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Silent Keys: Leukemia Mortality in Amateur Radio Operators

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SILENT KEYS: LEUKEMIA MORTALITY IN AMATEUR RADIO OPERATORS

In 1982 I reported increased mortality due to leukemia in men whose death-certificate occupation suggested exposure to electrical and/or magnetic fields(1). Similar findings have been reported by others(2-4). An amateur radio operator (Mr. Andrew R. Sabol, W2EVE) wrote to me suggesting that I study mortality in members of the American Radio Relay League, a group of amateur radio operators exposed avocationally to electromagnetic fields.

City and state of death of recently deceased members of the American Radio Relay League are reported in the "Silent Keys" section of QST, the monthly magazine of the organization. In the years 1971-1983, there were 296 male deaths listed for Washington State and 1,642 listed for California. Death certificates were obtained for 280 (95%) of the Washington State deaths and age-at-death, date-of-death, and cause-of-death information was obtained for 1,411 (86%) of the California deaths. Richard Monson's proportionate mortality ratio (PMR) program(5) was used to analyze the 1,691 male deaths in the two states. (Output from this computer program is attached.)

Table 1 shows mortality in Washington State and California. All malignant neoplasms, cancer of the prostate and the lymphatic and hematopoietic cancers have elevated PMRs in both states. Cancer of the large intestine and diseases of the nervous system have elevated PMRs in the California data only. Both data sets show deficits of deaths due to non-malignant respiratory diseases, digestive diseases and external causes of death.

Table 2 shows an increased proportionate mortality ratio for the leukemias. Interestingly, the leukemia excess is limited to the myeloid (8th ICD 205) and unspecified (ICD 207) types of

leukemia. The lymphatic (ICD 204) and monocytic (ICD 206) types of leukemia show no excess. The difference in mortality by cell type may have occurred by chance, but it is unlikely to have resulted from any bias inherent in proportionate mortality analysis. Wright et al(2) in the U.S., and McDowall(3) and Coleman et al(4) in the U.K. also showed a tendency toward a relative increase in the acute myelogenous type of leukemia in electrical workers.

There is a strong association between employment in occupations with exposure to electromagnetic fields and membership in the American Radio Relay League. Ninety-seven of the 280 (35%) Washington State Silent Key death records listed an electrical-exposure occupation (i.e., electronics technician, electrician, radio operator, etc.) while these occupations account for only 3% of male deaths in the Washington State death file(6). The PMR due to leukemia (8th ICD 204-207) in Washington State amateur radio operators who worked in electrical-exposure occupations was 264 (2 deaths observed/.76 expected) as compared to a PMR of 210 (3 deaths observed/1.4 expected) in amateur radio operators who worked in all other occupations. Occupational exposure alone, therefore, probably does not explain the leukemia excess in these men.

These findings offer some further support for the hypothesis that electromagnetic fields are carcinogenic.

References

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2. Wright, W.E., Peters, J.M. and Mack, T.M. Leukemia in Workers Exposed to Electrical and Magnetic Fields. The Lancet 1982, ii, 1160-61.

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Table 1

Proportionate Mortality in Male Members of the American Radio Relay League Resident in Washington State and California, dying 1971-1983

Cause of Death	8th ICD§	Washington Deaths			California Deaths			Washington and California		
		Observed	Expected†	PMR	Observed	Expected†	PMR	Observed	Expected†	PMR
Total Deaths	000-999	280			1,411			1,691		
All Malignant Neoplasms (MN)	140-209	77	62.0	124*	374	310.8	120**	451	372.8	121*
MN of Digestive Organs	150-159	16	16.3	98	91	81.6	112	107	97.9	109
MN of Large Intestine	153	4	5.7	70	49	28.8	170**	53	34.5	154*
MN Respiratory System	160-163	26	23.0	113	104	114.5	91	130	137.5	95
MN Prostate	185	10	4.7	213*	46	23.8	193**	56	28.5	196*
MN Kidney	189	3	1.5	201	12	7.5	160	15	9.0	167*
MN Brain	191	0	1.5	0	16	7.4	218**	16	8.9	180*
All Lymphatic and Hemato-poietic Cancers	200-209	11	5.5	201*	52	27.6	188**	63	33.1	190*
Lymphosarcoma & Reticulosarcoma	200	0	1.0	0	7	5.2	133	7	6.2	113
Hodgkin's Disease	201	1	.4	238	6	2.1	289**	7	2.5	280*
Other lymphomas, multiple myeloma	202,203	5	1.7	300**	19	8.4	227**	24	10.1	238*
Leukemia	204-207	5	2.2	229	19	11.1	171*	24	13.3	180*
Benign Neoplasms	210-228	3	0.7	458**	5	3.3	152	8	4.0	200*
Diseases of Nervous System	320-389	2	2.1	94	20	10.8	186**	22	12.9	171*
All Circulatory Diseases	390-458	157	149.2	105	752	756.8	99	909	906.0	100
All Respiratory Diseases	460-519	17	19.5	87	77	98.7	78*	94	118.2	80*
All Digestive Diseases	520-577	6	11.9	50	46	60.5	76	52	72.4	72*
All Accidents	800-845	9	12.1	74	39	57.4	68*	48	69.5	69*
All other causes		9	22.5	40**	98	112.7	87*	107	135.2	79*

