SECTION 6

DISCUSSION AND CONCLUSIONS

6.1 Estimates for the U.S. Population. Limitations and Strengths of the 1000-People Survey

The results presented in Section 5 were estimates for the general U.S. population obtained by applying proper weights to each participant in the survey. Although several measures of exposure were given, the most widely recognizable results of the survey are the 24-hour average magnetic fields. The estimated distribution of the 24-hour averages and its 95% Confidence Interval (CI) is shown again in Figure 6.1 and with expanded scales in Figure 6.2. Some of the parameters of the distribution and their 95% CI are shown in Table 6.1.

Table 6.1 Estimate, Standard Error, and 95% Confidence Interval of the Parameters of the Descriptive Statistics of 24-Hour Average Magnetic Field

Parameter	Estimate	Standard Error	95% CI 2.5%	97.5%
Mean of 24-Hour Average Fields	1.25 mG	0.044 mG	1.16	1.33
Standard Deviation	1.51 mG	0.19 mG	1.13	1.88
Geometric Mean of Average Fields	0.89 mG	0.022 mG	0.85	0.93
Geometric Standard Deviation	2.18	0.043	2.10	2.27
Median	0.87 mG	0.033 mG	0.81	0.93
People with 24-Hour Average > 0.5 mG	76.3 %		73.8 %	78.9 %
People with 24-Hour Average > 1 mG	43.6 %		40.9 %	46.5 %
People with 24-Hour Average > 2 mG	14.3 %		11.8 %	17.3 %
People with 24-Hour Average > 3 mG	6.3 %		4.7 %	8.5 %
People with 24-Hour Average > 4 mG	3.6 %		2.5 %	5.2 %
People with 24-Hour Average > 5 mG	2.42 %		1.65 %	3.55 %
People with 24-Hour Average > 7.5 mG	0.58 %		0.29 %	1.16 %
People with 24-Hour Average > 10 mG	0.46 %		0.20 %	1.05 %
People with 24-Hour Average > 15 mG	0.17 %		0.035 %	0.83 %

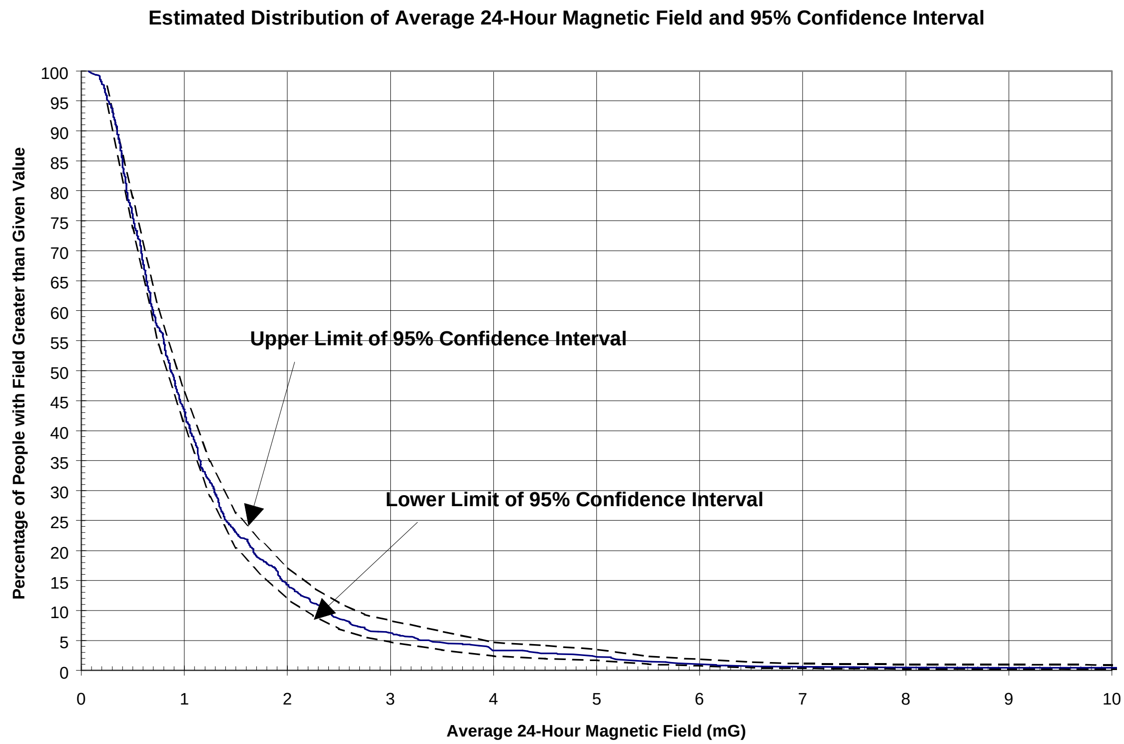

Figure 6.1 Estimated Distribution of 24-Hour Average Magnetic Fields and 95 % Confidence Interval

