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An affordable proxy of representative national survey on radon concentration in dwellings: Design, organisation and preliminary evaluation of representativeness

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HIGHLIGHTS

- In Italy a new national survey was designed and organised.
- A new approach for a proxy of a representative national survey was used.
- The aim is to estimate the frequency distribution of indoor radon concentration in all the 110 Italian Provinces.
- The realisation of this survey was feasible and affordable.
- Preliminary evaluation of sample representativeness was performed at national level.

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ABSTRACT

Representative national surveys in dwellings are important to unbiasedly evaluate the exposure of the general population to radon. In Italy, a representative national survey was conducted from 1989 to 1996, which involved about 5600 dwellings in 232 towns. Later on, some Regions carried out more detailed surveys, but a new national survey in dwellings is necessary in order to obtain a more thorough estimate of radon concentration distribution over the Italian territory. The need to make this survey in an affordable way led to implement a new approach based on the collaboration between the Istituto Superiore di Sanità and a national company with workplaces and employees' homes throughout the country. The intent is to carry out a proxy of a population representative survey by measuring radon concentration in the homes of a random sample of the company employees. The realisation of this survey was affordable, thanks to the availability of corporate e-mail for each employee, intranet service, and company internal mail service. A dedicated web procedure and e-questionnaires allowed to automatically manage the contact with employees and to collect their data, which were both cost- and time-saving. Using this e-mail contact approach, 53% of contacted employees consented to participate in the survey. Radon concentration passive measuring devices were distributed to about 7000 dwellings, using about 14000 CR-39 detectors (two measured rooms per dwelling). In order to reduce costs, the devices were exposed for 12 months instead of two consecutive 6-month periods (as with the former national survey). A first checking of the actual representativeness of the sample was done by comparing characteristics of dwellings and occupants in the sample with corresponding data from the latest National Census. This was accomplished thanks to the fact that the questions in the survey questionnaire were tailored to the categories adopted for the Census questionnaire. A preliminary comparison showed that, at national level, the Italian dwellings are quite well represented by the sample.

1. Introduction

International recommendations and regulations require the set-up and implementation of a National Radon Program (WHO, 2009; EC, 2011; IAEA, 2011) whose initial step is to carry out a national radon survey in order to obtain a representative distribution of the radon concentration within the country, and to plan appropriate actions accordingly.

However, carrying out a truly representative national survey on radon in dwellings can be quite difficult, expensive and time-consuming. It is difficult because a complete list of individuals (or

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families) from which to randomly extract a representative sample of the whole population is seldom available. In most cases, national lists (mail addresses, telephones, etc.) can only be used as proxy for residents. When registries of residents are available at the local level only, it is possible to use a multi-step sampling strategy. This is expensive and time-consuming because sampled persons have to be contacted by phone, by mail, or directly to ask them to join the survey. Then, a questionnaire is to be filled in for each participant and the ensuing data loaded into a PC file.

In Italy, with a previous national survey on radon in dwellings – carried out in 1989–1999 and involving ~5600 dwellings in 232 Municipalities (Bochicchio et al., 1996, 2005) – radon concentration distribution at the regional level was assessed for all 21 Regions. It was a survey that required a complex organisation, with the central coordination of National Institutions and the involvement of regional laboratories throughout the country. The National Institutes designed the sampling protocols, the questionnaire, and the experimental procedures; the regional laboratories were responsible for the preparation, processing, and analysis of the radon detectors, and managed the data entry from both filled-in questionnaires and detectors.

After the national survey, more detailed surveys were carried out but only in a few Regions. Therefore, an updated, more detailed, representative national survey on radon in dwellings was deemed necessary to better plan actions to reduce radon risk all over the country. A new national survey was designed and implemented by the Istituto Superiore di Sanità (ISS) in collaboration with an Italian telephone company (Telecom-Italia) with the aim to obtain a representative distribution of the radon concentration in dwellings in all the 110 Italian Provinces, by using an affordable approach. This survey started at the beginning of 2010 and all the radon concentration measurements will be available by the end of 2012.

