Abstract of EMF RAPID Engineering Project #7: Development of Field Exposure Prediction Models

Project #7 sought to develop a general model for estimating magnetic-field personal exposure (PE) of individuals or groups. The developed model combines time/activity pattern information with PE, area, and/or magnetic-field source information to estimate personal exposure.

Interviewers administer questionnaires that specifically target time/activity information germane to environments, EMF exposure components, and presence or use of appliances and tools. Measured and/or estimated magnetic-field information can be combined in the model.

The model defines four classes of subjects by age, and further distinguishes between urban and rural exposures. Contributions to exposure fall into three categories: (1) baseline exposures, (2) exposure components related to activity and/or location, and (3) field sources such as appliances and tools. Baseline exposures are defined so that exposure components and field sources generally increase estimated exposures.

The project demonstrates computational models that address three field parameters requiring different computational algorithms: time-weighted-average field (TWA), peak field, and harmonic field exposures. Point estimates or probability distributions can be assigned to the input parameters for the model. The exposure model is capable of computing estimates of either contemporaneous or historical exposure estimates. The demonstration models were developed using commercial spreadsheet software; however, they can readily be implemented on a variety of hardware and software platforms. The model can also be easily adjusted to accommodate new data or alternative assumptions. The questionnaire is being implemented in pilot studies; modeled exposures will be compared with measured exposures.

PE measurements are the preferred source for estimating baseline exposures and exposure components. Field values for sources were based on measurements reported in the literature and assumed distances during use. Criteria for inclusion of exposure components of sources in computations were established. Computational algorithms have been completed for the three demonstration exposure parameters.

The final report for this project is in preparation.

Study limitations

The demonstration of the model used probability distributions for field levels that were, in many instances, arbitrary. The empirical basis for combining fields associated with various EMF factors and for assigning probability distributions to inputs for the model is not strong. A limited number of sources is included in the model and, therefore, in the questionnaire. Except for electric blankets, only point estimates have been introduced for sources. The investigators used a subjective assignment of distance for estimating TWA and peak exposures.

Areas for future research

Additional investigation of probability distributions for field levels and their assignment would be useful. The model could readily include additional sources or incorporate a more sophisticated assignment of exposure values in the future.

Activity categories used in diaries and questionnaires are not necessarily linked to EMF exposures. Development of activity categories and questions specific to EMF exposures could reduce uncertainty in model predictions.

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Development of Field Exposure Prediction Models

Purpose and Focus

Project #7 sought to develop a general exposure model and demonstrate the technique for estimating magnetic-field personal exposure (PE) for individuals or groups.

Development of Method

The model employs exposure estimates for four environments (home, school, work, other); for four classes of subjects by age (preschoolers, children, adults, and seniors); and for two locales (urban/rural). It combines time/activity pattern information with PE, area, and/or magnetic-field source information to estimate personal exposure. Actual or estimated time/activity pattern information can be used.

Interviewers administer questionnaires to individuals or experts to obtain subject characteristics and estimated time/activity information. The questionnaire specifically targets time/activity information germane to environments, EMF exposure components, and presence or use of appliances and tools. Measured and/or estimated magnetic-field information can be combined in the model.

Contributions to exposure fall into three categories: (1) baseline exposures, (2) exposure components related to activity and/or location, and (3) field sources such as appliances and tools. The model specifies these exposure contributors for each of four environments: home, school, work, and other. Baseline exposures are defined so that exposure components and field sources generally increase estimated exposures.

The project demonstrates computational models that address three field parameters requiring different computational algorithms: time-weighted-average field (TWA), peak-field, and harmonic-field exposures.

- The TWA model (a traditional measure) requires that both the field level and time associated with environments, activity/locations, and sources be known.
- Modeling peak-field exposure (maximum exposure) requires knowledge about activity/locations and/or presence of sources.
- Estimating exposure to harmonics is difficult because there is so little data on harmonic fields. Consequently, this model will be less quantitative, with harmonic-field exposures expressed in terms of the percentage of time that harmonic fields may be present.

Sources are characterized by field levels at a distance determined by typical use. Estimates of baseline exposures, exposure components, and field sources were obtained from the literature, especially that of other RAPID projects. The exposure model is capable of computing estimates of either contemporaneous or historical exposure estimates. Point estimates or probability distributions

can be assigned to the input variables, yielding point estimates or distributions for the exposure estimates.

The demonstration models were developed using commercial spreadsheet software; however, they can readily be implemented on a variety of hardware and software platforms. The model can also be easily adjusted to accommodate new data or alternative assumptions.

The questionnaire is being tested in pilot studies. Modeled exposures will be compared with measured exposures from these pilot studies.

The investigators concluded that no single approach to modeling EMF exposure is appropriate. Different approaches, algorithms, and assumptions may be appropriate between and within environments and for different sources. Subject attributes (e.g., age, gender) may affect the time spent in environments, activities, and near sources, but these attributes are not likely to affect baseline field levels. The use of a Monte Carlo simulation program to introduce distributions for selected field and time variables greatly enhances the value of the model.

Summary

Baseline exposures were established for each of the eight groups (four age groups, urban and rural) in the four environments. Exposure components and sources were identified and assigned field values in the four environments. PE measurements are the preferred source for estimating baseline exposures and exposure components. Field values for sources were based on measurements reported in the literature and assumed distances during use. Criteria for inclusion of exposure components of sources in computations have been established. For example, for TWA estimates, only components with exposures (field multiplied by time) that exceed baseline exposures by a pre-selected percentage are included. Computational algorithms have been completed for the three demonstration exposure parameters. The final report for this project is in preparation.