Working towards Residential Radon Survey in South America

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Abstract. Information about residential radon levels in low and middle income countries is very sparse. In response to the World Health Organization initiative in the International Radon Project, we propose a research project that will address this knowledge gap in South America by conducting a residential radon survey. Following initial in vitro and in vivo studies of radon and studies of uranium miners exposed to radon, over twenty large case-control studies of lung cancer risk from exposure to residential radon have been completed worldwide by year 2004. Recently pooled data from these individual studies have been analyzed. These collaborative analyses of the indoor studies in Europe, North America, and China provide strong direct evidence that radon is causing a substantial number of lung cancers in the general population. To reduce radon lung cancer risk, national authorities must have methods and tools based on solid scientific evidence to develop sound public health policies. We propose to conduct a survey in ten South American countries using the distribution and analysis of passive alpha tracking detectors in houses selected at random in pre-selected cities in each participating country. We also present an approach to estimate the cost of carrying out such a survey and the radon laboratory infrastructure needed. The results of the proposed survey will allow to conduct assessment of the exposure to residential radon in the populations of South American countries and to assess the health impact of this exposure. The results of the project will also help national health authorities in developing national residential radon action levels and regulations, as well as provide public health guidance for radon awareness and mitigation.

KEYWORDS: radon, residential radon, risk, lung cancer, survey, South America, policy

1. Background

Radon is a chemically inert, naturally occurring radioactive gas without odor, color or taste. It is produced from radium in the decay chain of uranium, an element found in varying amounts in all rocks and soil all over the world. Radon gas escapes easily from the ground into the air and disintegrates through short-lived decay products called radon daughters or radon progeny. The short-lived progeny, which decay emitting heavily ionizing radiation called alpha particles, can be electrically charged and attach to aerosols, dust and other particles in the air we breathe. As a result, radon progeny may be deposited on the cells lining the airways where the alpha particles can damage DNA and potentially cause lung cancer [1]. An increased risk of lung cancer is the main health hazard from high radon exposure. This has been substantiated in many studies of uranium miners [1]. Based on these studies, the International Agency for Research on Cancer (IARC), a WHO agency

