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Cancer and Other Causes of Death among Embalmers

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ABSTRACT

To evaluate the potential carcinogenic effects of formaldehyde, we examined the proportionate mortality experience of embalmers licensed to practice in California. Mortality was significantly elevated for total cancer, arteriosclerotic heart disease, and suicide, whereas significant deficits were noted in mortality from diseases of the respiratory and genitourinary systems. Deaths from cancers of the brain, colon, and prostate and leukemia were significantly higher than expected. No increased mortality was seen for cancers of the respiratory tract, including the nasal passages, where an effect might be expected based on animal studies. A parallel mortality survey of embalmers from New York State showed similar findings, with excesses of brain tumors, leukemia, colon cancer, arteriosclerotic heart disease, and cirrhosis. Further investigation is needed to determine whether any of these outcomes is related to formaldehyde exposure.

INTRODUCTION

In inhalation studies, rats exposed to formaldehyde at 14.2 and 5.6 ppm developed squamous cell carcinomas of the nasal cavity (2, 9). These findings have raised concern about the long-term health effects of formaldehyde exposure in industry and home settings. Formaldehyde is widely used in the manufacture of resins, laminates, particleboard, plywood, and textile products and as a preserver of biological tissues.

Embalming fluids contain formaldehyde, an alcohol, and various other ingredients depending on the desired preservative and cosmetic results and the condition of the cadaver (3). In an industrial hygiene survey of a mortuary science college conducted by the National Institute for Occupational Safety and Health, the airborne formaldehyde concentrations ranged between 0.2 and 0.9 ppm and exceeded 3.0 ppm in 2 samples when the ventilation system was inoperative (15). A survey of 6 funeral homes revealed airborne formaldehyde levels ranging from 0.1 to 5.3 ppm, with average concentrations of 0.25 to 1.4 ppm (8). Paraformaldehyde particles with formaldehyde vapors were reported to be small enough to be deposited in the lungs.

This proportionate mortality study compares the causes of death among embalmers in California with those of the general population. The mortality experience of this group is then compared with that of an earlier survey of embalmers from New York State (16), in a search for consistent patterns that might be related to formaldehyde exposure.

MATERIALS AND METHODS

Although numerous state licensing bureaus were contacted in an attempt to identify a cohort of embalmers, no agency retained the information necessary to establish a retrospective cohort of embalmers. New York and California, however, had records on a sufficient number of deceased embalmers to examine their mortality patterns using the proportionate mortality approach. The results of the New York investigation have been published elsewhere (16).

The study group consisted of embalmers who were first licensed to practice in California from 1916 through 1978 and who were known to have died between 1925 and 1980. Names and demographic information were obtained from licensure records of the Bureau of Funeral Directing and Embalming in Sacramento, CA. Death certificates were received for 1109 embalmers from the appropriate state vital statistics offices. Underlying cause of death was coded by a qualified nosologist to the Eighth Revision of the International Classification of Diseases, Adapted, according to the rules in effect at time of death (18). Expected numbers of deaths were computed based on the age-, race-, and calendar year-specific proportions of deaths for each cause among the United States male population using a software package (14). Differences between observed and expected numbers of deaths for each cause-of-death category were expressed by the PMR,[2] the ratio of the number of deaths observed to that expected multiplied by 100. PCMRs were also calculated using the total number of cancer deaths as the denominator for computing the expected number of deaths for each cancer site. The statistical significance of each PMR and PCMR was tested by a χ^2 test with 1 d.f. (12).

RESULTS

The sex and race distribution of the 1109 decedents is shown in Table 1. All subsequent analyses refer to the 1007 white male embalmers. Their birth years ranged from 1847 through 1959, and the median age at death was 62. This relatively young age distribution reflects the fact that most deaths were ascertained among embalmers with active licenses.

Table 2 shows the mortality experience of embalmers according to major causes of death. Total cancer mortality was significantly elevated (PMR = 121). There was also a significant excess of deaths from ischemic heart disease (PMR = 119) and a nonsignificant excess of cirrhosis of the liver (PMR = 139). In contrast, there was a significantly low frequency of emphysema (PMR = 38) and nonsignificant deficits of pneumonia (PMR = 64) and gastric and duodenal ulcers (PMR = 81). Although overall mortality from external causes was not unusual, the ratio for suicides was significantly increased (PMR = 177).

