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INCREASED MORTALITY IN AMATEUR RADIO OPERATORS DUE TO LYMPHATIC AND HEMATOPOIETIC MALIGNANCIES

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Milham, S., Jr. (Washington State Dept. of Social and Health Services, Olympia, WA 98504). Increased mortality in amateur radio operators due to lymphatic and hematopoietic malignancies. *Am J Epidemiol* 1988;127:50–4.

To search for potentially carcinogenic effects of electromagnetic field exposures, the author conducted a population-based study of mortality in US amateur radio operators. Ascertainment of Washington State and California amateur radio operators (67,829 persons) was done through the 1984 US Federal Communications Commission Amateur Radio Station and/or Operator License file. A total of 2,485 deaths were located for the period from January 1, 1979 through December 31, 1984, in a population of amateur radio operators which accumulated 232,499 person-years at risk. The all-cause standardized mortality ratio (SMR) was 71, but a statistically significant increased mortality was seen for cancers of the other lymphatic tissues (SMR = 162), a rubric which includes multiple myeloma and non-Hodgkin's lymphomas. The all-leukemia standardized mortality ratio was slightly, but nonsignificantly, elevated (SMR = 124). However, mortality due to acute myeloid leukemia was significantly elevated (SMR = 176).

electromagnetics; leukemia, myelocytic; lymphoma; multiple myeloma; radio

In 1982, an updated occupational proportionate mortality ratio analysis of 429,926 male deaths in Washington State from 1950–1979 suggested that workers in occupations with exposures to electric and magnetic fields had increased mortality due to leukemia (1, 2). An amateur radio operator (Andrew R. Sabol, W2EVE, personal communication, 1982) suggested that it might be of interest to study mortality in members of the American Radio Relay League, a group of amateur radio operators who, in the pursuit of their hobby, are exposed to electromagnetic fields.

Recent deaths in American Radio Relay League members are reported in the "Silent Keys" section of *QST*, the League's monthly magazine. A proportionate mortality ratio analysis of 1,691 deaths of league members from Washington State and California during 1971–1983 revealed a ratio for deaths from leukemia of 191 (24 deaths observed, 12.6 expected; $p < 0.01$) (3). I could not obtain access to American Radio Relay League membership files, so it was not possible to do a standardized mortality ratio analysis of these deaths. Since all amateur radio operators in the US are federally licensed, I instead purchased the 1984 Federal Communications Commission Amateur Radio Station and/or Operator current license file from the National Technical Information Services.

MATERIALS AND METHODS

The Amateur Radio Operator file contains the following information for each licensee: name, call sign, birth date, effective date of current license, expiration date of current license, license class, mailing

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address, and station location (city and state). There were more than 400,000 records in the file. The effective and expiration dates of the current license were exactly five years apart, in accordance with the five-year license period at the time. Starting in 1984, the license period was extended to 10 years. No information was available on the date persons were first licensed or on the number of years licensed.

All amateurs with Washington State or California addresses, licensed between January 1, 1979 and June 16, 1984 (latest date on the file), were selected from the master file. Name (first, middle initial, and last) and date of birth (month, day, and year) were listed and used to search for deaths. A search for deaths by computer with manual backup was done in Washington State. In California, the CAMLIS system (a computer-based probability matching system) was used (4). In both states, all deaths were searched, but the study was limited to males because females made up such a small percentage of Federal Communications Commission registrants. Since the Federal Communications Commission file had no sex code, female names were eliminated manually. In all 67,829 names were searched for deaths in the two states. For a name to be included in the study, deaths and the commission file had to match exactly for date of birth and complete name. Causes of death were translated to *International Classification of Diseases*, Eighth Revision (ICD-8), codes and the standardized mortality ratio cohort mortality program of Monson (5) was run by state for males only. Person-years at risk started at the effective current registration day and ended at day of death or December 31, 1984.

Results

The 67,829 Washington State and California amateur radio licensees accumulated 232,499 person-years at risk and 2,485 deaths (2,083 in California and 402 in Washington) during the study period (January 1, 1979 to December 31, 1984).

Table 1 shows standardized mortality ratios by cause for California and Washington State licensees. Since 84 per cent (2,083 of 2,485) of the deaths occurred in California licensees, California deaths are primarily responsible for the mortality pattern seen here. The all-cause mortality ratio is 71, mainly due to a circulatory diseases ratio of 70. The all-cancer mortality ratio is 89. The rubric cancer of the other lymphatic tissues had a significant ($p < 0.05$) mortality excess. No other cause of death groups had significant excess deaths, while many had large deficits (e.g., cancer of the pancreas, all circulatory diseases, all respiratory diseases, and all accidents). The patterns of mortality seen in the two states are quite similar.

