TOPIC #10: SURROGATES FOR PERSONAL EXPOSURE

SYNOPSIS

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Purpose

To summarize the state of knowledge regarding surrogates for magnetic-field exposure, especially their effectiveness and generality.

Summary

Risk assessments require knowledge of the exposures of affected populations to a particular agent or agents; i.e., they require an exposure assessment. Such an assessment may be made using one or a combination of three basic tools: surrogates, models, and monitoring (CEQ, 1989). Surrogates are substitutes for the actual agent, and are assumed to reflect actual exposure levels. For a workplace exposure, the simplest surrogate is employment in the industry. Ideally, a surrogate can be used quantitatively. An investigator can use the number of cigarettes smoked per day, for instance, as a surrogate for exposure to cigarette smoke.

The most familiar surrogate for EMF exposure in residences is the Wertheimer and Leeper (1979) wire-code scheme. In their study of childhood cancer, they divided the study population into exposure groups according to the thickness, proximity, and number of phases of nearby electric lines. The bases of the scheme are that magnetic-field levels depend directly on current and decline with distance from a source. Thicker wires are assumed to carry more current than do thinner wires. Thus, higher-level magnetic fields occur closer to thicker wires. The original Wertheimer-Leeper wire code had two categories: high and low. They later modified the scheme to include five categories (Wertheimer and Leeper, 1982). In an attempt to simplify and generalize the Wertheimer-Leeper codes, Kaune and Savitz (1993) developed a simplified code with three exposure categories.

The wire-code classification schemes tend to predict magnetic-field exposures—that is, higher exposures tend to occur in the higher wire-code categories. In addition, both survey and PE measurements of randomly selected houses have indicated that proximity to power lines is a contributor to field levels and exposures in residences (Zaffanella, 1993; Zaffanella and Kalton, 1998a; 1998b). However, within each wire-code category there is a wide range of exposures, resulting in considerable overlap for the different wire-code categories. Typically, the wire-code category has explained about 15 percent of the variance in point-in-time measurements (Kaune et al., 1987; Bracken et al., 1994). However, wire-code category was found to explain 6% or less of the variance in PE measurements (Bracken et al., 1994). Thus, wire-code classification schemes are not a very accurate surrogate for contemporary magnetic-field measurements. An excellent review on the use of wire-code categories for exposure assessment is found in NIEHS (1998).

As noted above, the simplest surrogate for occupational exposure is a history of work in an industry. However, comparisons that assume differences in exposure based on industry may not be valid. For example, Methner and Bowman (1998) found that neither type of industry nor power consumption within an industry could serve as useful surrogates for magnetic-field levels in a facility.

The most commonly used surrogate for workplace exposures has been an occupational or job classification, a job title, or other descriptor. Examples include electrician, electronics worker, electrical engineer, lineman, office worker, and welder. Many investigators have used some form of job classification as an exposure surrogate, for example Milham (1982), and Calle and Savitz (1985).

However, job classifications need more development to be of real use, and they may not prove any better for reflecting occupational exposures than wire codes have been for residential exposures. Bracken and Patterson (1996) found that the greatest disaggregation possible for utility workers may be only at the level of broad job categories, such as line worker, generation worker, and substation worker: division of the general category, "line worker," into "distribution line worker" and "transmission line worker," or of "generation worker" into "generation operator" and "generation mechanic," did not seem to produce differences in exposures, because there is too much overlap. This shows the difficulty of establishing job categories as useful surrogates for occupational exposures, and the fact that *a priori* schemes may be quite problematic in their application.

As more and better exposure data are collected it may be possible to improve the present ability of job classifications to discriminate among exposures. This could allow industrial hygienists to develop more exposure assessments based on the traditional JEM approach. Such a matrix arrays exposures in different jobs against exposures incurred in those jobs. Intuitively, and assuming data are available, the more disaggregated the job titles that are used in a JEM (down to the level of individual tasks), the more reliably a worker's exposure could be reconstructed.

JEMs have been used for EMF exposure assessments of electric-utility workers. Kromhout et al. (1995) constructed a five-level JEM for the 120 occupational categories measured in five utilities. The placement of job categories within groups was based on the distribution of PE measurements and provided the greatest contrasts in exposure between groups of several grouping schemes. Even so, there was still considerable overlap in exposures between groups. Other studies of electric-utility workers have also used a JEM approach to assigning exposures (Cf., Sahl et al., 1993; Thériault et al., 1994)

Yost et al. (1997) developed a JEM to estimate exposure to magnetic fields for a study of brain cancer. Jobs were classified using the Standard Occupational Classification 1980 (SOC80, 1990) system. Job-exposure matrices were constructed with 209 job categories at the four-digit classification level and 46 job categories at the two-digit level. Geometric mean exposures at the two-digit level ranged from 0.6 to 7.8 mG, but many of the different job codes fell within a narrow range. For example, 35 of the 46 two-digit categories had geometric mean exposures of 2.0 mG or less. Of the 35 categories, 7 shared a geometric mean of 1.6 mG, 4 shared a mean of 1.1 mG, 4 shared a mean of 0.9 mG, and 3 shared a mean of 1.0 mG. These results do not reinforce the idea that exposures can be distinguished by these job classifications. Furthermore, this clustering of exposures is consistent with our understanding that relatively few occupations have magnetic-field exposures substantially higher than residential or common environmental exposures. To be useful for EMF exposure assessments, the JEM approach will require more exposure data at finer divisions of job classifications, different job classifications, or both.

Implications for Risk Assessment

Surrogates are key elements in risk assessments, especially those involving large populations.

Wire codes are poor surrogates for measured, residential exposures, and improvements (or development of some other surrogate) must precede their further use.

Job classifications/codes/titles may be the best surrogates for occupational exposure for use in studies of large populations. However, further work is needed. As more source and PE data are collected, they can be refined and used in improved job-exposure matrices. These in turn will provide input for improved risk assessments.

If exposures at finer levels within general job categories are not distinguishable without additional task/source information, there may be no cause to differentiate health data at that same level.

On the other hand, if health data do show different outcomes at the general job category level, and if the exposures at finer levels <u>within</u> the category are indistinguishable, then perhaps a different exposure measure (other than geometric mean or time-weighted average, for example), or agent is important.

Remaining Questions

1. Can wire codes be reliably related to field measurements for a particular study or for all studies. Is there a general relationship that wire codes suggest be used?

2. Can other surrogates, perhaps based on demographic factors, be developed for non-occupational exposures? These surrogates might incorporate factors such as lifestyle and appliance use, for example.

3. Can homogeneous exposure groups be developed within the job-exposure matrix format?

4. Which one or more of the following will be necessary to discriminate occupational exposures: More exposure data in more jobs? A different job classification scheme? A different way (other than geometric mean or time-weighted average, for example) of expressing exposures (assuming some biological significance)?

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