MAGNETIC FIELD EXPOSURE ASSESSMENT BY WIRE CODING

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ABSTRACT

We describe the development of a wire coding protocol based on a study of electrical installations in Melbourne. Because of very significant differences between our power distribution system and that used in Denver, a different approach from that used by Wertheimer and Leeper was required.

INTRODUCTION

The hypothesis that exposure to extremely low frequency (ELF) magnetic fields may be responsible for an increase in the incidence of cancer remains the subject of several epidemiological studies. Wire coding, that is the grouping of residences based on the type, number and distance of nearby visible electrical installations, has been repeatedly used for assessment of exposure[1-5]. In some studies[3-5] actual measurements of the magnetic fields were also carried out, but, where an association with cancer was found[3,5], it was stronger for classification based on wire coding than for that based on measured fields. This can be interpreted in two ways: i) wire coding is a better index of magnetic field exposure than measured magnetic fields, either because it is less affected by time variability or because it is correlated to a parameter of the magnetic field different from the one measured (usually the time weighted average) or ii) wire coding is also correlated to some unidentified confounder which is responsible for the association with cancer.

In either case, it is important that analysis of data classified by wire coding remain a part of current residential exposure studies, so that either the relevant magnetic field parameter or the confounding agent can be identified.

Wire coding was devised specifically for the Wertheimer and Leeper studies in Denver and Boulder, Colorado. Electric power distribution practices vary significantly from place to place and it can not be assumed that the Denver code may be used in a different locale.

We describe here a wire coding protocol that we have developed for Melbourne, Australia, as part of the preliminary work for an epidemiological study of residential exposure to ELF magnetic fields and childhood cancer.

METHOD

The main difficulty we encountered was due to the fact that, in Australia, pole mounted transformers have a typical power rating much larger than that common in the US. A single transformer may supply a secondary distribution line consisting of dozens of spans. The current drop along the secondary line is thus very gradual and the resulting variation in the strength of the magnetic field from point to point of the same line is less than random time variability. Moreover, the lines often branch into side streets and it is very difficult for a field worker to classify a house in relation to its distance from the transformer. The use of standard gauge wire contributes to make classification difficult.

Our objective is that of identifying two reasonably large groups of subjects that can be reliably regarded as 'high' and 'low' exposure and an intermediate category which will contain most of the subjects whose exposure is less easily determined. We anticipate that this approach will not allow a reliable estimate of a risk-exposure trend (because of the large misclassification of the intermediate group). However, it offers the advantage over simple dichotomous classification of comparing two smaller but reliably classified groups, rather than two groups both grossly affected by misclassification.

Using a random number generator, we identified 415 points in the Melbourne metropolitan area. At each of these points, measurements were taken directly under the power lines, if any existed or at an equivalent position on the sidewalk, if no electrical installations were visible.

RESULTS

The data obtained from the random measurements are summarized in Table 1. According to these data, in a sizable fraction of the metropolitan area there are no significant external sources of ELF magnetic fields. Thus, it should be possible to identify with a certain degree of confidence a sufficiently large reference group.

The approximate magnetic field profiles were calculated from the median values of the measured magnetic field. These are plotted in Figure 1 for the most important wire types, as a function of the horizontal distance in the direction perpendicular to the line.

Note that in several cases this profile is asymmetrical, due to the presence of an unbalanced current. This introduces an additional uncertainty, since in general we cannot determine the predominant direction of the unbalanced current. Thus at a distance of 10 m from a secondary line the field may be less than 20% or more than 40% of the field measured under the line.