The distribution of malignant neoplasms among white male embalmers is presented in Table 3. Mortality from cancers of the buccal cavity and pharynx was slightly elevated (PMR = 131), involving the tongue (3 cases) and other parts of the mouth (4 cases) and throat (1 case). The number of deaths from digestive tract cancers was close to that expected, but a significant excess of colon cancer was observed (PMR = 187). Respiratory cancer mortality was not unusual, and no deaths were attributed to nasal cancer (although the expected value was only 0.6). Mortality was significantly elevated for prostate cancer (PMR = 175),

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[2] The abbreviations used are: PMR, proportionate mortality ratio; PCMR, proportionate cancer mortality ratio.

eukemia (PMR = 175), and cancer of the brain and central nervous system (PMR = 194). The cell types of leukemia reported on the death certificates were: 0 lymphatic *versus* 2.2 expected; 6 myeloid (4 acute and 2 unspecified) *versus* 4.0 expected; 2 monocytic (acute) *versus* 0.3 expected; and 4 other leukemia (2 acute and 2 not otherwise specified) *versus* 1.4 expected. (Expected numbers of leukemia deaths by cell type were calculated using United States mortality rates for white males during the years 1970–1975.) The reported types of brain cancer were: 2 glioblastoma multiforme; 3 astrocytoma; 1 adenocarcinoma; and 3 not otherwise specified. Examination of the PCMRs resembled the pattern seen for the PMRs, with excess frequencies of cancers of the colon, prostate, and brain and leukemia.

Table 1

Distribution of deceased California embalmers by sex and race

Sex	Race		
	White	Nonwhite	All races
Male	1007	39	1046
Female	58	5	63
Both sexes	1065	44	1109

Table 2

Number of deaths and PMRs among white male embalmers, by cause of death

Cause of death (18)	No. of deaths		
	Observed	Expected	PMR
All malignant neoplasms (140–209)	205	169.6	121[a]
Circulatory system (390–458)	523	504.3	104
Ischemic heart disease (410–414)	355	297.9	119[a]
Cerebrovascular disease (430–438)	73	77.7	94
Respiratory system (460–519)	39	57.1	68[a]
Pneumonia (480–486)	18	28.1	64
Emphysema (492)	4	10.5	38[a]
Digestive system (520–577)	55	49.4	111
Gastric and duodenal ulcers (531–532)	7	8.7	81
Cirrhosis of liver (571)	29	20.8	139
External causes (800–999)	122	112.4	109
Accidents (800–949)	75	77.8	96
Suicide (950–959)	44	24.8	177[a]
Other causes	63	114.2	32[a]
All causes of death	1007	1007.0	100

[a] $p < 0.05$.

Table 3

Number of deaths from malignant neoplasms with PMRs and PCMRs

Cause of Death (18)	No. of deaths			
	Observed	Expected	PMR	PCMR[a]
All malignant neoplasms (140–209)	205	169.6	121[b]	100
Buccal cavity and pharynx (140–149)	8	6.1	131	99
Digestive organs and peritoneum (150–159)	69	57.0	121	89
Esophagus (150)	3	4.1		56
Stomach (151)	12	15.1	79	54
Colon (153)	30	16.0	187[b]	144
Rectum (154)	7	6.9	102	73
Liver and gallbladder (155–156)	4	4.7		70
Pancreas (157)	12	8.9	135	104
Respiratory system (160–163)	43	46.0	94	83
Nasal passages (160.0)	0	.6		
Larynx (161)	2	2.6		
Lung and pleura (162–163)	41	42.9	96	87
Skin (172–173)	2	3.4		
Prostate (185)	23	13.1	175[b]	126
Bladder (188)	8	5.8	138	103
Kidney (189)	4	4.0		
Brain and central nervous system (191–192)	9	4.7	194[b]	168
Lymphatic and hematopoietic system (200–209)	19	15.6	122	
Lymphosarcoma and reticulosarcoma (200)	3	3.1		
Hodgkin's disease (201)	0	2.5		
Other lymphatic neoplasms (202, 203, 208, 209)	4	3.0		
Leukemia (204–207)	12	6.9	175[b]	140
Other cancers	21	15.3	137	

[a] PCMRs could not be calculated for some sites due to limitations in the computer program used.
[b] $p < 0.05$.

