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Assessment of occupational risks to extremely low frequency magnetic fields: Validation of an empirical non-expert approach

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ABSTRACT

The expert method of exposure assignment involves relying on chemists or hygienists to estimate occupational exposures using information collected on study subjects. Once the estimation method for a particular contaminant has been made available in the literature, it is not known whether a non-expert, briefly trained by an expert remaining available to answer ad hoc questions, can provide reliable exposure estimates. We explored this issue by comparing estimates of exposure to extremely low frequency magnetic fields (ELF-MF) obtained by an expert to those from a non-expert. Using a published exposure matrix, both the expert and non-expert independently calculated a weekly time-weighted average exposure for 208 maternal jobs by considering three main determinants: the work environment, magnetic field sources, and duration of use or exposure to given sources. Agreement between assessors was tested using the Bland-Altman 95% limits of agreement. The overall mean difference in estimates between the expert and non-expert was 0.004 μT (standard deviation 0.104). The 95% limits of agreement were −0.20 μT and +0.21 μT. The work environments and exposure sources were almost always similarly identified but there were differences in estimating exposure duration. This occurred mainly when information collected from study subjects was not sufficiently detailed. Our results suggest that following a short training period and the availability of a clearly described method for estimating exposures, a non-expert can cost-efficiently and reliably assign exposure, at least to ELF-MF.

1. Introduction

Historical exposure reconstruction in community-based epidemiological studies is often done using exposure assignment methods, such as job-exposure matrices (JEMs), and the case-by-case expert method; their use, strengths and weaknesses have been well described (Correa et al., 1994; Kauppinen, 1994; McGuire et al., 1998; Teschke et al., 2002; El-Zein and Infante-Rivard, 2004). In particular, the expert method involves relying on experts such as occupational hygienists or chemists to estimate exposures based on details of work environments and practices provided by study subjects (Gerin et al., 1985; Gérin and Siemiatycki, 1991). The validity and reliability of this method were reported to vary considerably, (Teschke et al., 2002) depending on the expertise of assessors, their familiarity with specific work environments, and the quality of the coding procedure.

Hiring an expert to develop a JEM or to code exposure is labour-intensive and costly, and thus infeasible for most epidemiological studies. Recent approaches were developed in community-based studies that aimed at standardizing the exposure assessment process, increasing its reproducibility and transparency, and decreasing assessment time and associated costs. Their application resulted in comparable exposure estimates to those obtained by experts. These include a web-based application to automate part of the expert exposure assessment, (Fritschi et al., 2009) algorithms developed to assign decision rules for assessing occupational exposure to diesel exhaust, (Pronk et al., 2012; Friesen et al., 2013) statistical learning methods (classification and regression tress and random forests models) to explain and predict expert-based exposure estimates, (Wheeler et al., 2013) and a rule-based approach, made by experts, to assess exposure to diesel exhaust, pesticides and solvents (Peters et al., 2014). The present study reports an empirical low-cost approach when subject-reported lifetime occupational histories are available and the exposure of interest has already been the subject of published expert coding. The present approach of using a trained non-expert to assign exposure based on an existing

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job-exposure matrix involves minimal expert time for training a non-expert and reviewing exposure assignments.

Deadman and Infante-Rivard (2002) published a detailed method for estimating occupational exposures to extremely low frequency magnetic fields (ELF-MF) among young women, later applied to a study of childhood leukemia (Infante-Rivard and Deadman, 2003). The method identified exposure sources and durations from individual occupational histories, which were then combined with published magnetic field values to derive individual time-weighted average (TWA) exposures. The exposure values were condensed into a source-exposure matrix and a JEM applicable to women's jobs. With these tools available, it is not known whether non-experts (i.e., educated scientific personnel briefly trained) when presented with relevant self-reported information on exposure determinants can provide valid exposure estimates comparable to those obtained from experts.

The main objective of the current study was to explore whether a published exposure assessment method (Deadman and Infante-Rivard, 2002) can be used by a non-expert, briefly trained by an expert, to derive estimates of maternal occupational exposure to ELF-MF in a given study. We specifically measured agreement between estimates of maternal occupational exposure to ELF-MF obtained by a non-expert and an expert using the same exposure assessment method. Secondary objectives included detailing the exposure assignment decision process, and assessing the reliability of the assessors' judgments.