Table 1
Summary of magnetic field measurements

Wire type	Number of occurrences	Magnetic field (μT) mean	median	Stand. dev.	Quartile lower	upper
1	71 (17.1%)	0.067	0.017	0.146	0.017	0.042
2	18 (4.3%)	0.077	0.029	0.105	0.017	0.095
3	48 (11.6%)	0.078	0.017	0.149	0.017	0.032
4	20 (4.8%)	0.350	0.276	0.330	0.074	0.517
5	73 (17.6%)	0.359	0.279	0.306	0.121	0.489
6	74 (17.8%)	0.439	0.312	0.371	0.152	0.669
7	9 (2.2%)	0.530	0.461	0.356	0.288	0.695

(Wire type code: 1 = no visible wires; 2 = end pole; 3 = primary; 4 = 2 phase secondary; 5 = secondary; 6 = primary + secondary; 7 = high voltage distribution line + primary + secondary).

The 'strength' of a power line as a source of residential magnetic fields was defined as a function of the wire type and distance from the house. We arbitrarily defined a strong source as a power line capable of generating a typical field of 0.16 μT or more at the point of a house closest to the line.

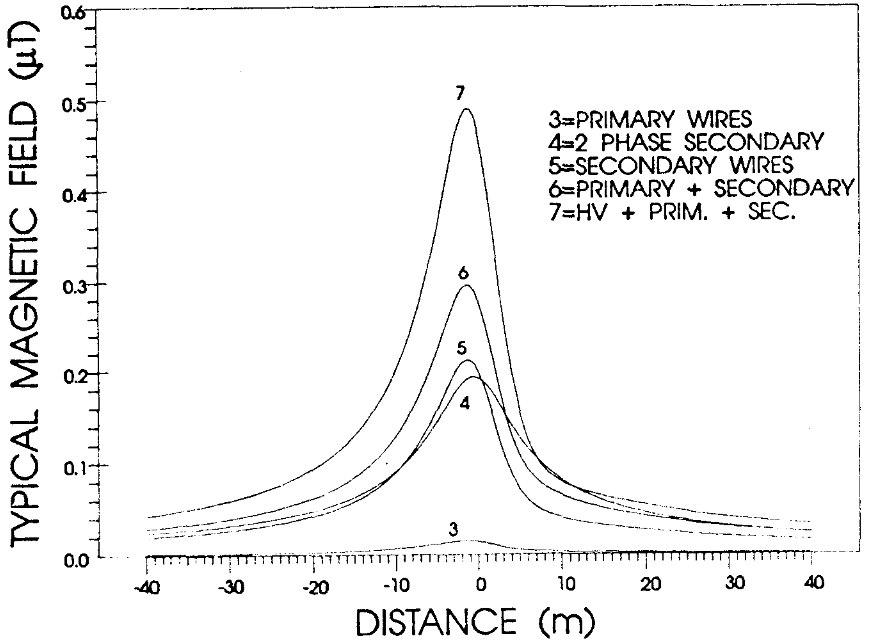

Figure 1. Typical magnetic field profile for several wire types.

Table 2
Exposure scores assigned to several wire types on the basis of their distance from a residence.

Wire type	Strong source (score = 4)	Moderate source (score = 2)	Weak source (score =1)
4	0 - 7.0 m	7.5 - 18 m	18.5 - 28 m
5	0 - 6.5 m	7.0 - 14 m	15.5 - 35 m
6 or 7	0 - 10.0 m	10.5 - 20 m	21.5 - 40 m

A line generating at that point a typical field of 0.08 to 0.16 μT is regarded as moderate and one generating a typical field of 0.04 to 0.08 μT is considered weak. From Table 1 and Figure 1 we determined, for each line type, the distances from the lines at which a median field of approximately 0.16, 0.08 and 0.04 μT could be expected. Exposure scores were assigned to reflect the relative strength of the various sources (Table 2). Less common wire types were also similarly classified.

Houses with nearby sources totalling a score of 4 or more are classified as high exposure, while houses affected by no more than one weak source are regarded as low exposure. Houses with a total score of 2 or 3 are classified as medium exposure.

Validation of this exposure assessment protocol is, strictly speaking, not possible, since we do not know what the 'true' exposure metric is. We are investigating the long term correlation between this and other possible exposure indices.

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