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# Brief Report

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## Electromagnetic Field Exposure and Leukemia Mortality in the United States

Reports of excess leukemia mortality or morbidity among men employed in "electrical" occupations who have potential exposures to a wide variety of electromagnetic radiation, including 60 Hz fields, have been described for populations in Washington State 1950 to 1979,<sup>1,2</sup> California 1959 to 1961,<sup>3,4</sup> Wisconsin 1963 to 1978,<sup>5</sup> Massachusetts 1971 to 1973,<sup>6</sup> United Kingdom 1970 to 1973,<sup>7</sup> South East England 1961 to 1979,<sup>8</sup> and New Zealand 1979 to 1983.<sup>9</sup> A review article used a meta-analysis<sup>10</sup> to compare 11 epidemiologic reports and found a statistically significant summary relative risk of 1.2 for total leukemias for the 12 electrical occupations.

We noticed increased mortality for 10 of 11 similar electrical occupations during our analysis of recent mortality data from 14 US states (Table). Our summary proportionate mortality ratio (PMR) for total leukemias for the 11 occupations combined excluded the null value from the 95% confidence interval, as did three occupation-specific PMRs. Our analysis was performed on recently available industry-coded and occupation-coded mortality data from Georgia, Kansas, Kentucky, Maine, Missouri, Nebraska, Nevada, New Hampshire, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, and Wisconsin for one or more years from 1979 through 1985. (States provided the National Institute for Occupational Safety and Health (NIOSH) with coded death certificate data. Occupational coding was supported by the National Cancer Institute, NIOSH, and the National Center for Health Statistics.) Age-adjusted PMRs were examined by occupation and industry to detect increased mortality risks among 426 705 white men over age 15. A PMR is considered to be elevated if it exceeds 100. PMRs were characterized with test-based or approximate 95% confidence limits based on a Poisson distribution.<sup>11</sup>

The Table shows mortality for all leukemia and acute myelogenous leukemia for white men whose usual (lifetime) work was in one of the 11 occupations with potential exposure to electric or magnetic fields. PMRs were elevated for all leukemia for 10 of 11 occupations previously associated with excess leukemia.<sup>10</sup> A summary PMR for all leukemia for the 11 occupations, computed by totaling expected and observed deaths, was 119. The 95% confidence limits were 102 and 137. Although the lower confidence limit was just above the null value and the 19% elevation in leukemia was modest in absolute value, our summary PMR was very similar to the summary relative risk across all studies and all jobs reported by Savitz et al.<sup>10</sup> The three highest PMRs for all leukemia (telephone linemen, installers, and repairmen; telegraph and telephone operators; and photographic equipment manufacturing) showed excess risks that were consistently elevated for both all leukemia and acute myelogenous leukemia. The PMR for photographic equipment manufacturing was the only one of the ten elevated PMRs for all leukemia to exclude the null value from the 95% confidence interval. (PMR = 157, 24 observed deaths, 95% CI = 103-230.) The highest PMRs were not based on broad industrial classifications but on relatively specific occupational titles.

When only mortality due to acute myelogenous leukemia was considered, all three highest PMRs increased, based on small numbers of deaths. As the Table shows, the PMR for telegraph, telephone, and other communications equipment operators was highest (PMR = 499, 3 deaths observed) and the lower 95% confidence limit excluded the null (95% CI = 127-1361). The PMR for telephone linemen, installers, and repairmen was 347 for acute myelogenous leukemia, based on two deaths, but the lower confidence limit did not exclude the null (Table). The PMR for photographic equipment manufacturing (includes movie projection equipment) increased to 213, based on 11 deaths, and the 95% confidence interval excluded the null (95% CI = 111-368) (Table).

A recent survey<sup>12</sup> reported having measured the extremely low frequency (below 100 Hz) electric and magnetic field exposures of workers in some of the "electrical" occupations that have elevated leukemia rates and, for comparison, in residences. Based on this

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**TABLE**  
Mortality from Leukemias among White Men in Electrical Occupations in 14 US States,\* 1979-1985