Table 4

Number of deaths and PMRs for selected malignant neoplasms among white male embalmers, by length of licensure

Cancer site (18)	Length of licensure			
	<20 years (n = 501)		20+ years (n = 506)	
	Observed	PMR	Observed	PMR
All malignant neoplasms (140–209)	103	136[a]	102	108
Buccal cavity and pharynx (140–149)	5	166	3	(97)[b]
Stomach (151)	9	104	3	47
Colon (153)	13	186[a]	17	188[a]
Pancreas (157)	7	198	5	93
Lung (162–163)	17	106	24	89
Prostate (185)	8	165	15	181[a]
Brain and central nervous system (191–192)	5	198	4	(189)
Leukemia (204–207)	4	(124)	8	221[a]

[a] $p < 0.05$.
[b] Numbers in parentheses, both observed and expected numbers of deaths are <5.

Since detailed job histories were not available for embalmers in the study group, length of licensure was used to approximate length of employment. Table 4 shows the PMRs for selected cancer sites by length of licensure. Although the numbers of deaths were small, mortality from prostate cancer and leukemia was significantly increased among embalmers licensed for 20 or more years, while colon and brain cancer mortality was high in both length-of-licensure categories.

DISCUSSION

The proportionate mortality experience of California embalmers revealed statistically significant excesses of total cancer, ischemic heart disease, and suicide and significant deficits of respiratory and genitourinary diseases. There were significant elevations for cancers of the colon, prostate, and brain and leukemia. When duration of employment was estimated by length of licensure (<20 years and 20+ years), the excesses of prostate cancer and leukemia were significant only in the latter category, while increases of colon and brain cancers appeared in both categories. There were no deaths from nasal cancer, and the pattern of lung cancer mortality was unremarkable. These findings are noteworthy in view of experimental evidence that rats exposed to formaldehyde vapors developed squamous cell carcinomas of the nasal cavity (2, 9).

In a survey of the mortality patterns of 1132 white male embalmers in New York State, we found significantly high frequencies of deaths from cancers of the skin and colon and from arteriosclerotic heart disease, whereas significantly fewer deaths were seen for respiratory diseases and accidents (16). PMRs were significantly elevated for cancers of the skin, kidney, and brain among those who were licensed only as embalmers, while mortality patterns were unremarkable among those licensed also

as funeral directors and presumably less exposed to formaldehyde.

In Table 5, the distribution of major causes of death among California embalmers is compared to that seen in our earlier survey of embalmers in New York State (16). Relative frequencies of total cancer, ischemic heart disease, respiratory diseases, and cirrhosis of the liver were remarkably similar in the 2 study groups. Suicide, however, was significantly elevated only among California embalmers. As shown in Table 6, both groups experienced an increase of deaths from leukemia and cancers of the brain and colon, suggesting the need to evaluate these particular neoplasms in future studies of formaldehyde-exposed populations. However, the excesses of skin and kidney cancers reported among New York embalmers were not found in the California survey, and the increase of prostate cancer among California embalmers was not seen in New York.

Epidemiological studies of other formaldehyde-exposed groups have yielded inconsistent results. No cancers occurred excessively in a cohort study of 1477 undertakers from Ontario (10), but a significant excess of liver cirrhosis was reported in this group. This is consistent with the increased frequency of cirrhosis observed among both New York and California embalmers (statistically significant in the latter group); however, no information was available in any of these studies to evaluate the possible influence of alcohol consumption. A cohort mortality study of British pathologists and medical laboratory technicians indicated an excess of lymphatic and hematopoietic neoplasms among the pathologists, but not among the technicians (5). At the Danish Cancer Registry, no association was found between cancers of the nasal passages or lung and employment in medical specialties such as anatomy and pathology that involve exposures to formaldehyde (6, 7).

