

## SHORT REPORT

## Exposure to extremely low frequency magnetic fields among primary school children in Spain

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Epidemiological studies have found an increased leukaemia risk in children with high residential exposure to extremely low frequency electromagnetic fields (ELF-EMF). Two recent independent reanalyses of published epidemiological studies<sup>1,2</sup> found statistically significant increased risks in children with average residential exposures equal or above 0.3 or 0.4  $\mu\text{T}$  (micro teslas, the unit of measurement of magnetic field density). An IARC working group (June 2001) evaluated that these findings were unlikely to be attributable to chance, but could be affected by selection bias. Therefore this association between childhood leukaemia and high residential magnetic field strengths was judged limited evidence for excess cancer risk in exposed humans.

Exposure at school could significantly contribute to children's overall exposure, but only few epidemiological studies incorporated such measurement.<sup>3–5</sup> We evaluated level of exposure to ELF-EMF in primary schools in the city of Oviedo and the province of Barcelona, the second region being one of the most industrialised areas of Spain.

## METHODS

This is a descriptive study of environmental exposures in schools with an ecological comparison within areas. All primary schools ( $n=43$ ) in Oviedo (Asturias) were contacted (participation rate 100%). In the Province of Barcelona, 75 of a total of 887 registered schools were selected through a two stage random stratified weighted sampling. To select the number of schools to be measured within each municipality we used as a weight the total number of primary schools per municipality. At a second stage, schools were randomly selected within each municipality. After being contacted by mail and telephone, 50 public and private schools took part (participation rate =67%). Approximately 2500 measurements were done by three of us (PR, SM, MR) in predefined points in the classrooms, canteen, playground, and entrance of

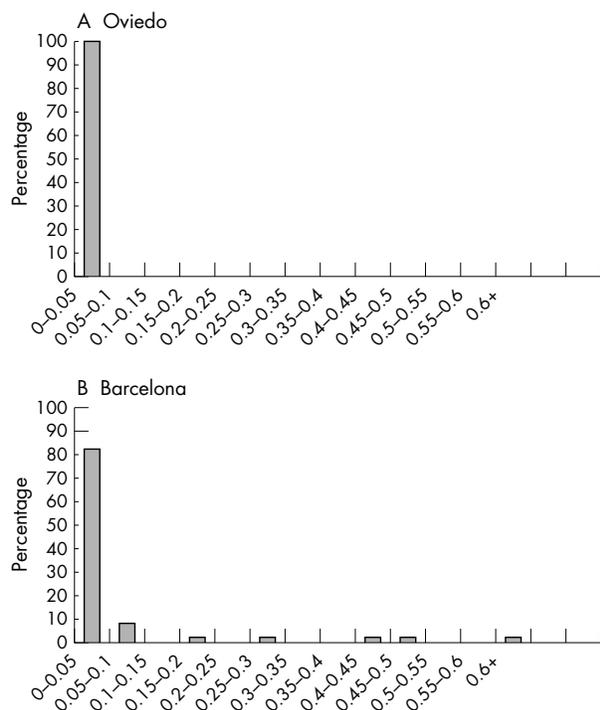
the schools following a standardised protocol. Spot measurements were done at the corner classrooms situated at the highest and lowest floors of each school. Measurements were done in the doorway, at the centre of the room, and at the window farthest from the door. The arithmetic mean of the measurements in all classrooms of a school (maximum 24 measurements) was assumed to provide an average estimate of exposure levels for the classrooms of the school. Two readings were done in the canteen, one in the doorway and one in the centre. Single readings were done at the centre of the playground and at the entrance way leading to the school premises. Proximity to high tension power lines was recorded through visual inspection. The same portable magnetic field meter (4004 AC ELF) measuring magnetic field density at a frequency of 50 Hz was used in both areas. This meter was calibrated weekly during the study.

