].

occupational order "paper and printing workers." Approximately 80% of the deaths in this category in each of these studies were among printing workers. In the 1959–63 study, the PMR for malignant melanoma in male paper and printing workers, ages 25–75, was 208 (14 observed deaths, $p < .01$) [Adelstein, 1972]. The SMR for ages 15–64 was 143 (10 observed deaths), and the PMR for ages 65–74 was 260 (4 observed deaths) [Registrar General, 1971]. In the 1970–72 study, the SMR for ages 15–64 was 77 (five observed deaths), and there were no malignant melanoma deaths among paper and printing workers, ages 65–74 [Registrar General, 1978].

The occupational order "paper and printing workers" has also been examined through the national cancer registration system in England and Wales [Registrar General, 1975]. In 1966–67, the age-standardized proportional registration ratio for malignant melanoma in male paper and printing workers, ages 15–74 was 170 (eight cases); in 1968–70, it was 121 (nine cases).

The results from these British studies must be interpreted cautiously, as there is no information as to how the malignant melanoma cases were distributed between paper workers and printing workers.

Finally, in eight additional mortality studies of the printing industry [Guralnick, 1963; Dunn and Weir, 1968; Goldstein et al, 1970; Moss et al, 1972; Lloyd et al, 1977; Paganini-Hill et al, 1980; Nicholson et al, 1981; Walrath et al, 1985] results were not reported for malignant melanoma (or for all malignant neoplasms of the skin).

The issue of reporting bias should be considered. The first six studies listed in Table I were surveillance studies that reported results for full matrices of occupation/industry-disease category combinations. There was no selective reporting—if a disease category was included in the analysis, the results for that category were reported for all occupations/industries. Thus, there could not have been a bias in favor of reporting positive results in these studies. With the exception of the present investigation, these six studies are the only surveillance studies that, to the author's knowledge, have examined malignant melanoma in the printing industry. The combined results of these studies are as follows: observed deaths, 16; expected deaths, 8.27; mortality/morbidity ratio = 193, $p < .05$ [Bailar and Ederer, 1964].

Of the eight mortality studies that did not report results for malignant melanoma (or for all malignant neoplasms of the skin), three clearly did not use malignant melanoma as an analysis category [Guralnick, 1963; Dunn and Weir, 1968; Walrath et al, 1985] and two were focused on respiratory diseases [Goldstein et al, 1970; Moss et al, 1972], so the reporting of results for malignant melanoma would not have been expected. That leaves three studies for which it is unclear whether results for malignant melanoma (or for all malignant neoplasms of the skin) were not reported because they were negative or because malignant melanoma was not an analysis category [Lloyd et al, 1977; Paganini-Hill et al, 1980; Nicholson et al, 1981].

Biological Plausibility

Ultraviolet light from the sun is thought to be the most important factor in the etiology of malignant melanoma [Elwood and Hislop, 1982]. However, nonsolar factors also appear to be involved [Hinds, 1982]. In a limited number of instances, malignant melanomas have been reported to be induced by chemical carcinogens in laboratory animals, most often by dimethylbenzanthracene [Kopf et al, 1984].

Solvents and inks are the major chemical exposures in the printing industry, the skin being a major route of exposure. About 2,800 chemicals are reported to be used in various ink formulations [National Institute for Occupational Safety and Health, 1979], including organic and inorganic pigments, dyes, oils, resins, solvents, and plasticizers. Some of the chemicals which have been used or are presently being used in the printing industry are known or suspected human or animal carcinogens [Kay, 1976; National Institute for Occupational Safety and Health, 1979]. There is suggestive evidence of a relationship between human exposure to carbon black, which is the most commonly used pigment in the printing industry, and malignant melanoma [International Agency for Research on Cancer, 1984].

There is also potential exposure in the printing industry to ultraviolet radiation through its use in printing processes such as photoengraving, lithographic plate making, and the curing of ink. In the present study, there was a suggestion of an association between malignant melanoma and work in lithography, the most commonly used printing process.

CONCLUSION

The hypothesis of a relationship between malignant melanoma and work in the printing industry will be followed up with a death certificate-based case–control study in a geographical area with a relatively heavy concentration of the printing industry. In addition, where feasible, it would be useful for investigators to report results for malignant melanoma from the mortality studies of the printing industry in which results were not originally reported. If the hypothesis is validated, more detailed analytical studies would be indicated.

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