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Proportionate Mortality Study of Golf Course Superintendents

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A proportionate mortality study of a cohort of golf course superintendents was conducted using death certificates for 686 deceased members of the Golf Course Superintendents Association of America who died from 1970 to 1992. White males were included in the study population from all 50 states. The study objective was to compare mortality from this cohort to the general U.S. white male population. The proportionate mortality ratio (PMR) for all types of cancer was 136 (CI: 121, 152). Significant excess mortality from smoking-related diseases was observed. The PMR for arteriosclerotic heart disease was 140, which was significantly elevated (CI: 127, 155). In addition, the PMR for all respiratory diseases was 176 (CI: 135, 230), while the PMR for emphysema was 186 (CI: 101, 342). The PMR for lung cancer was 117 (CI: 93, 148). Mortality for four cancer types—brain, lymphoma (non-Hodgkin's lymphoma, NHL), prostate, and large intestine—occurred at elevated levels within this cohort: brain cancer PMR = 234 (CI: 121, 454), non-Hodgkin's lymphoma (NHL) PMR = 237 (CI: 137, 410), prostate cancer PMR = 293 (CI: 187, 460), and large intestine cancer PMR = 175 (CI: 125, 245). The PMR for diseases of the nervous system was 202 (CI: 123, 333). A similar pattern of elevated NHL, brain, and prostate cancer mortality along with excess deaths from diseases of the nervous system has been noted among other occupational cohorts exposed to pesticides.

***KEY WORDS:* lymphoma, brain cancer, prostate cancer, smoking-related diseases, golf course workers, mortality, pesticides**

INTRODUCTION

Epidemiological information about the occupational health risks for golf course superintendents is not available in the literature. Moreover, only a few studies have been done to determine the occupational exposures and health risks for golf course workers and other turfgrass managers [Daniel et al., 1984; Harris and Solomon, 1992; Yeary and Leonard, 1993; Solomon et al., 1993]. Hence, the Golf Course Superintendents Association of America (GCSAA) contracted with the University of Iowa's Institute of Agricultural Medicine and Occupational Health to conduct a proportionate mortality study for its membership. The study objective was to compare mortality from this cohort to the general U.S. white male population. Results of the study were intended to help guide GCSAA with regard to future research initiatives and the development of health and safety programs for superintendents and their workers.

Golf course superintendents encountered a wide variety of occupational hazards, including mental and ergonomic stress; sunlight; machinery-related noise, vibration, and trauma incidents; and chemical exposures to pesticides, fertilizers, organic and inorganic dusts, fuels, diesel exhaust, and solvents. According to personal communication with GCSAA, most superintendents applied pesticides at some times during their careers, especially early in their careers and those working for smaller budget golf courses. Because the pattern of cancers and some other diseases observed for

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golf course superintendents in this study was similar to other studies of occupations exposed to pesticides, additional information about the use of pesticides on golf courses is provided.

The total amount of pesticides applied to golf courses on a national level was estimated as 12.3 million pounds in 1982, compared with agricultural use of 550 million pounds [Balogh and Walker, 1992]. Although the total amount of pesticides used on golf courses was relatively small, Iowa data in 1990 indicated that statewide average application rates and frequency of use were comparable for turf management and row crop agriculture. Turf management use at golf courses was 0.36 pounds/acre for insecticides, 3.31 pounds/acre for herbicides, and 2.21 pounds/acre for fungicides [Iowa State University, 1993]. Agricultural use on corn was 1.07 pounds/acre for insecticides and 3.24 pounds/acre for herbicides [Iowa State University, 1991]. Pesticide applications at golf courses in Iowa ranged from zero to 24 times per year, which was generally more frequent use of pesticides than for farming.

On a national basis, golf courses utilized more fungicide products and applied them more frequently than other pesticides. On a regional basis, the mid-continent, western, and Florida regions reported almost no fungicide usage on turf areas, other than greens. In contrast to fungicides, superintendents reported the application of herbicide products to all golf course surfaces, but most frequently to fairways. Insecticide usage was reported nationwide on greens and tees, while in the Florida region, insecticides were used frequently on all golf course surfaces [GCSAA, 1991].

Two observations can be made about golf course pesticide usage. First, large variations exist in regional pesticide use. Secondly, because of the application frequency and diversity of pesticide use on golf courses, the potential for occupational exposure among personnel applying those pesticides may be comparable or exceed the exposures encountered by farmers.

METHODS

The GCSAA provided records for 750 deceased members who died between 1970 and 1992, including obituaries, insurance records, and membership data. Life insurance benefits were provided to GCSAA members and membership dues were minimal for retired superintendents, so records encompassing all deaths within the cohort during this period were considered good. Ten members were excluded from the study population because they were female or non-white. Complete death records were not obtained for these excluded individuals.