Occupations/EM†/IOC‡	Mortality from all Leukemias (204-8§)			Mortality from Acute Myelogenous Leukemia (205§)		
	PMR	Obs¶	95% CI#	PMR	Obs¶	95% CI#
Telephone linemen, installers and repairmen/EM/527	210	4	(67-508)	347	2	(60-1180)
Telegraph, telephone, and other communications equipment operators/306, 348-53	194	4	(61-459)	499	3	(127-1361)
Photographic (includes movie projection) equipment mfg/M/380	157	24	(103-230)	213	11	(111-368)
Aluminum workers/272	136	11	(71-236)	—	1	—
Stationary (power plant) engineers/EM/696	135	27	(91-194)	67	4	(21-161)
Electrical, electronic engineers/M/055	128	19	(80-197)	132	6	(54-277)
Telephone installers, repairers/529	125	8	(58-237)	—	0	—
Electrical equipment assemblers/M/683	124	2	(21-413)	—	0	—
Locomotive operating occupations/824	114	12	(62-194)	100	3	—
Electric, gas utilities workers/460	109	45	(80-144)	122	15	(71-197)
Welders, flame cutters/M/783	84	27	(57-121)	60	6	(24-125)
<b>Totals</b>	<b>119</b>	<b>183</b>	<b>(102-137)</b>	<b>114</b>	<b>51</b>	<b>(85-150)</b>

\* The 14 states include Georgia, Kansas, Kentucky, Maine, Missouri, Nebraska, Nevada, New Hampshire, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, and Wisconsin.

† Indicated extremely low frequency (below 100 Hz) magnetic (M) or electric (E) field exposures reported in Bowman JD, Garabrant DH, Sobel E, Peters JM. Exposures to extremely low frequency (ELF) electromagnetic fields in occupations with elevated leukemia rates. *Appl Ind Hyg*. 1988;3:189-194.

‡ Industry and Occupation Codes (IOC) from the US Bureau of Census. *1980 Census of Population. Alphabetical Index of Industries and Occupation*. Final ed. US Dept of Commerce, Bureau of the Census; 1981. (Publication PHC-80-R3).

§ *International Classification of Diseases*. 10th rev. Geneva: World Health Organization; 1978.

|| Proportionate Mortality Ratio (observed/expected mortality × 100) was based on the proportionate mortality of 14 states' white men adjusted for age; PMRs were not calculated if number observed was less than 2.

¶ Obs, observed.

# 95% confidence intervals were calculated for PMRs based on a Poisson distribution. Rothman KV, Boice JD Jr. *Epidemiologic Analysis with a Programmable Calculator*. NIH Publication No. 79-1649. Washington, DC: US Government Printing Office; 1979.

report, the symbols E and M on the Table indicate occupations found to have exposures significantly above the 95th percentile of residential exposures.<sup>12</sup> As the Table shows, 6 of our 11 "electrical occupation" categories when measured<sup>12</sup> were found to have magnetic and/or electric field exposures.

We interpret our findings to be generally consistent with those reported previously and as a confirmation that occupational exposure in electrical occupations may be associated with enhanced leukemia risk. Particularly notable is the consistency across several studies of the elevated risk for telegraph, telephone, and related communications equipment operators and for telephone linemen and installers.

Although the exact cause of the leukemia excess is not clear, the occupations grouped as sharing exposures to electric and magnetic fields also may involve potential exposure to suspected leukemogenic chemicals, including pesticides, creosol, zinc chromate, coal tar pitch volatiles, polychlorinated biphenyls, polynuclear aromatics, and formaldehyde.

The job titles and classifications shown in the Table indicate the possible occupational exposures of "electrical occupations" but do not imply a causative link with increased leukemia mortality. Although electromagnetic field exposure cannot be definitely identified as a causative agent, some aspect of electrical occupations may be associated with increased mortality risk for the

workers in the occupations that should be investigated. Recent cellular level studies of electromagnetic fields have suggested that the fields may act as promoters rather than initiators of cancer.<sup>13</sup>

Limitations of the proportionate mortality methods include the random misclassification of retrospective exposure status and/or cause of death as reported on the death certificate. These limitations may result in biased estimates of risk, usually expressed as lowered PMRs.

The analytical investigations under way throughout the world should be pursued aggressively.

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### Politics: Indian Style

One of the most important political institutions borrowed from the Indians was the caucus. Even though the word appears to be proper Latin and some law students with a semester of Latin occasionally decline the plural as *causi*, the word comes from the Algonquian languages. The caucus permits informal discussion of an issue without necessitating a yea or nay vote on any particular question. This agreed with the traditional Indian way of talking through an issue or of making a powwow; it made political decisions less divisive and combative. The caucus became a mainstay of American democracy both in the Congress and in political and community groups all over the country. The caucus evolved into such an important aspect of American politics that the political parties adopted it to nominate their presidential candidates. In time this evolved into the political convention, which still functions as an important part of contemporary American politics, but is largely absent from European politics.

From *Indian Givers* by J. Weatherford, Fawcett  
Columbine, New York, 1988, p 145.