## RESULTS AND DISCUSSION

Median exposure levels to ELF-EMF (table 1) were similar in both cities (0.015  $\mu\text{T}$  in Oviedo, 0.016  $\mu\text{T}$  in Barcelona). The average exposure, however, was higher in Barcelona (mean 0.057  $\mu\text{T}$ ) than in Oviedo (mean 0.017  $\mu\text{T}$ ). In Oviedo, average levels in classrooms, entrance ways, and playgrounds were similar and the Friedman non-parametric and Wilcoxon signed rank tests did not indicate statistically significant differences between exposures at the different measuring points. In Barcelona these same tests revealed significant differences with all p values under 0.005. In Barcelona exposure was higher for entrance ways versus classrooms, and classrooms versus playgrounds. In Oviedo, no school exceeded an average value of 0.3  $\mu\text{T}$ . In Barcelona 6% (3 of 50) (fig 1) of the schools had exposure levels above this value (0.62  $\mu\text{T}$ , 0.49  $\mu\text{T}$ , 0.43  $\mu\text{T}$ ) and one additional school a mean value of 0.26  $\mu\text{T}$ . High voltage transmission lines were not located close to any of the four schools. Two of these schools were located outside

**Table 1** Mean ELF-EMF exposure levels at schools in Oviedo and Barcelona (Spain)

	Number	Mean	Median	SD	Min	Max
<i>Oviedo</i>						
Total	43	0.0170	0.0150	0.0093	0.004	0.043
Classrooms	42	0.0176	0.0140	0.0106	0.001	0.048
Canteen	38	0.0175	0.0160	0.0101	0.005	0.056
Entrance way	42	0.0177	0.0130	0.0147	0.002	0.075
Playground	42	0.0156	0.0120	0.0114	0.002	0.052
<i>Barcelona</i>						
Total	50	0.0576	0.0160	0.1253	0.001	0.618
Classrooms	50	0.0557	0.0100	0.1432	0.001	0.878
Canteen	40	0.0442	0.0140	0.1118	0.001	0.671
Entrance way	50	0.1228	0.0410	0.2669	0.002	1.320
Playground	50	0.0338	0.0070	0.0891	0.000	0.462



**Figure 1** Distribution (%) of exposure to extremely low frequency magnetic fields in the schools of Oviedo (A) and Barcelona (B). Average exposure ( $\mu\text{T}$ ).

Barcelona and had distribution lines attached to the exterior classroom wall. The other two were located within the city of Barcelona and had underground distribution lines within the school area located, as reported by the school authorities, at a depth of less than 50 cm. Potential exposure sources other than high voltage transmission lines were, however, not systematically registered in all schools.

Results from this study show that a small, though by no means negligible, proportion of primary schoolchildren in the most industrialised area may have average exposures exceeding 0.3  $\mu\text{T}$ . In Spain, statutory regulations governing the construction of schools in urban areas tend to be more stringent than those covering housing in general. Schools in Spain have, however, occasionally been built in areas that could not be commercially exploited and that, although legally suitable for the construction of schools, were situated in environmentally contaminated areas. There is no clear explanation for the observed differences in exposure levels between the two areas. Schools are smaller in Oviedo as compared with Barcelona but it is unclear whether this should have any relation to EMF exposure. The main reason probably lies in the different level of industrialisation with Barcelona having a much more dense power line structure and a higher population density.

In this study we did not measure total daily exposure of schoolchildren and cannot estimate the proportion contributed by exposure in the schools. Exposures to residential magnetic fields depend strongly on the electricity distribution system, being on average higher in North America than in most European countries. Epidemiological studies in Europe<sup>3</sup> indicate that less than 1% of children have average residential exposures exceeding 0.3  $\mu\text{T}$ . A higher proportion of schools in this area exceeded this limit indicating that an evaluation of children's mean exposure to EMF, should include measurements taken both at home and school. It should be noted, however, that childhood leukaemia peaks at age 2–3 years and exposures in the womb or during infancy could be more important than those in later ages. Only some of the school buildings evaluated in this study included kindergartens within or close to the premises of the primary school. Proximity to high tension power lines did not seem to be the main exposure source in the high exposure schools. Distribution lines situated at few metres from the classrooms, wiring within or under the buildings and other sources such as transformers identified within the schools and appliances could also have contributed considerably to field strength. Scientific evidence of the carcinogenic potential of ELF-EMF is still very limited, but it is essential that all due caution be applied to prevent high level exposures among school children.

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