An analysis of leukemia mortality by detailed cause (table 2) shows a slight, but nonsignificant increase in all leukemias and a significant increase in the acute myeloid leukemias (ICD-8 code 205.0). The increase for the rubric acute unspecified leukemia (ICD-8 code 207.0) may also reflect an excess of acute myeloid leukemia.

Discussion

The standardized mortality ratios in table 1 are slightly underestimated, since females are virtually eliminated from the deaths, but not from the population at risk. Further underestimation results from the fact that California and Washington State death rates are slightly lower than the US rates used to calculate expected deaths (table 3). This will result in the standardized mortality ratios as calculated by Monson's program being slightly lower than those calculated using state death rates. The California deaths also exclude 39 out-of-state deaths in California residents. The all-cause standardized mortality ratio of 71 is similar to that seen for Swedish academic cohorts (6). Swedish mining engineers and architects had an all-cause ratio of 65 and 67, respectively.

The 43 deaths in the rubric cancer of

TABLE 1

Mortality in Washington State and California US Federal Communications Commission Amateur Radio Operator Licensees, January 1, 1979 to December 31, 1984

Cause of death	ICD-8 code†	Washington State deaths			California deaths			Washington State and California deaths			95% confidence interval
		Observed	Expected	SMR‡	Observed	Expected	SMR‡	Observed	Expected	SMR‡	
All causes	000–999	402	562.0	72*	2,083	2,916.9	71*	2,485	3,478.9	71*	69–74*
All malignant neoplasms	140–209	112	136.3	82*	629	700.6	90*	741	836.9	89*	82–95*
Esophagus	150	5	3.2	157	17	16.2	106	22	19.4	113	71–172
Stomach	151	7	4.8	146	23	24.8	93	30	29.6	102	68–145
Large intestine	153	8	12.8	63	80	66.2	121	88	79.0	111	89–137
Rectum	154	1	3.0	34	13	15.2	86	14	18.2	77	42–129
Liver	155	2	2.7	73	9	14.1	64	11	16.8	65	33–117
Pancreas	157	3	6.8	44	24	35.1	68	27	41.9	64*	42–94*
Respiratory system	160–163	29	51.8	56*	180	263.8	68*	209	315.6	66	58–76
Prostate	185	21	10.8	195*	57	56.8	100	78	67.6	114	90–142
Urinary bladder	188	2	3.8	52	14	20.3	69	16	24.1	66	38–108
Kidney	189	4	3.3	121	15	16.8	89	19	20.1	94	57–148
Brain	191	4	3.5	115	25	17.3	145	29	20.8	139	93–200
Lymphatic and hematopoietic tissue	200–209	11	11.8	93	78	60.3	129*	89	72.1	123	99–152
Lymphosarcoma/reticulosarcoma	200	1	1.8	57	4	8.8	45	5	10.6	47	15–110
Hodgkin's disease	201	0	0.7	0	5	3.4	147	5	4.1	123	40–288
Leukemia	204–207	5	4.7	106	31	24.3	128	36	29.0	124	87–172
Other lymphatic tissue	202, 203	5	4.3	115	38	22.3	170*	43	26.6	162*	117–218*
All circulatory diseases	390–458	196	276.4	71*	1,012	1,455.3	70*	1,208	1,731.7	70*	66–74*
All respiratory diseases	460–519	28	40.0	70	99	212.5	47*	127	252.5	50*	42–60*
All accidents	E800–E999	19	28.3	67	86	136.2	63*	105	164.5	64*	52–77*

* $p < 0.05$.

† *International Classification of Diseases,* Eighth Revision.

‡ SMR (standardized mortality ratio) = observed/expected × 100.

TABLE 2

Analysis of leukemia deaths in Washington State and California US Federal Communications Commission amateur radio operator licensees, January 1, 1979 to December 31, 1984

Cause of death	ICD-8 code†	Deaths			95% confidence interval
		Observed	Expected‡	SMR§	
All leukemias	204–207	36	29.0	124	87–172
Lymphatic	204	9	8.7	103	47–196
Acute	204.0	3	2.5	120	26–381
Chronic	204.1	6	5.5	109	40–238
Unspecified	204.9	0	0.8	0	
Myeloid	205	18	12.9	140	83–220
Acute	205.0	15	8.5	176*	103–285*
Chronic	205.1	3	3.5	86	17–250
Unspecified	205.9	0	0.9	0	
Monocytic	206	0	0.6	0	
Unspecified	207	9	6.7	134	61–255
Acute	207.0	6	3.4	176	64–384
Unspecified	207.9	3	2.5	120	26–381

* $p < 0.05$.