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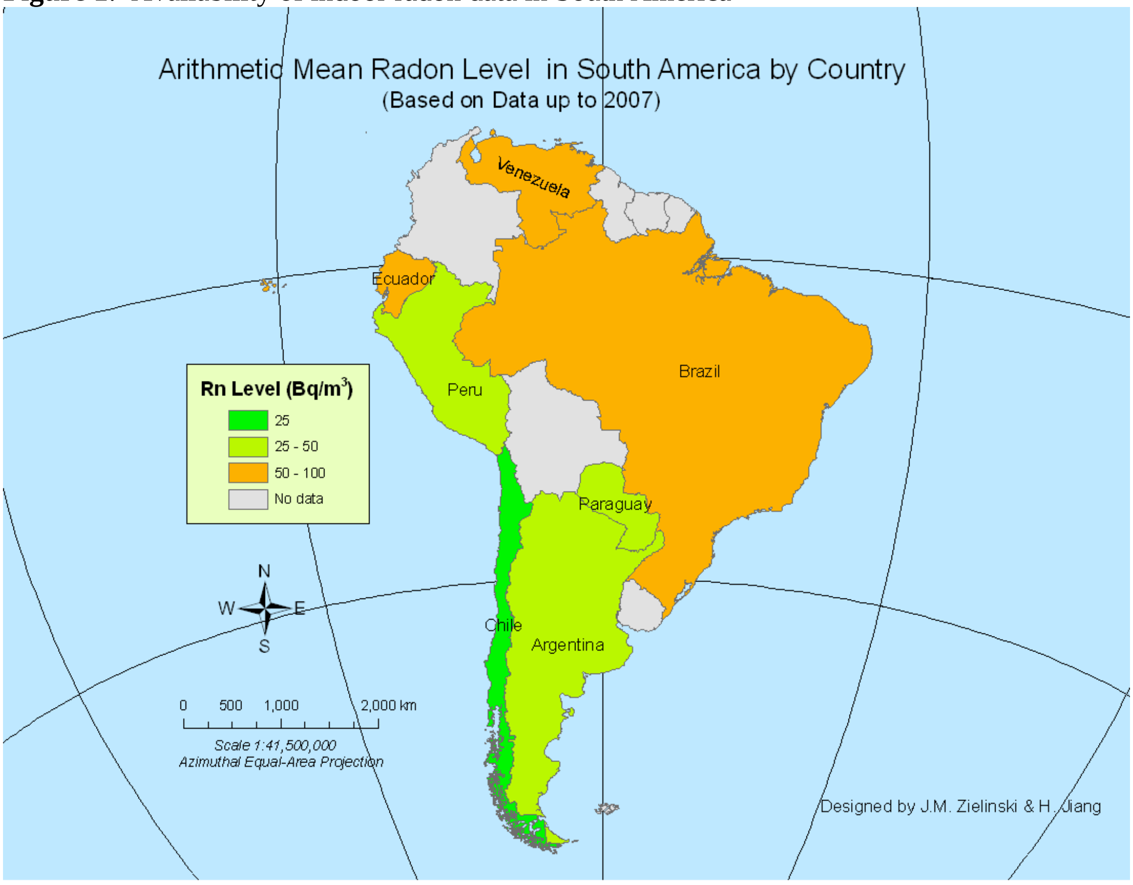
specializing in cancer, and the US National Toxicology Program have classified radon as a human carcinogen [2-4]. The health hazard of much lower levels of radon found in homes and other places has also been investigated. By the year 2004, over twenty large case-control studies of lung cancer risk from exposure to residential radon have been completed around the world [5-7]. Recently researchers have pooled the information from these individual studies and re-analyzed the data. These collaborative analyses of the indoor radon studies in Europe [8-9], North America [10-11], and China [12] provide strong direct evidence that radon is indeed causing a substantial number of lung cancers in the general population. To reduce lung cancer risk, national authorities need methods and tools based on solid scientific evidence. In particular, strategies for reduction of radon exposures must be based on information about the geographic variation of indoor radon concentrations within a country, as well as the number and location of homes with high radon levels. The concentration of radon in a home depends on the amount of radon-producing uranium in the underlying rocks and soils, the routes available for its passage into the home and the rate of exchange between indoor and outdoor air. Geographical variations of indoor radon concentrations are related to regional differences in soil composition, climate and other factors [1, 13]. Nationwide surveys of indoor radon concentrations have been conducted mostly in high income industrialized countries. In developing countries, the data about residential radon levels are very sparse.

Figure 1: Availability of indoor radon data in South America



In North America, comprehensive data from nationwide surveys of indoor radon concentrations exist in the United States [14] and Canada [15-18]. In Canada, the national radon survey involved measurements in 14,000 houses in 19 cities (approximately 0.5% of all dwellings in the target cities) [15-16, 18]. This sample is representative of the country with a territory of ≈9,000,000 squared kilometers and with a population of ≈33,000,000 inhabitants.

Measurements of residential radon concentration have been conducted in six South American countries: Brazil [19-23], Argentina [19,24], Ecuador, Peru, Venezuela [19], and Chile [25] (Figure 1). Though the measurements provide useful information on indoor radon levels for some population groups in selected areas, they are not representative of the entire populations and territories of the respective countries. The largest number of measurements (2034 measurements in 14 cities) was conducted in Argentina [19], a country with a surface area of ≈2,780,400 square kilometers and a population of ≈36,000,000 inhabitants. In Brazil (surface area ≈8,547,400 square kilometers, population ≈183,000,000), radon measurements were conducted in 869 dwellings [23]. These numbers are even smaller in Ecuador (61 measurements), Peru (168 measurements), and Venezuela (143 measurements) [19]. Available information on radon gas concentrations for Chile is limited to measurement in 119 houses in the city of Santiago (population ≈5 million), and in several of the 15 houses in the Sub-Antarctic Presidente E. Frei station [25]. To our knowledge, there are no published data on indoor radon concentrations for other South American countries. We propose a research project that will address this knowledge gap by conducting a residential radon survey in South America. The project responds to the World Health Organization initiative on residential radon [26].