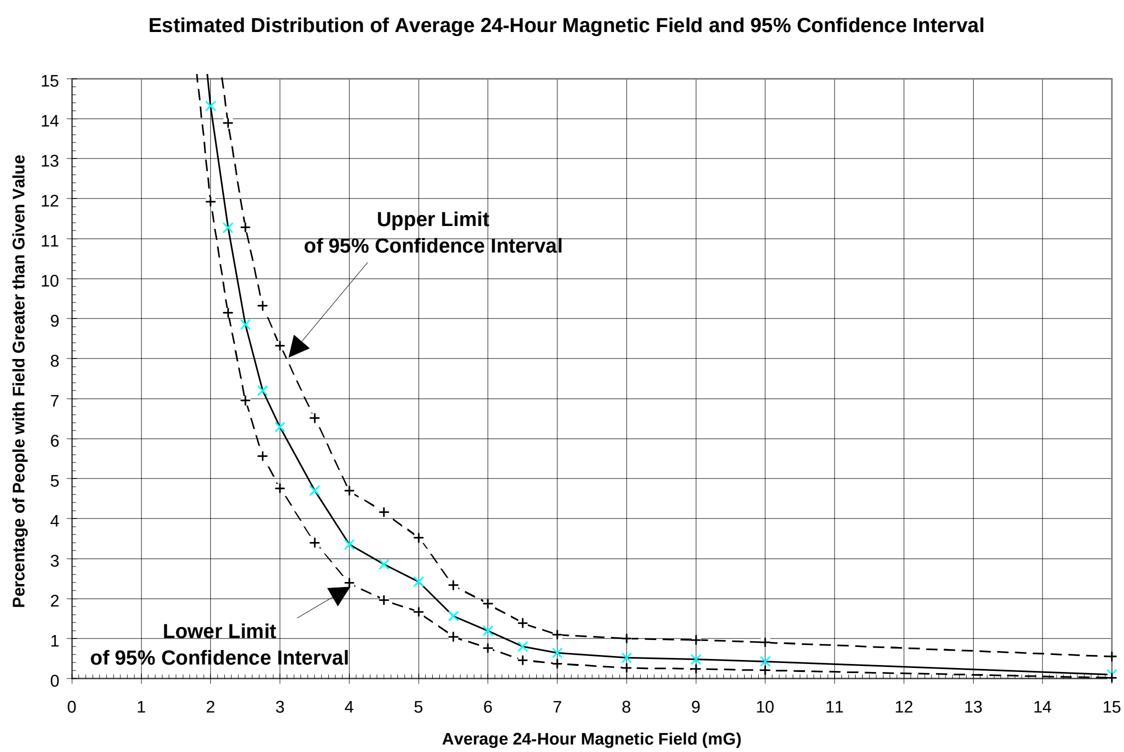

Figure 6.2 Same as Figure 6.1 but with an Expanded Vertical Scale. Estimated Distribution of 24-Hour Average Magnetic Fields and 95 % Confidence Interval

The accuracy described in Table 6.1 and Figures 6.1 and 6.1 is the "statistical accuracy", caused by the fact that the measurements were made with a limited number of samples. The data show that the relative accuracy is worse for the tails of the distribution than for the values around the median. For instance, the 95% CI of the percentage of people with 24-hour average fields greater than 1 mG is about ±2.8% around a value of 43.6%. This represent a relative value of the 95% CI equal to about 13%. On the other hand, the 95% CI of the percentage of people with 24-hour average fields greater than 5 mG goes from 1.65% to 3.55% with a central value of 2.42%; this is a much greater relative interval equal to 80% of the central value. If the above results are translated in number of people, using a figure of 267 million people for the U.S. population, the results can be expressed as follows: with 95% confidence, the number of people with 24-hour average magnetic field greater than 1 mG is between 109 and 124 million, and the number of people with 24-hour average magnetic field greater than 5 mG is between 4.4 and 9.5 million.

Statistical accuracy is not the only limitation of the study. There are other reasons why the results must be interpreted cautiously. First, being a telephone sample, the survey failed to cover non-telephone households (about 5% in the U.S.). Second, the survey did not include military personnel, nursing homes, hospitalized people, people in prison, and any other institutionalized people. Finally, and most importantly, the response rate was only 28.4 %, which is very low and raises the potential for a significant non-response bias.