† *International Classification of Diseases*, Eighth Revision.

‡ Calculated using 1981 US age-specific white male death frequencies by detailed ICD-8 code and a simple proportional model.

§ SMR (standardized mortality ratio) = observed/expected × 100.

TABLE 3

Death rates per 100,000 for selected causes from vital statistics of the United States, 1981 (11)

Cause of death	ICD-8 code*	US	California	Washington State
All causes	000–999	862.4	764.0	759.0
Leukemia	204–208	7.1	6.7	6.9
Other malignant neoplasms of lymphatic and hematopoietic tissues	200–203	9.4	8.6	8.9

* *International Classification of Diseases*, Eighth Revision.

other lymphatic tissue were composed of 22 deaths from ICD-8 code 202 (other neoplasms of lymphoid tissue) and 21 deaths from ICD-8 code 203 (multiple myeloma). Among all US white male deaths, ICD-8 codes 202 and 203 are present in the ratio of 57 per cent to 43 per cent, respectively. This yields crude standardized mortality ratios of 145 for ICD-8 code 202 and 184 for ICD-8 code 203. The excess of deaths for ICD-8 code 202 is not as secure as that for ICD-8 code 203, since there is potential misclassification between the lymphosarcoma-reticulosarcoma group (ICD-8 codes 200.0 and 200.1) and the groups for ICD-8 code 202. When ICD-8 codes 200.0 and 200.1 are considered together, their mortality deficit nearly cancels out the mortality excess for ICD-8 code 202.

The low standardized mortality ratios for malignant and nonmalignant respiratory diseases suggest that the members of the American Radio Relay League have a lower ratio of cigarette smoking than does the general US population.

The fact that the excess of leukemia is limited to the acute myeloid and acute unspecified cell types increases its biologic plausibility. Studies in the US (7) and the United Kingdom (8, 9) suggest a relative increase in acute myeloid leukemia in electrical workers.

Occupational information listed on the death certificates in Washington State showed that 31 per cent of Washington State amateurs (124 of 402) listed occupations with electromagnetic field exposures (radio operator, television repairman, electronics technician, etc.), while these occupations are listed on only three per cent of all male death certificates in the Washington state death file. Five of the 11 Washington State leukemia, lymphoma, and multiple myeloma death certificates listed an occupation with electrical exposure. Occupational information was not available for the California deaths.

In addition to electric and magnetic fields, these males are exposed to electric shock, soldering fumes, and degreasing agents in the pursuit of their hobby. Nearly one-third of the group also work in jobs with electric and magnetic field exposures.

In 1980, the American Radio Relay League surveyed 8,895 US and Canadian amateurs (a random sample of one in 44). Results published in 1981 (10) indicate that the average amateur was a 46-year-old male who was first licensed in 1963 and spent 6.1 hours a week on his hobby. A total of 72 per cent had some education beyond high school, and 43 per cent worked or had worked in a related field. Males accounted for 94 per cent of the amateurs. Some of the variation in mortality seen in Federal Communications Commission licensees may be related to social class.

There is some overlap between the Federal Communications Commission licensee population studied here and the American Radio Relay League deaths ascertained through listing in the League's journal. In the study of mortality in the American Radio Relay League, 1,691 deaths, including 24 leukemias, were ascertained in the years 1971–1983 (3). In the present study, 2,485 deaths, including 36 cases of leukemia, were ascertained in the years 1979–1984 by searching for deaths in a population of 67,829 Federal Communications Commission licensees. All amateur radio operators are required to be licensed by the Federal Communications Commission, but only a fraction of these licensees are members of the American Radio Relay League. In the years of overlap of the two studies (1979–1983), there were six cases of leukemia ascertained through the American Radio Relay League listings and 33 ascertained through a search of the Federal Communications Commission files.

As expected, the overall mortality of amateur radio operators is quite favorable when compared with that of all US males. However, this large population-based study indicates that amateur radio operator licensees in Washington State and California have significant excess mortality due to acute myeloid leukemia, multiple myeloma, and perhaps certain types of malignant lymphoma. Avocational and/or occupational exposures to electric and magnetic fields should be among the possible etiologies considered in explaining this excess mortality.

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