§ International Classification of Diseases, Eighth Revision

† Expected deaths based on age, sex, race, and year-of-death specific proportionate mortality

PMR Proportionate Mortality Ratio (Observed/Expected x 100).

* $P < .05$

** $P < .01$

Table 2

Leukemia Deaths by Detailed Type
Washington and California Data Combined

Type	8th ICD§	Deaths Observed	Deaths Expected†	PMR
All leukemia	204-207	24	13.3	180**
Lymphatic leukemia	204	3	3.6	83
Chronic Lymphatic	204.1	3	2.7	111
Myeloid leukemia	205	16	6.3	254**
Acute	205.0	11	4.5	244**
Chronic	205.1	4	1.6	250*
Unspecified	205.9	1	.3	333
Monocytic leukemia	206	0	.5	0
Unspecified leukemia	207	5	2.9	172

§ International Classfication of Diseases, Eighth Revision

† Expected deaths generated using 1976 U.S. male leukemia death frequencies by detailed ICD number and a simple proportional model.

PMR Proportionate Mortality Ratio (Observed/Expected x 100).

* $P < .05$

** $P < .01$

Washington State and California "Silent Keys" PMR (page 2)

TOTAL DEATHS = 1691. EXPECTED NUMBERS BASED ON PROPORTIONAL MORTALITIES FOR WM

	OBSERVED	EXPECTED	OBS/EXP	LL	UL	CHISQ
1 ALL MALIGNANT NEOPLASMS	451	373.56	1.21	1.11	1.31	20.76
2 ALL INFECTIVE AND PARASITIC DISEASE	13	10.72	1.21	0.71	2.08	0.49
9 ALL TUBERCULOSIS	4	3.59	1.11	0.42	2.96	0.05
140 CANCER OF BUCCAL CAVITY AND PHARYNX	12	11.33	1.06	0.60	1.86	0.04
149 CANCER OF DIGESTIVE ORGANS AND PERITONEUM (1925- APPROXIMATE)	107	97.92	1.09	0.91	1.31	0.90
150 CANCER OF ESOPHAGUS (1925- APPROXIMATE)	9	8.88	1.01	0.53	1.94	0.00
151 CANCER OF STOMACH	10	15.71	0.64	0.35	1.17	2.09
153 CANCER OF LARGE INTESTINE (1925- APPROXIMATE)	53	34.57	1.53	1.18	2.00	10.04
154 CANCER OF RECTUM (1925- APPROXIMATE)	8	10.42	0.77	0.39	1.53	0.56
155 ALL CANCER OF LIVER (1925- APPROXIMATE) 1970+ - PRIMARY ONLY	7	5.61	1.25	0.60	2.61	0.34
157 CANCER OF PANCREAS (1925- APPROXIMATE)	20	20.68	0.97	0.63	1.49	0.02
160 CANCER OF RESPIRATORY SYSTEM (1925- APPROXIMATE)	130	138.05	0.94	0.80	1.11	0.52
161 CANCER OF LARYNX (1925-, 1930- APPROXIMATE)	2	5.57	0.36	0.10	1.35	2.29
162 ALL CANCER OF LUNG - PRIMARY AND SECONDARY (1925-,1930- APPROXIMATE)	126	131.62	0.96	0.81	1.13	0.26
170 CANCER OF BONE (1925-,1930-,1945- APPROXIMATE)	3	1.42	2.11	0.70	6.36	1.75
172 CANCER OF SKIN	6	5.52	1.09	0.49	2.41	0.04
185 CANCER OF PROSTATE (1925- APPROXIMATE)	56	28.21	1.98	1.54	2.56	27.98
186 CANCER OF TESTIS (OTHER GENITAL ORGANS 1925-49)(1925-,1930- APPROXIM	2	1.19	1.68	0.43	6.61	0.56
188 CANCER OF BLADDER (1925- APPROXIMATE)	12	12.05	1.00	0.57	1.75	0.00
189 CANCER OF KIDNEY (1925- APPROXIMATE)	15	9.04	1.66	1.01	2.73	3.95
190 CANCER OF EYE (1950-1969 ONLY)	0	0.29	0.00	0.00	0.00	0.29
191 CANCER OF BRAIN AND OTHER CENTRAL NERVOUS SYSTEM (1925- APPROXIMATE)	16	8.88	1.80	1.11	2.91	5.74
193 CANCER OF THYROID (1950-1969 ONLY)	1	0.59	1.70	0.25	11.79	0.29
200 LYMPHOSARCOMA AND RETICULOSARCOMA (1950-1969 ONLY)	7	6.31	1.11	0.53	2.32	0.08
201 HODGKIN'S DISEASE (1940-,1945- APPROXIMATE)	7	2.51	2.79	1.37	5.66	8.04
204 LEUKEMIA AND ALEUKEMIA	24	13.28	1.81	1.22	2.68	8.72
208 CANCER OF OTHER LYMPHATIC TISSUE (1950-1969 ONLY)	24	10.06	2.39	1.62	3.51	19.43
209 ALL LYMPHOPOIETIC CANCER	63	33.16	1.90	1.49	2.42	27.41

