First Representative Sample of Radon Measurements in Dwellings of a French Area for Health **Risk Characterisation**



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Background

Radon is reported as being the second risk factor for lung cancer, after tobacco, with 543 to 3108 attributable cases assessed per year in France. This level is due to the near multiplicative interaction between radon and smoking on risk of lung cancer.

In Franche-Comté (eastern regional area of France), a health risk assessment of dwelling radon exposure has been planned by the regional unit of the ministry of health. The only data available for this region were issued from the French national radon exposure assessment database.

This database contains 445 corresponding measurements which have been collected between 1984 and 1999 with detectors (Kodalpha films) laid 2 months in the living room or the bedroom. One house was selected per 49 km2 on a voluntary base and one measurement was performed per house. For exposure and health risk assessment these data present several flaws:

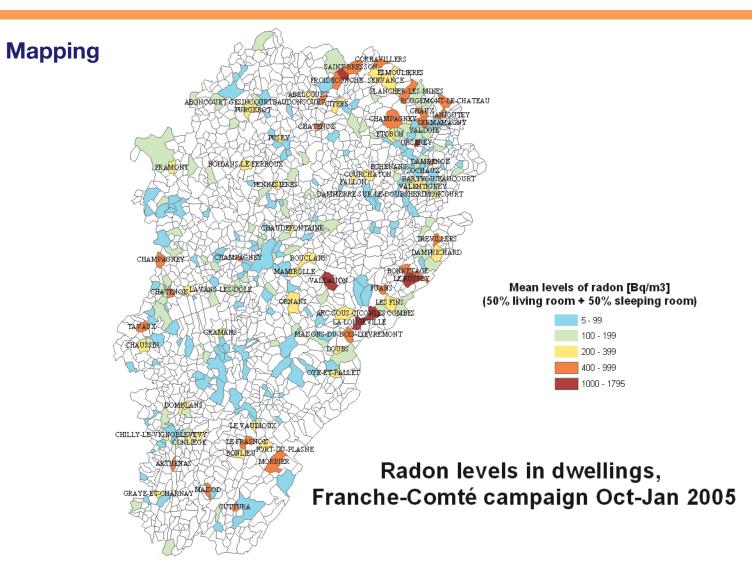
- the main one is a biased sample due to the non random selection of the houses measured.

- indoor variations between rooms and periods of occupation are not taken into account, In order to overtake these limits, a more accurate campaign of exposure measurement in Franche-Comté was planned. A new health risk assessment relying on the data of this specific campaign was performed.

Objectives

The objectives of this study were to assess :

- the regional exposure to radon in dwellings and its correlation with modifying factors the attributable risk of lung cancers due to radon.



Radon rough distributions considering strata or characteristics of the buildings

The overall geometric mean in granitic part is 75% more important than in sedimentary part. The geometric mean in detached houses is two-fold higher than in blocks of flats (respectively 123.02 and 58.8 Bq/m³; p < 0,001). The concentrations measured on the ground floor, in detached houses are more important than in flats (respectively 122.4 and 56.12 Bq/m³; p<0.001).

Table 1 : Results of radon measurements in living rooms (Bq/m³),

- the possible improvements by acting on factors modifying radon levels or lung cancer risk.

Methods

The first step of the process was to assess as representatively as possible the exposure of the Franche-Comté population to annual indoor radon. This means taking into account distribution of type of houses and geological soils, indoor variations of radon levels and time activity patterns of the population.

Measurements

- Measures were performed with a Kodalpha film during autumn 2005 and lasted two months.
- These detectors were laid in October and November 2005.
- Two measurements were done in each home; one in the living room, the other in one of the house bedroom.

Sampling

A sample of 452 homes (1/1000th of the homes of the region) was selected from the telephone directory. To increase the precision of the assessment of the radon distribution, the sample was stratified on a geological basis and, for the sedimentary part, also on the type (block of flats / detached house) of the dwellings. Sixty homes were selected in the granite part and 392 in the sedimentary part of the region (respectively 68 in blocks of flats and 324 detached houses). For each stratum a random selection on the base of the phone list was done. To choose the bedroom for measurements, a person was randomly selected in each home.

Collecting information on the modifying factors of exposure

Variations during year:

In thirty homes chosen by quotas in the 452 house sample, consecutive 2 months measurements were recorded during the entire year to point out seasonal variations.

