TOPIC #12: GENERAL PUBLIC EXPOSURES

SYNOPSIS

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Purpose

To characterize the EMF exposure of the general public.

Introduction

Exposure of the general population occurs in several general environments: home, work, school, travel, and other, where the latter category includes time spent on such activities as shopping, recreation, health care services, and visiting friends. With the exception of the RAPID Engineering Project # 6 (Zaffanella and Kalton, 1998a; 1998b), EMF exposure assessments for the general public have concentrated on residential or occupational exposures or were not representative of the general population. Specific aspects of public exposure that are of interest are: the distribution of daily average exposures; distributions of average exposures within environments; differences in exposure associated with gender, age, work status, geographic region, and location (urban, suburban, rural); factors in different environments, such as residence characteristics or job category, that are associated with exposure measures; the temporal stability of personal exposures over different time periods and seasons; and relationships between different exposure measures.

Summary

The most extensive characterization of public exposure to magnetic fields was undertaken in RAPID # 6 (Zaffanella and Kalton, 1998b). This study characterized magnetic-field PE of the general population by performing PE measurements for a random sample of subjects from the general population. Significant effort went into developing a practical and cost-effective protocol for recruiting subjects, distributing instrumentation, recording time-activity information and collecting magnetic-field data. More than 1000 people participated in the survey of personal exposure for a 24-hour period. Based on the time and event data in an activity diary, the measurements in each data file were partitioned into the following categories: at home not in bed, at home in bed, at work, at school, during travel, and other. A variety of measures of the magnetic field was extracted for each subject and for each type of activity.

Some results of the Project are listed below. Additional results can be found in the published project summary and in the full report.

- The distribution of the average fields during a 24-hour period for the population of the U.S. is estimated to be log-normal, with a geometric mean of 0.89 mG (95% confidence interval [CI] from 0.85 to 0.93 mG) and a geometric standard deviation equal to 2.18 (95% CI from 2.10 to 2.27).
- It is estimated that 14.3% (95% CI from 11.8% to 17.3%) of the U.S. population is exposed to a 24-hour average field exceeding 2 mG, and 2.42% (95% CI from 1.65% to 3.55%) to a field exceeding 5 mG.
- About 1.6% of the people experience a field of at least one gauss (1000 mG) during a 24-hour period.
- The average field in school exceeded 2 mG for about 3.5% of the students, while the field at work exceeded 2 mG for about 21% of the workers, and the field at home exceeded 2 mG for about 14% of the people.
- Very little difference in 24-hour average magnetic field was found between men and women. The largest geometric mean among age groups was found for working-age people (geometric mean: 0.97 mG), followed by retirement-age people (0.80 mG), pre-school children (0.80 mG), and school-age children (0.76 mG). Little difference was found among different regions of the U.S.
- The lowest exposure at home was measured for people living in mobile homes, followed by single-family residences; duplex and apartments correspond to the largest exposures.

The results seen in the RAPID #6 study are consistent with earlier measurement projects. The results provide much more robust support for observations that had been made previously on the basis of limited samples or survey measurements alone.

A study sponsored by the RAPID Program measured 24-hour PE on several days for 70 office workers in the Seattle area (Hogue, 1995). For this group, the geometric mean 24-hour exposure was 1.28 mG, somewhat higher than the 0.89 mG found for the large sample in RAPID #6. This difference may be due to the small sample size and the limited urban area from which it was drawn. The geometric means in other categories were also higher for the limited office-worker study than for the large random sample. Contrary to the findings in the large sample, the office workers were observed to have higher exposures at home than at work. However, at-home PE measurements for the office workers did yield similar trends for higher exposure with the proximity to power lines, house size (number of bedrooms), and type of building (multi-family vs. single-family).

The distribution of average fields at home and wearing a meter observed during RAPID Project #6 was similar to that observed during the EPRI EMDEX Residential Study (Bracken et al., 1994). In that study, houses throughout the US and at one location in Canada were visited up to six times over a two-year period; PE measurements were collected by residents during periods when they were awake. A comparison of the data from that study with measurements from the RAPID Engineering Project #6 shows similarity in the distributions of the at-home exposures (Figure 12-1). The larger measured exposures for the lowest 80% of subjects in the EMDEX Residential Study may be due to the (non-random) sample that was limited to utility employees, and/or an artifact of the meter used in that study, which may not have been as stable or accurate at low fields as present-day instruments. The slightly higher exposures in the EMDEX project produced average at-home wearing-meter exposures of 1.44 mG, compared to 1.27 mG for RAPID #6, and median exposures of 0.97 mG compared to 0.73 mG for RAPID #6.