The study population comprised active and retired members of the association. This occupational cohort was characterized by individuals who, presumably, all shared a common work history and similar work practices. Individuals' work histories while in the GCSAA, previous employment records, and actual job descriptions were not available for this study.

Death certificates were obtained for 686 white males (representing 93% of the study population) from all 50 states. Using these death certificates, date of birth and death, age at time of death, and underlying cause of death for each individual were determined. A nosologist working for the Iowa Department of Public Health recorded the cause of death based on standardized ICD-9 codes. Although the ICD-8 coding system was in place until 1978, revisions in the new system were minor, generally refining only the fourth digit of the code. The coding system change did not have an effect on this study.

Proportionate mortality ratios (PMR) were calculated for major types of cancer using statistical methods [Breslow and Day, 1987]. The comparison population used for this study consisted of deceased white males from the U.S. general population, 1970–1988 [U.S. Dept. Health and Human Services, 1991]. To adjust for age differences between our cohort and the general population, estimates of expected deaths were calculated on an age-specific basis and then summed. Confidence intervals were calculated for all PMRs using the method of Jensen et al. [1991].

RESULTS

The total number of deaths, PMR, and 95% confidence intervals are presented for specific types of cancer in Table I. Similar data for other selected causes of death are given in Table II.

The PMR for all types of cancer was 136 (confidence interval, CI: 121, 152). Lung cancer was the most common cancer among this cohort, representing about 31% (63 of 203 total cancer deaths). The PMR for lung cancer was 117 (CI: 93, 148).

Significant excess mortality from other smoking-related diseases was observed for this cohort. Arteriosclerotic heart disease was the single most common cause of death among this cohort, representing about 34% of total deaths (236 of 686). The PMR for arteriosclerotic heart disease was 140, which was significantly elevated (CI: 127, 155). In addition, the PMR for respiratory diseases was 176 (CI: 135, 230), and the PMR for emphysema was 186 (CI: 101, 342).

Two uncommon cancer types, brain and lymphoma (non-Hodgkin's lymphoma, NHL) occurred at increased levels within this cohort. The PMR for brain cancer was 234 (CI: 121, 454), while the PMR for NHL was 237 (CI: 137, 410). Two more common cancer sites were also significantly elevated among cohort members. The PMR for cancer of the large intestine was 175 (CI: 125, 245), while the PMR for prostate cancer was 293 (CI: 187, 460). Diseases of the nervous and sensory systems also were significantly

TABLE I. Proportionate Mortality Ratios for Selected Cancers in White Male GCSAA Members: 1970–1992

ICD-9 codes	Description of cancer	No. of deaths	PMR	95% confidence interval
140–239	All cancers	203	136	121–152
141–149	Other buccal/mouth	3	81	26–247
150	Esophagus	5	139	58–330
151	Stomach	7	124	60–258
153–154	Large intestine	32	175	125–245
155	Liver	3	150	49–462
157	Pancreas	10	128	70–236
152,156,158,159	Other digestive	3	146	47–449
162	Lung	63	117	93–148
160, 161, 163	Other respiratory	2	82	21–323
170, 171	Bone & connective tissue	3	259	84–793
172, 173	Skin	2	66	17–260
185	Prostate	18	293	187–460
188	Bladder	4	85	32–225
189	Kidney	3	80	27–244
191	Brain	8	234	121–454
200, 202	Non-Hodgkin's lymphoma	12	237	137–410
203	Multiple myeloma	1	44	6–307
204–207	Leukemia	8	162	83–316

TABLE II. Proportionate Mortality Ratios for Selected Causes of Death in White Male GCSAA Members: 1970–1992

ICD-9 codes	Description cause of death	No. of deaths	PMR	95% confidence interval
All	Total deaths	686	100	
140–239	All cancers	203[a]	136	121–152
320–389	Diseases of nervous system	15[a]	202	123–333
332	Parkinson's disease	2	155	39–612
345	Epilepsy	1	229	33–1601
393–398	Rheumatic heart disease	1[a]	40	6–278
401–405	Hypertension	6[a]	94	43–206
410–414, 429.2	Arteriosclerotic heart	236[a]	140	127–155
430–438	Cerebrovascular disease	34[a]	110	79–152
460–519	Respiratory disease	49[a]	176	135–230
492	Emphysema	10	186	101–342
520–579	Digestive diseases	18[a]	68	43–106
571–571.8	Cirrhosis of liver	6	46	21–101
580–629	Genitourinary disease	5[a]	75	31–179
582	Chronic nephritis	1	109	16–763
800–949	All injuries	29[a]	99	72–135
810–829	Motor vehicle injuries	17	114	76–170
820–825	Motor vehicle nontraffic injuries	1	310	46–2080
880–888	Falls	4	140	54–365
919	Machinery injuries	1	220	31–1542
925	Electrical current	1	226	36–1432
950–959	Suicide	12[a]	93	56–154
	Other	78[a]	36	29–44

[a]Causes of death that sum to the number of total deaths (686).

elevated in this population, with a PMR of 202 (CI: 123, 333).