The strength of the survey is in the random selection of the participants. The response rate, although low, was relatively uniform across the age, gender, and region of the participants. The survey is the first significant study that quantifies the exposure of the general population for the entire day, not only for the time spent in one's residence but also for the time a person is outside the home, working, in school, traveling, or performing other activities.

Despite its limitations, the 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. The survey provided data not only regarding the 24-hour average magnetic field, but also data on the time above defined field values, on the length of time during the field is constant, on the number of sudden field changes, and on the magnetic field values during different types of activities.

6.2 Estimating Yearly Average Magnetic Field for the U.S. Population.

The study was conducted using a practical approach to provide as much information as possible in a cost effective way. In the determination of individual yearly average exposure, the study has three weaknesses that must be overcome:

1. The 1000-people survey of personal magnetic field exposure has provided a snap shot of 24-hours of exposure for each survey participant. The study did not generate any

information on the variability of the 24-hour average magnetic field of a person measured during different days of the year.

2. Almost all (95.3%) the measurements were taken during a week day. Exposure during weekends may differ significantly because of the absence of "work" and "school" periods and because of the possibility of significantly different people activity patterns.
3. Because of the desire to deliver results in a short period of time, all measurements were made in four months: December 1997, and January, February, March, 1998. These months are the coldest months of the year; electricity consumption and people activity patterns (two factors affecting magnetic field response) during these months are not representative of the entire year.

The possible ways to estimate the effect of each of the above three items on the yearly average are discussed below.

Variability throughout the year

As mentioned, this study did not provide any data on the variability throughout the year. The best data available are from EPRI's "EMDEX Project" [5]. In that study, the residential exposure was measured for 396 residences visited several times throughout the year for a total of 1552 visits (about 4 visits per residence). Several quantities were measured, including personal exposure measurements for the period "at home not in bed". The study looked at the variability between houses and at the variability within-house (between visits) and concluded that "magnetic field measurements in a house were generally stable from visit to visit" and "between-house variability was generally greater than within-house variability". The study reported the variance between visits to the same house for each wire code. From the data reported in reference [5] the overall standard deviation associated with this variance was calculated and was found to be equal to about 0.55 times the average. If, for all persons, we assume that the distribution of 24-hour averages measured in different days is log-normal, then the geometric standard deviation of the distribution is 1.55 and the arithmetic mean of this distribution is about 12% greater than the geometric mean.

The variance of the distribution of 24-hour measurements reported in Figures 6.1 and 6.2 and whose parameters are described in Table 6.1, is a combination of the variance between the yearly median values of the 24-hour average magnetic fields of all the people in the population and the variance of the distribution of the 24-hour averages measured for the same person in different days of the year.

The geometric mean of the true distribution of yearly medians of the 24-hour averages coincides with the geometric mean (0.88 mG) of the measured distribution, assuming that the day of the measurements is randomly chosen throughout the year (this is not entirely true and it will be discussed separately). The geometric standard deviation of the true distribution, however, is lower than the measured value. In fact, the measured geometric standard deviation (2.18) results from the combination of the geometric standard deviation, GSD_{true}, of the true distribution of yearly medians and the geometric standard deviation of the distribution of individual 24-hour averages measured throughout the year (1.55). If the assumptions made are true, the true geometric standard deviation is: GSD_{true} = 2.04. To obtain the distribution of the yearly median of the 24-hour averages, the distribution of Figures 6.1 and 6.2 should be corrected as follows: no correction for the 50% value, an adjustment factor of 2.04/2.18 = 0.935 at the 84% value (median plus one standard deviation), an adjustment factor of 0.875 at the 97.5% value (median plus two standard deviations) and so on.

The distribution of yearly average magnetic field can be calculated by multiplying by 1.12 the previously calculated distribution of the yearly median of the 24-hour averages.

Difference between weekday and weekend

The exposure for a weekend day was estimated by assuming that the average field during the periods "at work" or "in school" were the same as the average field during the "at home" period. In other words, it was assumed that the people stayed at home, instead of going to school or work. The 24-hour average was then built for an average day of the week, equal to five times the weekday average plus two times the weekend average divided by seven. The distribution of magnetic field averages for the average day of the week was calculated. The geometric mean of the 24-hour average magnetic field distribution for the average day of the week (0.880 mG) is only slightly lower than the geometric mean of the 24-hour average magnetic field distribution for a weekday (0.889 mG). The geometric standard deviation was practically the same (2.191 instead of 2.185). Thus the effect of the day of the week translates into a correction factor equal to 0.99 at the 50% value of the distribution and equal to 0.996 at the 2.5 % value (median plus two standard deviations).

