

The Effects of High Voltage Transmission Lines on the Health of Adjacent Resident Populations

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Abstract: A community health survey of 438 individuals was taken to detect health problems related to high voltage electrical transmission among an adjacent residential population. Results revealed no significant or consistent relationships between exposure to a high-voltage DC power line and the perceived health problems that were measured. The sample was not, however, large enough to draw statistically significant conclusions regarding possible health effects with a very low incidence. (*Am J Public Health* 1984; 74:76-78.)

As energy costs rise and new sources of energy are tapped, high voltage transmission lines become more and more economical for transferring large amounts of electrical power because the higher the transmission voltage, the more efficient and cheaper the transmission. As more and more high voltage lines crisscross the nation, related public health concerns mount.

There is no doubt that electric and magnetic fields can have biological effects. Yet epidemiologic studies which have attempted to detect related health effects in human populations have to date proved contradictory and inconclusive. Some indicate measurable effects,¹⁻⁴ while others do not.⁵⁻⁹ This research was designed to add to the available research in this area, examine several specific symptoms which have been connected to power line exposure in past research, and address some of the methodological problems which have plagued similar studies of adjacent resident populations.

Methods

A health effects survey was taken in a California community along the 400 kilovolt (kV) DC Pacific Intertie power line. This community includes a relatively dense cluster of houses close to a high-voltage power line, with a substantial number located immediately adjacent to the power line right-of-way. The Pacific Intertie line had been in place for over 10 years, so many long-term effects would have had time to develop in adjacent populations. This community never saw the kind of political controversy over power line construction and operation common to other communities, so the kinds of perception biases which can influence surveyed assessments of health were minimized.

The Pacific Intertie is a high voltage DC line, the type most often proposed for modern high volume power transmission. DC lines of this voltage are usually in corona, generating ions in the vicinity of the conductors that affect the magnitude of surrounding electric fields and ion concentration levels. According to measurements on a test line

comparable to the Intertie, electric field at ground level is approximately 21 kV/m under the positive pole and -16kV/m under the negative pole. This compares to an approximate average of .13 kV/m for ambient fair weather conditions. Charge density, a measure of ionization, is in the order of $\pm 10^{-8}$ C/m³ at ground level compared to background conditions of around $+ 10^{-11}$ C/m³. The line's magnetic field, around $.22 \times 10^{-4}$ T, is significantly less than ambient levels of about $.53 \times 10^{-4}$ T.¹⁰

These levels change substantially at any distance from the line. The power line right-of-way through the surveyed community varied but was generally 305 feet wide. The closest houses in the sample were within 125 feet of the power line ground center. At this distance, nominal electric and magnetic fields are barely distinguishable from background levels although the field effects of power line corona are often detectable. It is impossible to be more precise about corona field and ionization effects over distance because of the degree to which these depend on wind, precipitation, and other factors.

Ionization is of particular concern here because it is generally much more prevalent around DC lines than around AC lines and because of the degree to which it can be distributed by winds. Several researchers have posited that the noticeable physiological and psychological effects associated with dry desert winds in various parts of the world are due to higher than normal concentrations of positive air ions. Positively charged air ions have been thought to produce the "serotonin response" as well, in which an increase in the neurotransmitter substance, 5-hydroxy tryptamine (5HT), causes symptoms such as mucous membrane irritation, migraine headaches, nausea, and a variety of other symptoms.¹¹⁻¹³ In addition, despite the extremely low magnetic field levels present at any distance away from high-voltage lines, recent research has raised concerns about possible health effects of low level magnetic fields.^{2,9}

The study sample included all households living in homes five years or older in an area bounded on one side by houses directly adjacent to the Pacific Intertie right-of-way and, on the other, by an imaginary line .85 miles to the west. The neighborhood on the west side was chosen in order to minimize the confounding effects of a 230 kV AC line which paralleled the Intertie on the east.