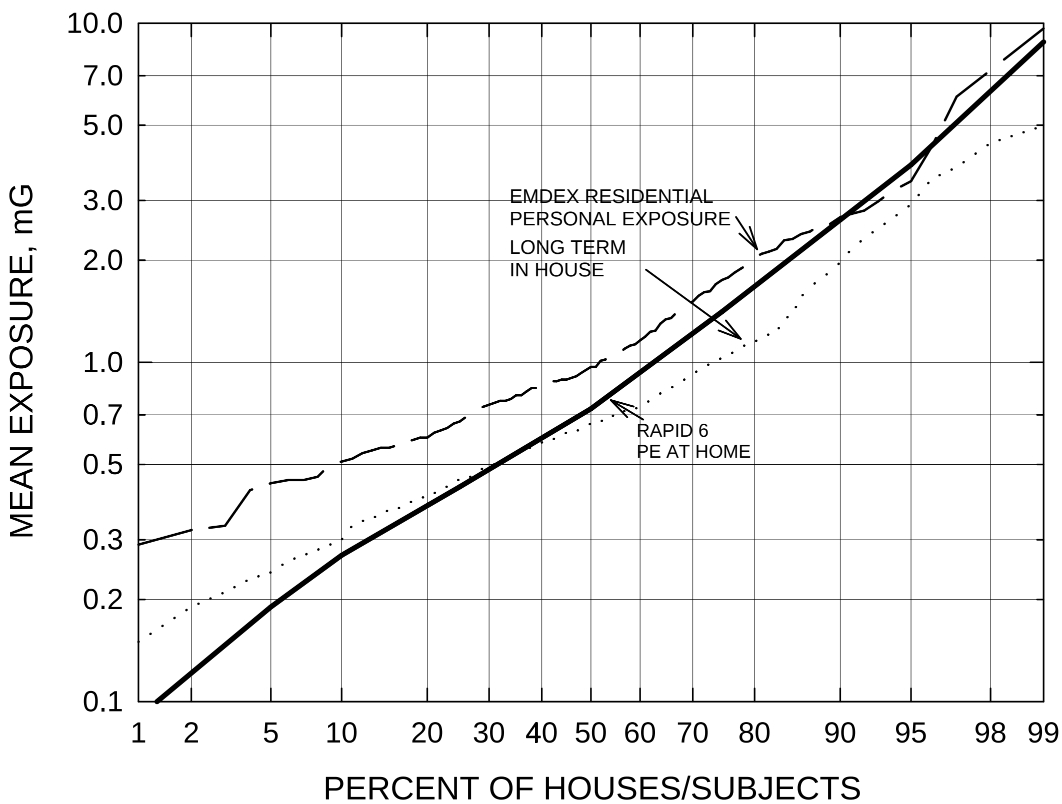

Figure 12-1. Distributions of average long-term measurements from EMDEX Residential Study and of average at-home exposures while wearing PE meter for the EMDEX Residential Study and RAPID Project #6, respectively. (Bracken et al., 1994; Zaffanella and Kalton, 1998b)

The observations from RAPID Project #6 that higher at-home exposures in residences are associated with the proximity of overhead power lines, multi-family dwellings, smaller houses, and metallic water lines (grounding efficacy) are consistent with fields measured during the EPRI 1000-home study (Zaffanella, 1993a; 1993b) and the other previously mentioned studies

(Bracken et al., 1994; Hogue, 1995). However, there is still considerable variability of exposures within specific categories, such as among small houses or within houses with the same wire code category (cf., Zaffanella, 1993a; Bracken et al., 1994). This variability within seemingly similar houses is sufficient to make problematic the use of these broad categories as accurate predictors of personal exposure for individuals.

The relatively low exposures in schools noted in RAPID #6 are consistent with survey measurements in schools conducted during RAPID Engineering Project #3 (Zaffanella, 1996) and with PE measurements during the pilot studies for RAPID Engineering Project #4 (Bracken et al., 1997), although these latter were performed in only two schools.

PE stability over time is of particular concern when trying to extrapolate from contemporary measurements to past or future exposures. The longest period over which personal exposures have been compared is approximately 700 days.

The Seattle office worker study compared exposures up to about 40 days apart and found that they were relatively stable over that period: the Pearson correlation coefficient between exposures more than 40 days apart was about 0.6, and higher values were observed for shorter periods between measurements. The principal source of variability for a subject's exposure in the study was within-day, not between-day, variability.

The EMDEX project found that, in general, PE measurements at a house were relatively stable over the two-year period of the study. The correlation between PE measured during the first visit to a house and the mean of PE for all visits to a house was 0.79. There was no apparent temporal pattern for the differences between average exposures for successive visits to a house separated by from 50 to more than 700 days. A variance component analysis indicated that the differences in fields between houses are much greater than the difference in fields between visits to a house.

Personal exposure includes exposures to appliances and other sources while moving through the variable field found in a house, and so can be expected to be higher than long-term average measurements or spot measurements taken away from sources. The consistent elevation of PE data above long-term measurement data from the EMDEX Residential Study is shown in Figure 12-1.

The contribution of domestic appliance use to time-weighted average (TWA) exposures could not be ascertained in an assessment of the exposures of 50 women in the U.K. in a study sponsored by the RAPID Program (Kaune et al., 1996). However, the use of domestic appliances was found to be associated with peak exposures.

Implications for Risk Assessment

Despite its limitation, the RAPID #6 survey provides data for an assessment of the number of people at risk, should researchers one day be capable of defining risk in terms of some of the quantities measured during this survey. Besides the TWA during a 24-hour period and while in specific environments, the survey provided data on other possible measures of exposure during the same periods.

The number of individuals with exposures many times greater than the overall geometric mean exposure is relatively small, making identification of high-exposure (purportedly high-risk) population difficult.

The reduced levels of exposure for children when compared with adults may indicate that adjustment of previously estimated exposures for children based on measurements of adult exposure is warranted.

Care must be taken in extrapolating to general population exposures from studies with small sample size or limited geographic diversity. Conversely, the distribution of exposures for a large diverse population may not be representative of the exposures in a particular locale.

Remaining Questions

RAPID #6 has provided a large data set that can be analyzed to investigate the association of exposure with the subject and residence information collected during the project. These analyses can examine indicators of elevated exposure in terms of TWA and other measures such as peak and time above thresholds and investigate relationships between different measures of exposure.

The stability of exposure over time remains an issue, especially in assigning past exposures. Questions that remain include:

1. the variability of personal exposure from day to day;
2. the effect of the day of the week (weekday versus weekend);
3. the association of exposures with seasons, and the variability of occupational and residential exposures over periods longer than a year.

What factors contribute to the finding that PE measurements are consistently higher than average spot measurements? *Possible contributors are: 1) exposures from appliances during PE; and 2) higher fields near the walls which spot measurements do not necessarily capture but PE measurements do because of activity patterns.*

References

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