Questionnaires

Data were collected during a face to face interview at home. Information collected concerned home and room characteristics (type of building, date of construction, floor level for rooms...) and dwellers characteristics (age, sex, occupation, tobacco...).

A time activity budget of the selected person was collected to allow a weighting between results in both rooms to assess exposure.

Statistical analysis

Non parametric Wilcoxon rank tests for unpaired and paired data were performed with the Stata package (version 9.2) to compare radon concentrations.

Variable	Arithmetic mean	S.D.	Geometric mean	> 200 Bq/m ³ %	> 400 Bq/m ³ %	> 1000 Bq/m ³ %
Total	189.6	258.2	110.8	27.9	11.9	2.1
Granitic part	287.6	279.9	184.7	46.7	30.0	5.0
Sedimentary part	173.9	251.5	102.1	24.9	9.0	1.6
Detached houses	182.8	243.0	112.9	27.8	9.7	1.6
Blocks of flats	124.2	292.2	58.3	8.8	5.3	1.8

Table 2 : Results of radon measurements in sleeping rooms (Bq/m³)

Variable	Arithmetic mean	S.D.	Geometric mean	> 200 Bq/m³ %	> 400 Bq/m³ < %	> 1000 Bq/m ³ %
Total	151.4	211.5	91.8	20.2	7.3	1.6
Granitic part	229.7	251.8	147.3	31.8	17.5	1.6
Sedimentary part	138.3	201.4	84.8	18.3	5.6	1.6
Detached houses	148.2	208.0	93.3	21.07	6.0	1.9
Blocks of flats	84.3	150.4	50.6	3.5	3.5	0.0

Indoor variations

The concentrations in living rooms were 25% more important than in bedrooms, (110.8) and 91.8 Bq/m³; p<0.001) even when the living room and bedroom were on the same floor.(e.g. for the ground floor 105.6 and 94.04 Bq/m³; p=0.002).

Variations during year

No increase was observed from October-November to December-January in bedrooms (geometric means respectively 74.2 and 87.6 Bq/m³; p=0.100) or in living rooms (89.8 and 94.9;p=0.300)

First comparisons of the results between campaigns

Geometric and arithmetic means were corrected to allow comparison. For the Franche-Comté 2005 campaign, 50% of the living room level was added to 50% of the sleeping room level. Mean values for each stratum were added taking into account the percentage of the houses included in each of them in the area.

For the national campaign in Franche-Comté (1984-1999), the data have been weighted by the number of houses in each of the four departments (French administrative unity) of the region.

Table 3: First comparison of corrected results of radon measurements between both campaigns

	Correction	Arithmetic mean (Bq/m ³)	Geometric mean (Bq/m ³)
French national campaign (1984-99)	50% living room + 50% sleeping room results Sum (% of each strata to total houses of the area * mean level)	144.5	89.8
Campaign of 2005	Sum (% of houses in each department * department mean level)	146.2	87.3

Discussion – Conclusion

The statistical analysis has just begun and many important steps have to be performed (multivariate assessment of modifying factors, standardisation of the measurements for

Multivariate analysis and stratification adjustments are currently performed with the SAS 8 package.

First Results

Sampling

A letter was sent to 1356 sampled addresses, followed by 1356 calls, 1/3 were excluded (no answer, false telephone number, not main home), 1/3 did not accept, 1/3 accepted (454) to be included in this study. 97% (877/907) of detectors were got back by mail. In total 454 houses were measured (65 in the granitic region, 61 in blocks of flats (blocks of flats) and 328 detached houses in the sedimentary area.

annual means, correction of the distribution considering the stratification). The indoor variations are important and justify the performing of a sensitivity analysis based on the different measures and information on the time activity patterns in order to determine their influence on the exposure assessments. Those results will be necessary to produce an estimation of the distribution of exposure to dwelling radon of the population. Nevertheless a first comparison of the results of this campaign to the former's ones seems to show close mean levels. This campaign confirms that the radon levels measured in the Franche-Comté are

particularly important even in mainly sedimentary area. These results justify an accurate assessment of the exposure to dwelling radon and risk of lung cancer associated. The important information of the home and occupants characteristics should allow the assessment of different risk reduction strategies' efficiencies.

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