The survey questionnaire was adapted from the National Health Interview Survey (HIS). This provides an extent of comparability to other community health surveys.¹⁴ Specific questions regarding symptoms connected to power line exposure in past research were added to the general items taken from the HIS. Households were the primary sampling unit, with data collected on all members of each household over the age of 2. Questions were asked directly of all adult household members who were present and indirectly about children and members who were not present.

Interviewing was conducted door-to-door over a 12-day period by three part-time interviewers who were college graduates and trained in the particular interviewing techniques used in this research. The intent of the survey with regard to power line health effects was kept hidden from respondents in order to minimize possible perception biases.

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Furthermore, interviewers and interview times were alternated over the entire sample in order to randomize possible bias.

Altogether, data were obtained from 128 households, a total of 438 individuals. The overall response rate (61.5 per cent) was lower than usually expected from door-to-door interviewing, probably because the community had been recently subject to sales people and pranksters posing as survey interviewers and so was unusually suspicious.

Weather conditions and spatial distribution governing the sample area ensured that there is relatively substantial exposure to power line electric field and ionization effects among a portion of the sample, and that there is another portion of the sample essentially insulated from such effects. Line operating conditions and weather patterns during and prior to the survey period are relevant to analysis of the symptoms which refer to a specific period of time prior to the survey point. Line operations during the period in question included a variety of conditions including full capacity, partial capacity, switching periods, and temporary down times. These conditions ensure a variety of electromagnetic environments which could cause effects in terms of the symptoms measured. Sensitivity tests were conducted to ensure that the brief down-time periods did not alter the basic effectiveness of the research design and analytic techniques.

Results

The houses in the sample clustered naturally into two groups, one group within about .14 miles of the power line center line and the other between .65 and .85 miles away. This provides an ideal situation for an exposed group—control group comparison that is immediately descriptive of the survey results. Table 1 presents proportion differences between these two groups for the health items that were measured. In addition, data for the group living immediately adjacent to the power line right-of-way are also presented for comparison to the control group proportions to identify possible effects of intense exposure.

As Table 1 indicates, there are no meaningfully significant differences between the proportions of people living

near the power line and those living away from it in terms of these reported health problems. This applies to both the exposed and adjacent groupings.

Several analytic techniques were used to search for other identifiable effects, including those possibly hidden by extraneous factors. For example, perceptions of health are clearly influenced by a number of social and situational factors.¹⁵⁻¹⁷ A number of variables including sex, age, occupation, level of education, race, and ethnicity were measured and analyzed to ensure that perceptual factors were not obscuring underlying health effects. In addition, individuals' presence or absence during the interview was recorded and analyzed to ensure that reporting bias did not affect the results.

Household distance from the power line is not the only variable affecting overall exposure to power line electromagnetic phenomena. The number of hours a person spends at home, the number of years in residence near the power line, and the construction materials and design of the dwelling could all conceivably affect exposure. Consequently, these factors were also measured. Finally, a number of scales were constructed in order to test for the possibility that power line exposure was resulting in cumulative health problems without being identifiable as the cause of the specific symptoms.

Extensive regression analysis of all of the above factors indicated no determinable health effects. Table 2 presents the result of one of the regression models used, in this case using a cumulative symptom scale as the dependent variable.*

Discussion

Because of limited population size, this research cannot confidently address questions regarding possible low-incidence health effects from power line exposure. Nevertheless, the distribution of health problems among this population was highly skewed and the patterns in this skewness point to the possibility of low incidence effects. For example, six people living directly adjacent to the power line

* Data from other regressions available from the author.

TABLE 1—Proportions of Exposed, Control, and Adjacent Groups Reporting Health Problems Near High Voltage Transmission Lines