Washington State and California "Silent Keys" PMR

210 BENIGN NEOPLASMS	8	3.96	2.02	1.03	3.98	4.13
240 ALLERGIC,ENDOCRINE,METABOLIC,NUTRITIONAL DISEASES (1950-1969 ONLY)	35	29.74	1.18	0.85	1.63	0.95
250 DIABETES MELLITUS	27	24.98	1.08	0.74	1.57	0.17
280 ALL DISEASES OF BLOOD AND BLOOD-FORMING ORGANS (1925-,1930- APPROXIM	3	3.42	0.88	0.28	2.72	0.05
319 MENTAL,PSYCHONEUROTIC,AND PERSONALITY DISORDERS (1950-1969 ONLY)	4	8.43	0.47	0.18	1.23	2.35
320 ALL DISEASES OF NERVOUS SYSTEM AND SENSE ORGANS	22	12.90	1.71	1.13	2.57	6.48
390 ALL DISEASES OF CIRCULATORY SYSTEM	909	904.34	1.01	0.96	1.05	0.05
393 CHRONIC RHEUMATIC HEART DISEASE(1925- APPROXIMATE)	11	11.73	0.94	0.52	1.69	0.05
410 ARTERIOSCLEROTIC HEART DISEASE,INCLUDING CHD (1925- APPROXIMATE)	679	661.97	1.03	0.97	1.09	0.73
430 ALL VASCULAR LESIONS OF CNS	95	122.88	0.77	0.64	0.94	6.92
460 ALL RESPIRATORY DISEASES (1925-,1930- APPROXIMATE)	94	117.79	0.80	0.66	0.97	3.19
480 ALL PNEUMONIA (1925-,1930- APPROXIMATE)	12	37.10	0.32	0.19	0.55	17.42
492 EMPHYSEMA (1950-,1955 APPROXIMATE)	28	32.23	0.87	0.60	1.25	0.57
493 ASTHMA (1925-,1930- APPROXIMATE)	5	1.32	3.78	1.67	8.53	10.22
520 ALL DISEASES OF DIGESTIVE SYSTEM	52	72.81	0.71	0.55	0.93	6.26
531 ALL GASTRIC AND DUODENAL ULCER	9	8.08	1.11	0.58	2.14	0.10
571 CIRRHOSIS OF LIVER	23	39.46	0.58	0.39	0.87	7.11
580 ALL DISEASES OF GENITO-URINARY SYSTEM	14	18.27	0.77	0.46	1.29	1.01
582 CHRONIC NEPHRITIS	2	4.46	0.45	0.12	1.72	1.36
709 ALL DISEASES OF THE SKIN AND CELLULAR TISSUE	0	1.05	0.00	0.00	0.00	1.05
739 ALL DISEASES OF THE BONES AND ORGANS OF MOVEMENT	3	3.01	1.00	0.32	3.09	0.00
799 SYMPTOMS,SENILITY,AND ILL DEFINED CONDITIONS	2	20.31	0.10	0.03	0.30	16.72
800 ALL EXTERNAL CAUSES OF DEATH	78	108.15	0.72	0.59	0.88	10.62
801 ALL ACCIDENTS	48	69.91	0.69	0.53	0.89	8.04
810 MOTOR VEHICLE ACCIDENTS	17	29.43	0.58	0.37	0.90	5.90
959 SUICIDE	27	26.34	1.02	0.71	1.48	0.02
TOTAL RESIDUAL	3	2.55	1.18			
CANCER RESIDUAL	28	25.91	1.08			