2. WHO International Radon Project

In January 2005, the WHO launched the International Radon Project in which over 20 countries have formed a network of partners to identify and promote programs that reduce the health impact of radon [27]. The first meeting of the Project was held in Geneva in January 2005 to develop a strategy for dealing with this important health issue. The key objectives of the Project are to:
- identify effective strategies for reducing the health impact of radon;
- promote sound policy options, prevention and mitigation programs to national authorities;
- raise public and political awareness about the consequences of exposure to radon;
- raise the awareness of financial institutions supplying home mortgages to the potential impact of elevated radon levels on property values;
- monitor and periodically review mitigation measures to ensure their effectiveness;
- estimate the global health impact of exposure to residential radon and so allow resources to be allocated effectively to mitigate the health impact of radon; and
- create a global database (including maps) of residential radon exposure.

3. Methodology of South American Radon Survey

3.1 Scope

Table 1: Population and number of dwellings in each country from South America.

Country	Population	Surface area (km^2)	Number of people / km^2	Year	Number of dwellings
Argentina	36,270,130	2,780,400	13	2001	10,073,625
Bolivia	8,328,700	1,098,581	8	2000	2,082,175
Brasil	183,162,261	8,547,404	21	2005	45,790,565
Chile	15,498,930	756,096	20	2002	3,874,733
Colombia	41,589,018	1,141,748	36	1999	10,397,255
Ecuador	12,645,095	272,045	46	2000	3,161,274
Paraguay	5,734,000	406,860	14	1999	1,433,500
Peru	26,090,000	1,285,216	20	2001	6,522,500
Uruguay	3,360,868	175,016	19	2002	840,217
Venezuela	23,706,000	912,050	26	1998	5,926,500
South America	356,385,002	17,375,416	21		90,102,344

Passive alpha tracking detector will be distributed in houses selected at random in pre-selected cities in each country. Some important issues have to be defined, such as: the number of dwellings in each country, the measurement period, and the logistic to distribute and collect detectors in each country and within countries. Some considerations regarding those issues had to be done in order to estimate the involved costs. Table 1 presents data from each country regarding population size, surface area, population density and an estimation of number of dwellings by considering 4 people in each house.

In Table 2 we summarize administrative features of each country, and provide estimates of the number of dwellings in cities with more than 100,000 inhabitants. We propose to select 0.5% of all dwelling in the target 413 cities with more than 100,000 inhabitants (i.e. 217,000 dwellings) for long term (12 months) radon monitoring. This is a similar sampling rate as in the residential radon survey in Canada that was carried out in 1977, 1978 and 1980 in nineteen Canadian cities [15-16, 18]. The proposed sampling frame should allow the estimation of not only national population averages for participating countries, but also reliable averages for smaller geographical units (Federal States, Departments or Provinces). One of the primary objectives of the proposed survey will be to estimate with a good precision the proportion of the population of households (or individuals) subject to a radon concentration level higher than 200 Bq/m3.

Table 2: Demographics of South America countries. Estimates of number of dwellings in the survey.

Country	Number of Federal States, Departments or Provinces	Number of Main cities [a]	Number of cities > 100,000 inhabitants	Population in cities > 100,000 inhabitants	Number of dwellings in cities > 100,000 inhabitants	0.5% of dwellings cities > 100,000 inhabitants
Argentina	24	21	58	20,780,089	5,195,022	25,975
Bolivia	10	14	9	3,853,490	963,373	4,817
Brasil	27	33	219	87,084,400	21,771,100	108,856
Chile	13	24	24	9,407,530	2,351,883	11,759
Colombia	33	20	38	22,087,318	5,521,830	27,609
Ecuador	22	17	14	5,335,807	1,333,952	6,670
Paraguay	18	14	7	1,498,712	374,678	1,873
Peru	25	11	7	10,329,369	2,582,342	12,912
Uruguay	19	14	1	1,303,182	325,796	1,629
Venezuela	25	22	36	11,955,000	2,988,750	14,944
South America	216	190	413	173,634,897	43,408,724	217,044

[a] Some important cities (such as provincial capitals) with less than 100, 000 inhabitants are included in this category

3.2 Radon laboratory infrastructure (capacity building)

The Radon laboratory at the Institute of Radioprotection and Dosimetry (IRD) in Brazil, which uses the tracking etching technique, has a limited capacity of analysis. In order to carry on all analyses for the South America survey, the IRD Radon Laboratory will need to be upgraded with an automatic radon system RADOSYS, which has an analytical capacity of 450 samples per day [28].