Item	Exposed Group*	Control Group*	Difference**	Adjacent Group*	Difference**
Reporting health as only fair or poor	19 (.078)	18 (.093)	(-.015)	10 (.079)	(-.014)
Have been to doctor in the past month	58 (.237)	43 (.223)	(.014)	34 (.270)	(.047)
Been to doctor more than once in year	95 (.389)	81 (.418)	(-.029)	55 (.440)	(.022)
Had illness days in the past month	44 (.182)	38 (.202)	(-.020)	23 (.184)	(-.018)
Have limitations because of health	15 (.061)	19 (.098)	(-.037)	6 (.048)	(-.050)
Headaches at least once in past 2 weeks	67 (.273)	59 (.306)	(-.033)	31 (.246)	(-.060)
Sore/dry throat in past 2 weeks	64 (.261)	50 (.259)	(.002)	33 (.262)	(.003)
Stuffy nose/respiratory congestion in past 2 weeks	70 (.286)	52 (.269)	(.017)	34 (.270)	(.001)
Drowsy for no apparent reason in past 2 weeks	11 (.045)	5 (.026)	(.019)	5 (.040)	(.014)
Had rashes in past 2 weeks	12 (.049)	11 (.057)	(-.008)	4 (.032)	(-.025)
Tense for no apparent reason in past 2 weeks	4 (.016)	7 (.036)	(-.020)	2 (.016)	(-.020)
Felt dizzy in past 2 weeks	7 (.029)	5 (.026)	(.003)	3 (.024)	(-.002)
Depressed for no apparent reason in past 2 weeks	6 (.024)	7 (.036)	(-.012)	1 (.008)	(-.028)
Irritated eyes or dim vision in past 2 weeks	20 (.082)	17 (.088)	(-.006)	12 (.095)	(.007)
Reported conditions:					
allergies	6 (.024)	4 (.021)	(.004)	2 (.016)	(-.005)
asthma	4 (.016)	7 (.036)	(-.020)	3 (.024)	(-.012)

*Exposed group includes 245 people living within .14 miles of the power line; control group includes 193 people living between .65 and .85 miles away; adjacent group includes that portion of the exposed group living immediately adjacent to the power line right-of-way.

**None of the positive proportion differences are significant at the $p = .05$ level (one-tailed t test).

TABLE 2—Multiple Regression Results with Dependent Variable being Cumulative Symptoms Scale

	B	Beta	F
Factors Affecting Exposure			
Distance from the power line	-.015	-.035	.427
Years of Residence	.032	.054	1.058
Number of stories in house	-.665	-.061	1.329
Number of hours/day at home	.064	.014	.034
Factors Affecting Perceptions and Reporting			
Present during interview	.877	.136	6.066
Age	-.020	-.100	2.663
Occupational scale	.154	.100	1.557
Sex	.391	.061	1.315
Household size	-.270	-.116	4.146
Race (high = non-White)	.224	.031	.341
Household educational level	-.052	-.035	.392
Constant	5.186		

N = 376; R² = .053

right-of-way (4.8 per cent) reported having sore or dry throats for more than five days in the prior two weeks, while only one person living more than two-thirds of a mile away from the power line (0.5 per cent) reported this symptom to this degree. Also, nine people living adjacent to the line (7.1 per cent) reported having stuffy noses or respiratory congestion for more than five days in this same period, compared to five people (2.6 per cent) for the more distant group. The first difference is significant at the $p = .01$ level and the second at the $p = .05$ level. Because of the very small numbers of respondents responsible for these differences, they can not be attributed to power line exposure.

Another unresolved question involves the relationship between ion polarity and related power line health effects. High voltage DC power lines like the Pacific Intertie carry two conductors, one positive and one negative. Consequently, positive ions are generally created and transferred on the positive conductor side of the line and negative ions on the negative side. Because existing research appears to point to different biological effects relating to positive and negative ionization, this becomes an issue in analyzing research on power line health effects. Unfortunately, varying line operating conditions and sample sizes associated with this research make it impossible to analyze relationships between ion polarity and possible health effects.

It is possible that there are health effects resulting from power line exposure that have not received attention in research and, consequently, were not measured in this survey. If, for example, power line exposure of more than 10 years were to cause increased susceptibility of various types of cancer or affect the fetus during pregnancy, these impacts could not have been discovered by this research.

After noting all of these unaddressed issues, however, it is important to add that almost all of the health effects attributed to power line exposure in the literature to date have been the relatively high incidence effects of the type measured in this research.

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