Role of residential radon in childhood leukaemia incidence: the Geocap program.

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Abstract

Childhood acute leukaemia (AL) etiology is still largely unknown. The main environmental exposures currently investigated are exposures to pesticides, hydrocarbon, ionizing and non ionizing radiation. The Geocap program investigates potential links between Childhood AL and several environmental exposures, among which domestic exposure to radon.

The Geocap approach consists in the comparison of residential exposure of children who suffer from AL in France to contemporaneous controls who are representative of the French population under the age of 15 years.

Overall, 2 760 AL cases were recorded in the Inserm French National Registry of Childhood Haematological malignancies between 2002 and 2007. A random selection procedure led to gather yearly control groups (30 000 controls over the same period).

IRSN mapped with an accurate geographic resolution (500 to 1000 m) the estimated geogenic radon potential (GRP), i.e. the capacity of geological units to produce radon and to facilitate its transfer to the atmosphere.

A first work aimed at validating the GRP map by comparison with a national sample of radon concentration measurements carried out in 10 843 houses by IRSN between 1982 and 2003.

Mean radon concentration increased along with growing GRP and this relation persisted after adjustment for known building characteristics (e.g.: material, floor).

Preliminary results demonstrate the usefulness of the GRP for prediction of home exposure to radon and the added value of contextual information for such predictions will be further explored.

Studying the statistical distribution of predicted radon concentration among the 30 000 Geocap controls will provide information on children exposure to radon in France. Finally, the comparison of this distribution to that observed among the AL cases will allow documenting further the association between radon exposure and AL incidence among children.

Key words: childhood leukaemia; indoor radon exposure; home characteristics; radon mapping; France

1. Introduction

With an incidence of 41.7 cases per million per year in the population of mainland France aged less than 15 years (approximately 11 million children), acute leukaemia (AL) accounts for a third of childhood cancer cases [1]. The risk factors for childhood AL have yet to be fully elucidated. In addition to a few genetic factors and exposure to high-dose ionizing radiation and chemotherapy, a few environmental exposures, such as low-dose ionizing radiation, pesticides, high-voltage power lines and domestic exposure to radon are suspected risk factors.

The Geocap study consists in the comparison of residential exposure of children who suffer from AL in France to contemporaneous controls who are representative of the French population under the age of 15 years. With this objective, radon exposure needs to be estimated for the Geocap subjects.

A first work aimed at validating a geogenic radon potential (GRP) mapped by the Institute for Radiological Protection and Nuclear Safety (IRSN) by comparison with a national sample of radon concentration measurements carried out in 10 843 houses by IRSN between 1982 and 2003.

2. Material and methods

The Geocap study

The case-control study included all the 2 760 French childhood leukaemia cases aged up to 15 years at the end of the year of diagnosis, diagnosed between 2002 and 2007, and residing in metropolitan France. The cases were recorded in the Inserm French National Registry of Childhood Haematological malignancies (NRCH). In collaboration with the National Institute for Statistics and Economic Studies (INSEE), a procedure to gather controls groups was created. Since 2002, 5 000 controls a year are included, so the GEOCAP program concerns 30 000 controls. With a level of participation of 100%, these controls (as it has been closely verified) are closely representative of the childhood French population in terms of age and number of children in the household, and in terms of contextual socioeconomic and demographic variables: size of the urban unit, median income, proportion of blue-collar workers, proportion of subjects who successfully completed high school, and proportion of homeowners in the municipality of residence. Cases and controls home addresses were geocoded, blindly with respect to their case or control status.

The geogenic radon potential map [2]

To identify radon-prone areas in France, a harmonized methodology to derive a single map of the GRP has been developed. This approach consists of determining the capacity of the geological units to produce radon and to facilitate its transfer to the atmosphere, based on the interpretation of existing geological data. This approach is based on a classification of the geological units according to their uranium content, to create a radon source potential map. This initial map is then improved by taking into account the main additional parameters which control the preferential pathways of radon through the ground and which can increase the radon potential. The final map results in the categorization of the whole French territory in five classes: from low to high GRP with an accurate geographic resolution (500 to 1000 m).

National sample of radon concentration measurements [3]

In order to improve regulatory tools for radon risk management in France, to estimate the percentage of private dwellings above action levels, and to investigate factors affecting radon concentrations, IRSN conducted a national radon survey in collaboration with the French Ministry of Health. These radon concentration measurements have been performed from 1982 until 2003, using track-etch detectors (LR 115). In order to take into account the seasonal variation of the indoor radon concentration, a correction factor was applied according to the method described by [4]. Overall, 10 843 radon measurements were used. Among these, 8 136 whose complete address was available were geocoded at the address point. The others were geocoded at the town hall point. Dwellings characteristics were collected to examine factors that might influence radon concentration. Housing characteristics and lifestyle as the type of building, building materials, foundations, construction period, floor and type of room where the measurement was made, type of ventilation and air exchange frequency were available.