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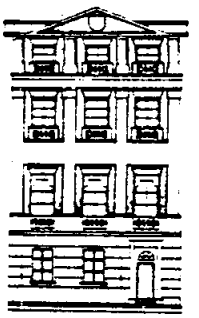

THE LANCET

SILENT KEYS: LEUKAEMIA MORTALITY IN AMATEUR RADIO OPERATORS

SIR,—In 1982 I reported increased mortality due to leukaemia in men whose death-certificate occupation suggested exposure to electrical and/or magnetic fields.[1] Similar findings have been reported by others.[2-4] An amateur radio operator (Mr Andrew R. Sabol, W2EVE) wrote to me suggesting that I study mortality in members of the American Radio Relay League, a group of amateur radio operators exposed during their hobby to electromagnetic fields.

Recent deaths of members, with City and State, are reported in the "silent keys" section of *QST*, the league's monthly magazine. For 1971–83, there were 296 male deaths listed for Washington State and 1642 listed for California. Death certificates were obtained for 280 (95%) of the Washington State deaths and age, date, and cause of death information was obtained for 1411 (86%) of the California deaths. A proportionate mortality ratio (PMR) programme[5] was used to analyse the 1691 male deaths in the two States.

ANALYSIS OF LEUKAEMIA DEATHS IN MALE MEMBERS OF THE AMERICAN RADIO RELAY LEAGUE RESIDENT IN WASHINGTON AND CALIFORNIA, 1971–83

Cause of death (ICD 8)	Deaths		PMR
	Observed	Expected*	
All causes	1691	1691	100
All leukaemias (204–07)	24	12·6	191 (p<0·01)
Lymphatic (204)	3	3·9	77
Chronic (204·1)	3	2·1	143
Myeloid (205)	16	5·7	281 (p<0·01)
Acute (205·0)	11	3·8	289 (p<0·01)
Chronic (205·1)	4	1·5	267 (p<0·05)
Unspecified (205·9)	1	0·4	250
Monocytic (206)	0	0·4	0
Unspecified (207)	5	2·7	185

*Expected deaths for leukaemias generated using 1976 US age-specific white male death frequencies by detailed ICD number and a simple proportional model.

The table shows an increased PMR for the leukaemias, limited to myeloid (8th ICD 205) and unspecified (ICD 207) leukaemia. Lymphatic (ICD 204) and monocytic (ICD 206) leukaemias show no excess. This difference by cell type may have happened by chance, but it is unlikely to have resulted from any bias inherent in proportionate mortality analysis. Studies in the USA[2] and UK[3,4] also revealed a tendency toward a relative increase in the acute myelogenous type of leukaemia in electrical workers.

There is a strong association between employment in occupations with exposure to electromagnetic fields and membership in the American Radio Relay League. 97 of the 280 (35%) Washington State "silent key" death records listed occupations such as electronics technician, electrician, and radio operator, while these occupations account for only 3% of male deaths in the Washington State death file.[6] The PMR due to leukaemia (ICD 204–207) in Washington State amateur radio operators was 264 (2 deaths observed, 0·76 expected) in those who worked in electrical-exposure occupations and 210 (3 deaths observed, 1·4 expected) in those who worked in all other occupations. Occupational exposure alone, therefore, probably does not explain the leukaemia excess in these men.

These findings offer some further support for the hypothesis that electromagnetic fields are carcinogenic.

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