Effect of concentrating the measurements during the winter months

Data on seasonal effects of personal exposure measurements are not available at this time. In some region of the country (e.g. some parts of California), seasonal effects may be minor. In some other regions (e.g. Midwest and Northeast) peoples activities are more concentrated indoors and consumption of electricity is higher in the winter than in the other seasons. Therefore, it is expected that, in these regions, personal exposure measurements would give higher values in the winter than in other seasons. Finally, in some other regions (e.g. South) people activities are more concentrated indoors and consumption of electricity is higher in the summer than in the other seasons. Therefore, it is expected that, in these regions, personal exposure measurements would give lower values in the winter than in other seasons. Overall, no correction factor can be proposed to compensate for the effect of season. This, however, remains an open issue.

Conclusion

In conclusion, the distribution of yearly average magnetic fields can be estimated from the distribution of 24-hour average magnetic fields (Figures 6.1 and 6.2, Table 6.1) by multiplying the field values by the a factor F: at the 50% value F = 1.12 x 0.99 = 1.11; at the 84% level F = 1.12 x 0.935 x 0.993 = 1.04; and at the 2.5 % level F = 1.12 x 0.875 x 0.996 = 0.98.

6.3 Comparison with Other Data

Comparison with other data can be made for residential exposure, which has been studied more than exposures in any other environment.

The distribution of the average magnetic fields obtained by the 1000-people survey during the period “at home not in bed” were compared with the data obtained by the EPRI 1000-home study [4] (average spot measurements in randomly selected residence), and with the personal exposure data obtained by the EMDEX Project [5] (measurements in single family dwellings of electric utility volunteers, adjusted to reflect the prevalence of wire codes in the general population). The data from the three different studies are compared in Table 6.2. The distributions of the at-home data are compared also in Figure 6.3. Personal exposure measurements show consistently higher values than spot measurements. The agreement between the two sets of data for average fields greater than 2 mG is excellent.

Table 6.2 Comparison between the “at Home not in Bed” Data from Different Studies

	1000-People Study	1000-Home Study	EMDEX Project
Number of people/residences with field			
> 1 mG	38.3 %	28 %	48 %
> 2 mG	14.3 %	10.5 %	21 %
> 3 mG	7.7 %	4.8 %	
> 5 mG	3.5 %	1.8 %	4 %
>10 mG	0.46 %	0.1 %	