Proportionate cancer mortality ratios (PCMR) were calculated for the 203 cancer deaths. As expected, the PCMRs were less than the PMRs, with wider confidence intervals due to the smaller sample size. The PCMR for brain cancer was 156 (CI: 87, 279), while the PCMR for NHL was 165 (CI: 98, 276). The PCMR for cancer of the large intestine was 130 (CI: 95, 178), while the PCMR for prostate cancer was 217 (CI: 142, 331). The PCMR for lung cancer was 89 (CI: 73, 109).

DISCUSSION

From a public and occupational health perspective, the excess number of deaths among this cohort from smoking-related diseases is a primary concern. Respiratory diseases, including emphysema and lung cancer, and to a lesser degree, arteriosclerotic heart disease, are strongly associated with smoking rates. Smoking-related diseases (cancers of the lung, esophagus, and mouth, plus respiratory diseases and arteriosclerotic heart disease) account for about 52% of total deaths. The PMRs for these smoking-related diseases are high, particularly when compared with studies of other outdoor occupations, such as farming. As shown in Table III, the PMRs for smoking-related diseases, as well as all cancers, are considerably higher in this cohort than for white male farmers during three reporting periods that span similar times as our study.

Golf course superintendents, like farmers, are likely to come in contact with a variety of hazardous substances, including pesticides, solvents, fuels and oils, diesel exhaust, and organic and inorganic dusts. Specific risk factors or agents that might contribute to excesses in mortality for various cancers and other causes of death among this cohort perhaps have not yet been identified because of the variety of potential exposures and the difficulty of determining the intensity and duration of these historical exposures. A number of occupational or ethnic cohorts have been associated with elevated cancer rates for specific cancer sites. A study found excesses of brain cancer among petroleum workers who were exposed to fuels and solvents [Thomas et al., 1982]. Risk of NHL has been significantly associated with workers involved with special industrial machinery, real estate, and personal services [Blair et al., 1993a]; with

TABLE III. Comparison with Other Studies: PMRs for Selected Cancers and Other Causes of Death Among White Male Farmers and GCSAA Members

Causes of death	Farmers[a] Iowa PMR 1971–1978	Farmers[b] Iowa PMR 1979–1986	Farmers[c] 23 states PMR(CI)[e] 1984–1988	GCSAA national PMR 1970–1992
All cancers	97	103	89 (88–91)	136 (121–152)
Smoking-related cancers				
Lung cancer	78	66	87 (83–89)	117 (93–148)
Esophagus	74	82	84 (76–98)	139 (58–330)
Mouth (other than lip)	82	64	83 (73–93)	81 (26–247)
Other respiratory cancer	65	na	na	82 (21–323)
Lip cancer	162[d]	118	231 (143–353)	0
Stomach cancer	114[d]	97	104 (96–112)	124 (60–258)
Leukemia	110[d]	94	127 (120–135)	162 (83–316)
Non-Hodgkin's lymphoma	114[d]	122	121 (113–130)	237 (137–410)
Multiple myeloma	127[d]	100	115 (104–127)	44 (6–307)
Prostate cancer	110[d]	124	118 (114–122)	293 (187–460)
Brain cancer	na	122	115 (105–126)	234 (121–454)
Diseases of nervous system	na	na	85 (81–109)	202 (123–333)
Arteriosclerotic heart disease	na	na	102 (101–103)	140 (127–155)
Emphysema	na	na	86 (81–92)	186 (101–342)
Respiratory disease	na	na	96 (95–98)	176 (135–230)

[a]Burmeister [1981].
[b]Burmeister [1990].
[c]Blair et al. [1993[b]].
[d]Statistically significant.
[e]For cancer, the proportionate cancer mortality ratios (PCMR) are reported.
na = data not available.

plumbers [Cantor et al., 1986]; and with the rubber, plastics, and synthetic industries [Schumacher and Delzell, 1988], to name a few. Prostate cancer risk has been significantly associated with firefighters [Demers et al., 1994] and consistently among black males [Morton, 1994].

For the past two decades mortality studies have reported excess risks for cancer of the lip, stomach, brain, prostate, connective tissues, non-Hodgkin's lymphoma, and the hematopoietic system among male farmers [Burmeister, 1981, 1990; Blair et al., 1985, 1990, 1993b]. (see Table III). A similar pattern of elevated NHL, brain, and prostate cancer mortality was observed for this cohort.

