**SURVEY OF PERSONAL MAGNETIC FIELD EXPOSURE**
**Phase II : 1000-Person Survey**

## SUMMARY

The objective of this project is to characterize personal magnetic field exposure of the general population, by performing personal exposure measurements for a sample of the population. The project is in two phases. Phase I was designed to develop survey methodologies and to conduct a small scale survey. Phase II consisted in a large scale survey using the methodology developed in Phase I. A little more than 1000 people participated in the survey of personal exposure for a 24 hour period. The protocol of the survey consisted of the following steps:

1. Telephone numbers were randomly selected using list-assisted Random Digit Dialing (RDD) methodology.
2. An introductory letter was sent to all persons corresponding to the selected numbers who were listed on telephone directories.
3. The letters were followed up by telephone calls. Telephone calls were also made to households that were not sent an introductory letter. The respondent was interviewed in order to select and recruit a household member for possible participation in the survey.
4. A Consent Form and a letter that illustrated the reasons and modality of the survey was sent to all the people who had agreed to participate.
5. The Consent Form was to be signed by the participants (or their parents or guardians) and returned before measurements could be performed.
6. Upon return of the signed Consent Form, the participants were sent a package containing a personal meter, the instructions for the use of the meter, a small diary to be used to write the type of activities performed, a questionnaire, and a fifty dollar check for compensation for participating in the study. The personal exposure meter was of the size of a pager and could be clipped to a belt or placed in a pocket. For infants and toddlers, the meter was to be placed inside a teddy bear, to be worn as a backpack or kept near them for the day of the measurements.
7. The participants wore or kept the meter with them for 24 hours from the moment they first activated the meter. Magnetic field values were recorded every 0.5 seconds. Summary statistics were stored in the meter's memory every ten minutes. The participants recorded the time when certain activities (at home not in bed, at home in bed, travel, work, or school) started or ended. After 24 hours of measurements, the meter was mailed back.
8. The meter's data were transferred to a computer file. The information from the diary and from the questionnaire was transcribed in a computer database. The magnetic field exposure for the entire 24-hours was calculated using a special software developed for the meter. The meter's calibration was checked and the meters were prepared for new participants. A letter was sent to the participants with the results of their individual measurements.
9. The data from the meters, diaries, and questionnaire were analyzed.

The personal exposure measurements started in November 1997 and were completed on April 3, 1998. In total 1,012 meters with usable data were returned. Overall 3,867 households were contacted, 1,796 persons were recruited by phone, 1,718 persons were sent a Consent Form, 1,120 persons returned a signed Consent Form, 1079 persons were sent a meter, 1050 meters were returned in time for inclusion of the data in this final report, and 1012 meters had valid data. Based on the time and event data in the 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 were extracted for each subject and for each type of activity, including time spent for the activity, mean, standard deviation, geometric mean, geometric standard deviation, minimum and maximum, various percentiles from 1$^{st}$ to 99$^{th}$, time spent above various field thresholds (from 0.5 to 64 mG), number of sudden field changes, length of time with constant field, and an index of intermittence.

In order to generate representative sample estimators of the general population, each participant was assigned a weight that takes into account the chance of selection of the person in the sample, and that can be interpreted as the number of persons in the population that the sample person is "representing". The parameters of the estimated distribution of the 24-hour magnetic field for the U.S. population are shown in Table S-1.

**Table S.1 Estimate and 95% Confidence Interval of the Parameters of the Distribution of 24-Hour Average Magnetic Fields**

| Parameter | Estimate | 95% CI | |
|---|---|---|---|
| | | 2.5% | 97.5% |
| **Mean** of 24-Hour Average Fields | 1.25 mG | 1.16 | 1.33 |
| Standard Deviation | 1.51 mG | 1.13 | 1.88 |
| **Geometric Mean** of Average Fields | 0.89 mG | 0.85 | 0.93 |
| Geometric Standard Deviation | 2.18 | 2.10 | 2.27 |
| **Median** | 0.87 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 % |

Participants were asked to keep a diary of their activities so that magnetic field exposure could be evaluated not only for the total 24-hour period but also for different types of activities. The results for different activities are shown in Table S.2.

**Table S.2 Descriptive Statistics for Different Activity Periods**

| Parameter | Home not in Bed | In Bed | Work | School | Travel | 24-Hour |
|---|---|---|---|---|---|---|
| Number of Valid Data Sets | 1011 | 996 | 525 | 139 | 765 | 1012 |
| 1st Percentile | 0.10 mG | 0.01 mG | 0.14 mG | 0.13 mG | 0.13 mG | 0.18 mG |
| 5th Percentile | 0.20 mG | 0.08 mG | 0.24 mG | 0.18 mG | 0.29 mG | 0.27 mG |
| 10th Percentile | 0.27 mG | 0.12 mG | 0.30 mG | 0.29 mG | 0.41 mG | 0.35 mG |
| 25th Percentile | 0.44 mG | 0.24 mG | 0.60 mG | 0.35 mG | 0.66 mG | 0.51 mG |
| **50th Percentile** | 0.75 mG | 0.48 mG | 0.99 mG | 0.60 mG | 0.98 mG | 0.87 mG |
| 75th Percentile | 1.39 mG | 1.24 mG | 1.78 mG | 1.01 mG | 1.46 mG | 1.41 mG |
| 90th Percentile | 2.49 mG | 2.44 mG | 3.32 mG | 1.64 mG | 2.18 mG | 2.38 mG |
| 95th Percentile | 3.89 mG | 3.63 mG | 5.00 mG | 1.77 mG | 2.73 mG | 3.38 mG |
| 99th Percentile | 9.50 mG | 9.19 mG | 13.5 mG | 3.55 mG | 5.43 mG | 6.16 mG |
| **Mean** | 1.29 mG | 1.11 mG | 1.73 mG | 0.82 mG | 1.22 mG | 1.25 mG |
| Standard Deviation | 2.54 mG | 2.06 mG | 3.09 mG | 0.70 mG | 0.99 mG | 1.51 mG |
| **Geometric Mean** | 0.80 mG | 0.52 mG | 1.03 mG | 0.64 mG | 0.96 mG | 0.89 mG |
| Geometric Standard Deviation | 2.50 | 3.52 | 2.57 | 2.06 | 2.03 | 2.18 |

The following conclusions could be drawn from the 1000-person sample:

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.