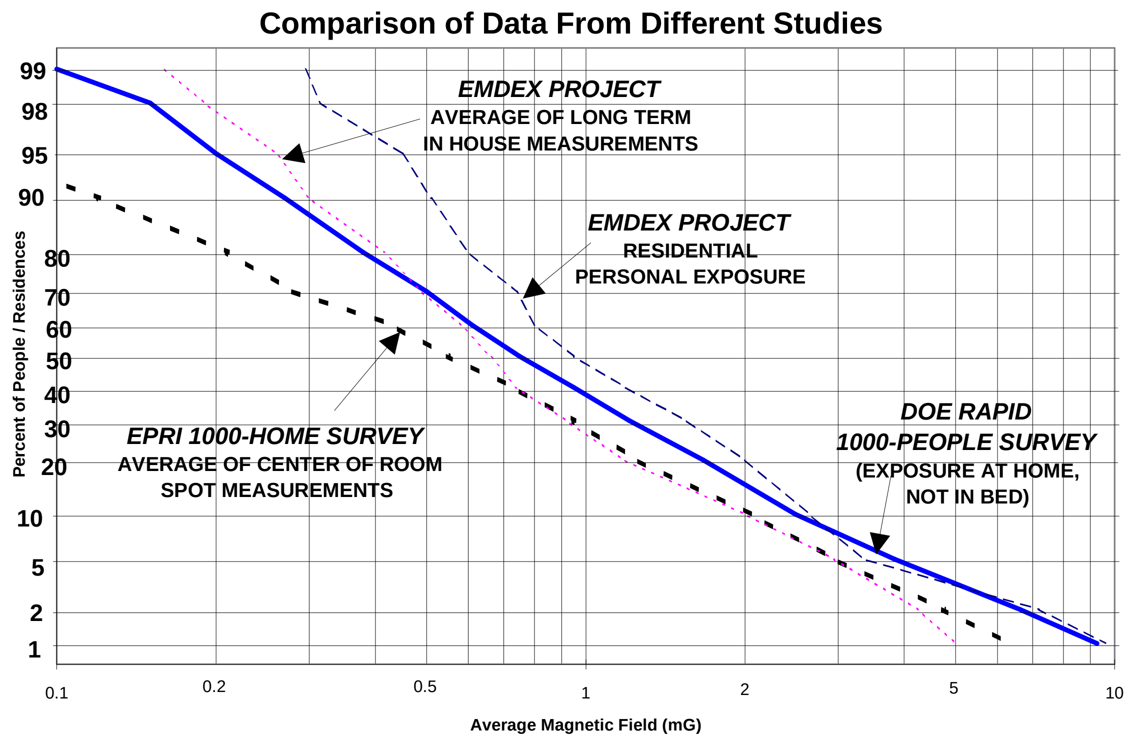

Figure 6.3 Comparison of Data from Different Studies

Another possible comparison is with the data obtained on 200 randomly selected adults during Phase I of this project [1]. This comparison is shown in Table 6.3. It should be noted that the results from the pilot were not weighted for response from various groups of people. The results from Phase I and Phase II agree well within the accuracy of the data.

Table 6.3 Comparison with 24-hour Average Data on Adults from Phase I

	874 Adults Phase II	200 Adults Phase I
Number of people/residences with field		
> 1 mG	45.6 %	52.2 %
> 2 mG	15.3 %	18.4 %
> 3 mG	6.6 %	8.0 %
> 5 mG	2.7 %	3.5 %
>10 mG	0.6 %	0.5 %

6.4 Conclusions

1. The estimated distribution of the average fields during a 24-hour period for the population of the U.S. has a geometric mean of 0.89 mG (95% 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). The distribution is close to log-normal in the range of average 24-hour fields from 0.3 mG to 3 mG. For average 24-hour fields greater than 3 mG, the best log-normal approximation has a geometric mean equal to 0.5 and a geometric standard deviation equal to 3.1.

2. 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. It is estimated that 6.3 % (95% CI from 4.7 % to 8.5 %) of the U.S. population is exposed to a 24-hour average field exceeding 3 mG. It is estimated that 2.42 % (95% CI from 1.65 % to 3.55 %) of the U.S. population is exposed to a 24-hour average field exceeding 5 mG. It is estimated that 0.46 % (95% CI from 0.20 % to 1.05 %) of the U.S. population is exposed to a 24-hour average field during a 24-hour period exceeding 10 mG.

3. About 25% of the people spend more than one hour at fields greater than 4 mG, and about 9% of the people spend more than one hour at fields greater than 8 mG.

4. About 1.6% of the people experience at least one gauss (1000 mG) during a 24-hour period.

5. The largest average fields (experienced by a few percentage of the people) were recorded during the period “at work”. The lowest average fields were recorded during the period “at home, in bed”. 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.

6. For the periods “at work” the distribution of the average magnetic fields had the largest geometric mean (1.61 mG) for the electrical occupations (whose data, however, were few), followed by the service occupations with 1.59 mG, technical, sale, and administrative support occupations with 1.09 mG, managerial and professional specialty occupations with 0.99 mG, precision production, craft and repair occupation, operators, fabricators, and laborers with 0.89 mG, and farming, forestry, and fishing occupations with 0.45 mG. The geometric standard deviation of the “at work” distribution of average field (2.57) is significantly larger than for the distribution of the 24-hour period averages (2.18). Some people at work are significantly more exposed than in other situations.

7. Very little difference in 24-hour average magnetic field was found between men and women (geometric mean 0.90 mG versus 0.88 mG). The largest geometric mean among age groups was found for working age people (geometric mean = 0.97 mG), followed by retirement age people and 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 largest geometric mean was found for the Northeast (1.00), followed by West and Midwest (0.87), and South (0.86).

8. The following parameters appear to affect the distribution of exposures at home: residence type, residence size, type of water line and proximity to overhead power lines. 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 highest exposures at home is in smaller houses and in houses with metallic, rather than plastic, pipes. The exposure at home tends to increase as the distance to the nearest overhead line decreases. Proximity to three-phase electric power distribution and transmission lines correspond to the larger exposures than proximity to other types of lines or no line at all.

9. The response rate was very low and there is the potential for a significant non-response bias. The strength of the survey is in the random selection of the participants. The response rate, although low, was relatively uniform across age groups, gender, and regions of the participants.

10. The survey is the first significant study that quantifies the exposure of the general population for the entire day, not only for the time spent in one's residence but also for the time a person is outside the home, working, in school, traveling, or performing other activities.

11. The survey provided 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. The survey provided data not only regarding the 24-hour average magnetic field, but also data on the time above defined field values, on the length of time during the field is constant, on the number of sudden field changes, and on the magnetic field values during different types of activities.