2. Materials and methods

2.1. Study population and data collected

Fig. 1 presents an overview of the sources of information that were used in the current study. Detailed information on maternal occupational history prior to and during pregnancy was collected in a case-control study of childhood brain cancer in the Province of Québec (Shaw et al., 2006; Li et al., 2009). The approach used to collect this information is similar to one described previously (Infante-Rivard et al., 2005). For each maternal job, information was obtained on the job title and the industry or company, its products, nature of the worksite, mothers' main and subsidiary tasks, equipment and materials used, number of hours worked per week, and any additional information (i.e., activities of coworkers) that could provide clues about possible exposures. For some occupations, additional job-specific questionnaires were used for more detailed probing. Each occupation was assigned to standard Canadian industrial titles at the three-digit level, and job titles at the seven-digit level (Statistics Canada 1980, 1992). As a convenience sample, we selected 75 case and 75 control mothers for the current study covering jobs with a wide range of expected exposure levels, but over-sampling for jobs where exposures were expected to be high. The 150 women had held a total of 208 jobs, of which 106 were office occupations (mainly secretaries, receptionists, office clerks, data entry or accounting clerks), 16 were bank tellers, 11 were sewing machine operators, 11 were nurses, and 10 were cashiers.

2.2. Assignment of ELF-MF exposures

The main guidance material used by both assessors in their estimation process is the one described in full detail in the Deadman and Infante-Rivard publication (Deadman and Infante-Rivard, 2002). The exposure assessment process involved the use of self-reported work history information which was transcribed into an electronic database by the non-expert. Blind to case-control status, the estimation process was independently done by an expert (JED, PhD, experienced hygienist with a specialty in ELF-MF) and a trained non-expert (MZ, newly graduated PhD student in occupational health who is neither a chemist nor an ELF-MF specialist). The work history was reviewed by each assessor to identify the activities of the industry, and tasks performed by the worker. Subsequently, information on potential determinants of exposure was identified and extracted; specifically the work environment, magnetic field sources of ELF-MF (up to three sources primarily from electrical equipment), and duration of use or exposure to the source. For each job held by a subject, a weekly TWA exposure estimate, expressed in micro-tesla (μT), was calculated by multiplying the ELF-MF intensity of each identified source by the weekly duration of use for that source. Any remaining work duration was multiplied by the background field level, which had been assigned to the specific work environment. The products of source and duration as well as of environment and duration were summed and divided by the total weekly hours spent at work. When magnetic field levels for newly identified potential sources were not in the published matrix, the non-expert consulted the expert. This type of consultation could occur naturally in a setting where an expert is not necessarily part of the study, and thus is not considered a violation of the independence criterion of the assessors' exposure assessment. Both assessors took detailed notes of their decision-making process, documenting reasons and/or justifications to support each of their decisions, and the time it took to estimate the exposure of each job as a proxy indicator of the monetary cost of hiring experts.

2.3. Training of the non-expert

Prior to assessing exposure to ELF-MF for the present study, the non-expert was trained by the expert in two stages to use the published method and matrix. To accomplish that, data from the childhood leukemia study, which had been used to develop the published matrix, (Deadman and Infante-Rivard, 2002) were used. In the first stage (equivalent of a working day), the expert explained the different sources and work environments considered, giving examples of jobs entailing high and low exposures. The second stage (also equivalent of a working day) was a self-learning phase, where the non-expert was provided with a sample of 15 leukemia cases and 15 controls to assess and compare estimates of ELF-MF with those initially obtained by the expert. A total of 34 job descriptions were reviewed by the trained non-expert, blind to case-control status. Of these jobs, 18 were sewing machine operators while the 16 other jobs were varied. Points of disagreement were discussed when the non-expert was not able to

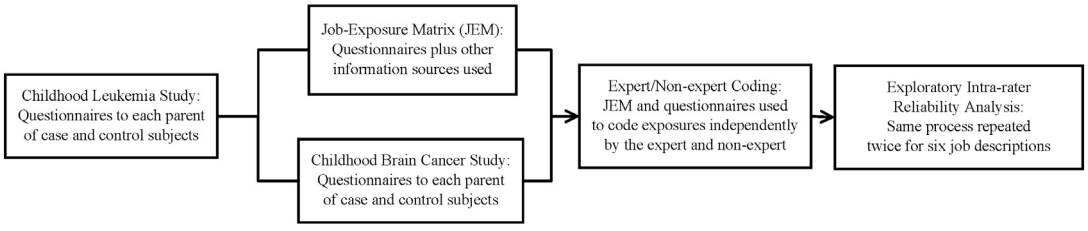

Fig. 1. Overview of information sources. A job-exposure matrix (Deadman and Infante-Rivard, 2002) had been developed using information from a case-control study of childhood leukemia (Infante-Rivard and Deadman, 2003) and published data on the intensities of ELF-MF associated with occupational environments. This JEM was largely based on questionnaires to each parent in the leukemia case-control study. The same questionnaire was used in another case-control study of childhood brain cancer (Shaw et al., 2006; Li et al., 2009). Based on reported information in these childhood brain cancer questionnaires and the job-exposure matrix, the expert and trained non-expert independently assessed exposure to ELF-MF in the current study.