The elevated mortality from brain cancer among California and New York embalmers is consistent with results of a recent cohort study of anatomists.[3] Among 2239 men who were members of the American Association of Anatomists for at least 1 year during 1888–1969, the standardized mortality ratio for brain cancer was 271 based on 10 deaths. When psychiatrists, a group of comparable socioeconomic status and presumably similar health care, were used as a referent group, the standardized mortality ratio climbed to 474. A significant excess of chronic myeloid leukemia was also reported, with 3 cases observed *versus* 0.34 expected.

While suggestive findings have been reported for professional groups using formaldehyde (*e.g.*, embalmers, pathologists, anatomists), the results of mortality surveys among industrial workers have been less remarkable. A cohort study of 2026 workers from Texas employed in formaldehyde manufacture revealed some excess deaths, based on small numbers, from cancers of the prostate and brain and lymphomas (17). Mortality from prostate cancer was significantly high among those employed for 20 years or more, a pattern seen also in the present study of California embalmers. However, a recent cohort study of 7680 chemical workers from Great Britain revealed no unusual risks except for an excess of lung cancer in the largest of 6 plants in the study (1). Finally, a PMR study of 136 formaldehyde production workers in a Massachusetts plant showed no remarkable patterns compared to the general population or unexposed workers (13), but a survey of more recent deaths from the same plant suggested an excess of cancers of the colon and oral cavity (11).

Our surveys of embalmers in New York and California should be interpreted cautiously due to inherent weaknesses of the PMR methodology (4). In addition, information was not available on levels of specific exposures or length of employment, ascertainment of deaths among retirees was incomplete, and the sample sizes were insufficient to detect rare conditions such as nasal cancer. Furthermore, the embalmers were exposed to embalming fluids containing not only formaldehyde but also coloring and modifying agents, anticoagulants, surfactants, deodorants, and vehicles (3). Despite these limitations, our findings and those of other occupational surveys call for more thorough investigation to quantify the risks of cancer and other chronic diseases in relation to formaldehyde exposure. Nested case-control studies are planned among embalmers and certain other professional groups to evaluate the role of work-related exposures in the development of selected cancers. Although the bioassay studies have pointed to the respiratory tract as the potential target site for formaldehyde carcinogenicity in humans, the available epidemiological evidence suggests that attention be given also to possible cancer risks at other sites, including the brain, bone marrow, and colon.

Table 5

Number of deaths and PMRs for major causes of death among white male embalmers, by state of licensure

Cause of death (18)	State of licensure: California (n = 1007) Observed	PMR	New York (n = 1132) Observed	PMR
All malignant neoplasms (140–209)	205	121[a]	243	111
Ischemic heart disease (410–414)	355	119[a]	481	112[a]
Respiratory system (460–519)	39	68[a]	52	77[a]
Cirrhosis of liver (571)	29	139	34	133
Accidents (800–949)	75	96	28	49[a]
Suicide (950–959)	44	177[a]	21	99
All causes of death	1007	100	1132	100

[a] $p < 0.05$.

Table 6

Number of deaths and PMRs for selected malignant neoplasms among white male embalmers, by state of licensure

Cause of death (18)	State of licensure: California (n = 1007) Observed	PMR	New York (n = 1132) Observed	PMR
All malignant neoplasms (140–209)	205	121[a]	243	111
Buccal cavity and pharynx (140–149)	8	131	8	113
Stomach (151)	12	79	12	90
Colon (153)	30	187[a]	29	143[a]
Pancreas (157)	12	135	13	105
Lung (162–163)	41	96	72	108
Skin (172–173)	2	(59)[b]	8	221[a]
Prostate (185)	23	175[a]	15	91
Kidney (189)	4	(100)	8	150
Brain and central nervous system (191–192)	9	194[a]	9	156
Leukemia (204–207)	12	175[a]	12	140

[a] $p < 0.05$.

[b] Numbers in parentheses, both observed and expected numbers of deaths are <5.

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