The paper reports the design and implementation of the survey, highlighting the aspects that made this survey affordable, and describing the criteria used to assess the extent to which a sample of Telecom-Italia employees' homes is representative of the dwellings of the general population in Italy.

2. Methods

2.1. Sampling design

The sampling base of this survey is the complete list of the about 54000 employees of Telecom-Italia, which is the largest Italian telecommunication company. Telecom-Italia workplaces and employees' homes are distributed all over the country, covering all the 110 Italian Provinces, that is a fundamental condition to make this approach usable for the intended nationwide survey. In particular, employees' dwellings are spread over about 4200 Municipalities out of the 8100 Italian Municipalities, while workplaces are located in 1028 sites distributed in 536 Municipalities (Table 1).

The eligibility criteria for employees to be included in the sample were: i) working and living in the same Region; ii) being less than 60 years old; iii) not planning to move within one year from the beginning of the survey. These criteria were adopted to account for survey organisational issues and to avoid losses from the sample of employees during the survey period. A percentage of about 4% did not meet the first two eligibility criteria.

The survey hereby described is intended to estimate radon distribution parameters for each Italian Province since a stratified sample of the 110 Italian Provinces (administrative divisions updated to 2009) was used as strata. A simple random sample was drawn for each stratum. Sample size of each stratum was defined accounting for both the desired precision of the estimates of the radon distribution parameters, and resource constraints in terms of survey duration, available detectors, staff costs, etc. An overall sample size of about 6000 was chosen to have a precision of about 20% on geometric and arithmetic means. Finally sample size was increased to about 7000 dwellings, assuming a certain number of refusals.

Table 1
Distribution of Italian dwellings, Telecom employees and Telecom workplaces in the 110 Italian Provinces (median and range among Provinces).

	Number of dwellings		Number of towns	
	Total	Per province	Total	Per province
All Italian dwellings	~20,000,000	378,000 (58,000–4,100,000)	8100	60 (6–315)
All Telecom employees	54,168	190 (10–12,833)	4198	32 (6–184)
Telecom workplaces	1028	6 (1–114)	536	4 (1–19)

2.2. Radon concentration measurements

The technique to measure radon concentration uses nuclear track detectors. Specifically, passive radon measuring devices consist of a small dome-shaped diffusion chamber of 5-cm diameter and 2-cm height, made of conductive plastic, housing a CR-39 nuclear track detector (Intercast Europe srl, Parma, Italy) on the bottom. After exposure, the detectors are chemically etched and read out with an automatic, high-reproducibility system (Politrack system operating with software Politrack version 4.1, produced in Italy).

In each dwelling two rooms were monitored, a living room and a bedroom, with one device per room. In order to reduce costs, the detectors were exposed for a single period of 12 months instead of two consecutive 6-month periods, as in several other surveys, including the former national survey (Bochicchio et al., 1996, 2005).

Considering the long period of exposure, great care was taken to avoid particular conditions that could affect measurements. In particular, it was recommended to place devices far from the stove in the kitchen in order to avoid condensation of cooking vapours on the device, which could affect radon entry and, in turn, the measurement sensitivity. On the opposite, dust layer deposited on the detector holder surface does not affect the radon entry into the diffusion chamber.

To evaluate the effect of ageing and fading for an exposure period of 12 months, as well as the precision of measurement in field conditions, a supplementary survey is being carried out in about 60 dwellings, with paired radon devices exposed in two rooms for three different periods of exposure (3, 6 and 12 consecutive months). Remarkably, from a previous study performed using the same CR-39 detector type (from Intercast) and the same automatic read-out system, no appreciable fading and ageing effect was noted for detectors exposed for six months (Caresana et al., 2011).

2.3. Organisation of the survey

In view of cost, time, resource and staff constraints, this survey was organised in an affordable and feasible way at each stage: i) sampling procedure; ii) contacts with employees and sample recruitment; iii) data collection; iv) shipping of detectors.

2.3.1. Sampling procedure

The availability of a database management system (DBMS), containing information on all the Telecom employees, including their workplaces and home addresses, made the design, testing and implementation of the sampling scheme very easy and cost free.