Non-Hodgkin's lymphoma has been linked to phenoxy herbicides (including 2,4-D) in many studies [Hardell et al., 1981; Hoar et al., 1986; Zahm et al., 1990; Wigle et al., 1990]. However, other studies found no excess risk for NHL associated with exposure to phenoxy herbicides [Pearce, 1989; Woods and Polissar, 1989; Cantor et al., 1992; Bloeman et al., 1993]. NHL was also elevated among grain millers exposed to fumigants and insecticides [Alavanja et al., 1990] and among forest and soil conservationists [Alavanja et al., 1989]. Clearly, epidemiologic evidence and animal toxicologic data are not conclusive with respect to a causal relationship between pesticide exposure and NHL, or any other specific cancer types [Zahm and Blair, 1990]. The excess mortality from NHL that occurred in this cohort is another piece of evidence for this debate. The phenoxy herbicide 2,4-D is commonly used on golf courses, primarily on fairways and roughs. Although there are likely variations on a regional basis, data from Iowa indicate that 2,4-D is the most common herbicide used on Iowa golf courses, representing about 42% of the total amount of herbicide applied [Iowa State University, 1993].

A study in Italy found an association between brain cancer and agricultural workers who used insecticides and fungicides [Musicco et al., 1988]. Another study related childhood brain tumors to chlordane and heptachlor exposure [Infante et al., 1978]. These epidemiological studies, coupled with animal test results, are consistent with the suggestion that exposure to pesticides may be related to increased risk of brain cancer [Reif, et al., 1989]. Significant excess mortality from brain cancer was observed for this cohort of golf course superintendents.

Noncancer health effects from exposures to pesticides have also been studied extensively [Ecobichon et al., 1990]. Acute neurotoxicity of pesticides, especially from organophosphates and carbamates, has been defined [Fuortes et al., 1993]. Chronic exposure to pesticides has been associated with a number of neurological effects, including decreased function of neurobehavioral performance using standard test batteries [Rosenstock et al., 1991]. While epidemiological data are not clear now, pesticides have been proposed as etiologic agents for neurodegenerative diseases [Tanner and Langston, 1990; Deapen and Henderson, 1986; Gunnarsson et al., 1992]. This cohort of golf course superintendents had significant excess mortality from diseases of the nervous system.

This mortality study cannot be interpreted to mean that golfers are at risk. Other occupational exposure assessment studies indicated that workers who mixed, loaded, and applied pesticides received greater exposure than did casual observers who used the environment where pesticides were applied. For example, a recent study observed 2,4-D dose levels received by professional lawn applicators compared with dose levels of bystanders (property owners where applications were performed). Professional applicators applying 2,4-D received a geometric mean dose of 0.154 mg/person/day over a 14 day period, as measured in the urine. The acceptable daily intake (ADI) is 0.3 mg/kg/day, which equates to 21 mg/person/day for a 70 kg adult. Residues of 2,4-D were not detected in air collected on the property or in urine samples supplied by 10 bystanders who received a professional application of 2,4-D to their property. The Canadian study concluded that "bystanders to homeowner and professional applications showed no detectable exposure to 2,4-D . . . and exposure measurements in volunteers exposed to sprayed turf indicate that these [dose levels] should present little risk to humans" [Harris and Solomon, 1992]. In view of this study and other [Solomon et al., 1992], we believe that potential exposure levels to golfers playing on courses after pesticide applications will be significantly less than the levels encountered during occupational use exposure of pesticides.

Limitations in proportionate mortality study methods may bias these study results. The lack of actual exposure histories for cohort members was a problem. Overall mortality estimates for this cohort of golf course superintendents could not be determined from available data about the live members of the association during the study period. The sum of all PMRs (expressed as weighted fractions) for all causes of death must equal one. Hence, an excess in one disease must be offset by a deficit in another disease. For the diseases reported in Tables I and II, there were no diseases with statistically significant deficits in mortality. However, the PMR for all other causes of death not reported in Table II was 36 (CI: 29, 44). For validation purposes, the PMR for all causes of death was determined to be equal to 100.

In conclusion, mortality from smoking-related diseases among golf course superintendents was significantly elevated. Preventive strategies, such as smoking cessation programs and no-smoking areas at golf courses, may have a significant impact on reducing overall mortality among golf course superintendents.

A pattern of mortality from specific cancers (NHL, brain, and prostate) and from diseases of the nervous system was noted in this study and in other cohorts occupationally exposed to pesticides and other risk factors. It is recommended that specific pesticide exposure reduction practices should be developed and promoted based on exposure measurements of golf course workers while performing actual mixing and application tasks at various regions of the country. Efforts may also include an aggressive program to educate golf course workers about the need to employ personal protective equipment during pesticide mixing and application. Exposure measurements and risk assessments should be done for representative pesticides and common equipment used in golf course operations.

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