Statistical analyses

A simple multiple linear regression model was performed with the SAS 9.2 software to study the factors influencing the level of radon measurement.

3. Results

Descriptive statistics as the geometric mean radon concentration (Figure 1) and the percent of measurement results higher than 100 $Bq.m^{-3}$ and 300 $Bq.m^{-3}$ increased along with growing GRP and this relation persisted after adjustment for known building characteristics (e.g.: material, floor).

As regards factors influencing the level of radon measurement, the GRP and all the housing characteristics and lifestyle except the room where the measurement was made were significant in the multiple linear regression.

4. Conclusion

Further analyses considering contextual information on GRP surrounding measurement points rather than using punctual GRP alone will be performed in order to improve radon concentration prediction. Moreover, the spatial autocorrelation of the radon concentration measurements will be considered. Studying the statistical distribution of predicted radon concentration among the 30 000 Geocap controls will provide information on children exposure to radon in France. Finally, the comparison of this distribution to that observed among the AL cases will allow documenting further the association between radon exposure and AL incidence among children.

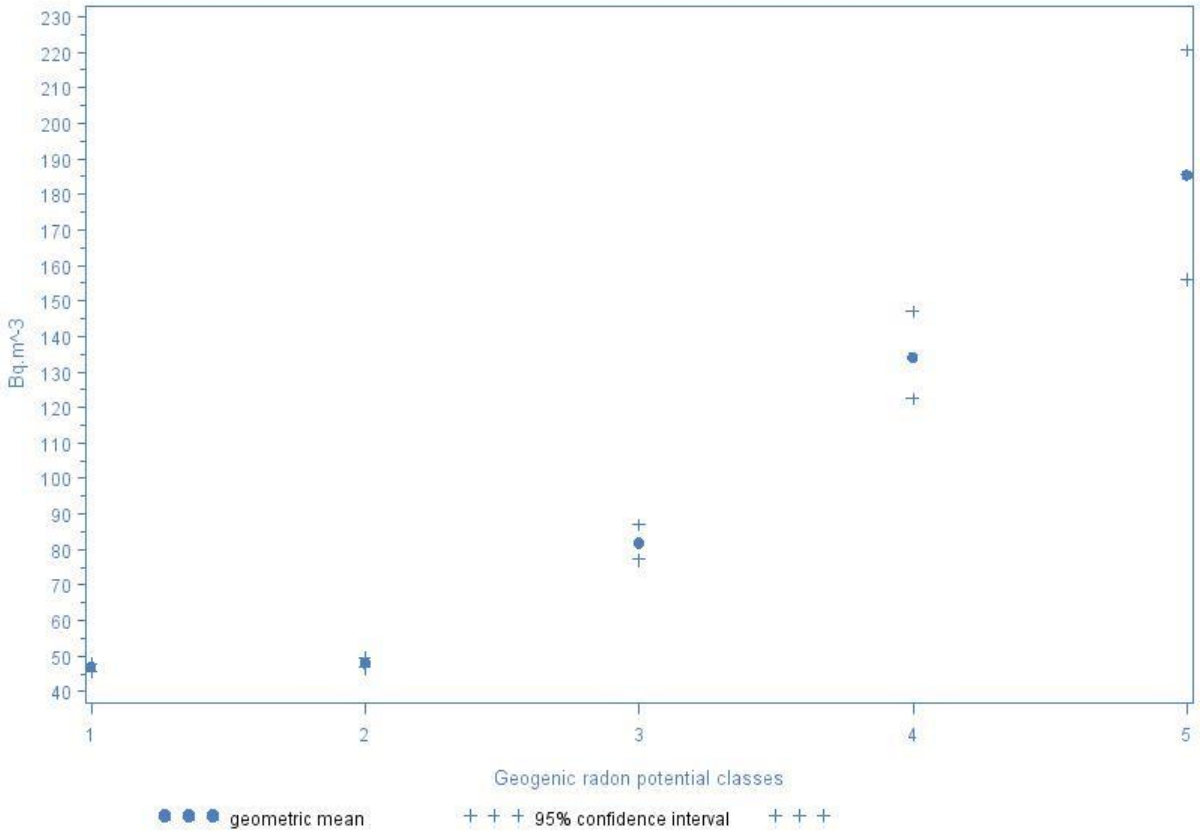

Figure 1. Geometric mean of the radon concentration measurements according to the geogenic radon potential class

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