Table 3: Institutions in South America countries contacted to take part in a radon survey project.

Country	Contact
Argentina	Lic. Analia Canoba Gerencia Apoyo Cientifico Autoridad Regulatoria Nuclear - Centro Atomico Ezeiza Tel: 54-11-6-779-8363 Fax: 54-11-6-779-8460 E-mail: acanoba@cae.arn.gov.ar
Bolivia	Dr. Alberto Miranda Cuadros Instituto Boliviano de Ciencia y Tecnología Nuclear Av. 6 de Agosto No. 2905 - Casilla 4821 - BOLIVIA Tel: + 59 12 433481 Fax: + 59 12 433063 e-mail: ibten@caoba.entelnet.bo
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Chile	Jorge Gamarra Comisión Chilena de Energía Nuclear Jefe Sección Dosimetría Amunategui 95 - Casilla 188-D -CHILE E-mail: jgamarra@cchen.cl
Colombia	Dr. Jorge Ignacio Vallejo Mejia Ministerio de Minas y Energía Av. El Dorado - CAN - Oficina 403 - COLOMBIA TE: + 57 1 3245242 Fax: + 57 1 3245241 e-mail: asesornuclear@col.net.co
Equador	Ing. José Carrion Arguello Comisión Equatoriana de Energia Atomica Calle Juan Larrea 534 y Riofrío - Casilla 17-01-2517 - ECUADOR Tel + 593 2 225 166/545 861/773/649 Fax: + 593 2 563 336 e-mail: comecen1@comecenat.gov.ec
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Uruguay	Dr. Sylvia Fascioli Dirección Nacional de Tecnologia Nuclear - Uruguay E-mail: dntncoop@adinet.com.uy
Venezuela	Dr. Angel Dias Aponte Ministério de Energia y Minas E-mail: adiaz@mem.gov.ve

3.3 Distribution of radon detectors

Recruitment of participants will be the most difficult task. Usually, in most South American countries, owners do not allow strangers to enter their homes (mainly in big cities). Therefore, it would be very difficult to select houses at random and get permission from the owners to install radon detectors. A strategy will need to be developed to overcome this problem. One possibility is to select dwellings through some national or provincial organism, like Army, Federal and State Institutions or some big industries/companies in each city and ask for permission to use employees' residence to do the radon survey. Usually employees' residences are spread over all parts of the city. This strategy does not represent a statistically random collection but could be a good alternative to overcome the difficult task of recruiting participants. Independent of the sampling strategy, we propose to setup a survey team in each city consisting of a project leader and five assistants.

3.4 Partners in South American countries

Table 3 presents a list of Institutions and respective researchers that were contacted by IRD-Brazil to ask about their interest in taking part in a radon survey in South America and also to ask for information about their country. Most were very interested in taking part in the project.

3.5 Evaluation

Evaluation framework for this project will be developed with the office of the director of Pan-American Health Organization.

4. Cost of the program

4.1. Management

It is estimated that the project duration will be four years. All management costs for the project will be covered by in-kind contributions from team members, local collaborators, but this project does not mean an economic funding by the institutions of each country. Therefore international funding will be sought in accordance with the scale of the project.

4.2 Radon Laboratory Infrastructure

In order to carry on all analyses for the South America survey, the IRD Radon Laboratory will need to be upgraded with an automatic radon system an estimated total cost of US$ 23,736.00.

The number of detectors to be bought will depend on the number of dwellings to be sampled. It was considered that two detectors would be used at the same time per house (one in a living room and one in a bedroom). Therefore, 434,088 detectors will be needed. As the cost of 250 detectors is US$1206.00, the total cost for 434,088 detectors will be US$ 2,094,037.

4.3 Transportation

Transportation of the detectors from and to the IRD Radon Laboratory in Brazil was estimated using the cost of a 30 kg international SEDEX. The estimated cost is US$ 1,500.00 per country. Considering 9 countries, the total cost of transportation would be US$ 13,500.00. Transportation of detectors from the coordinator Institution in each country to all participant cities in the country was estimated considering the cost of a national SEDEX in Brazil of U$ 40.00. Considering 413 cities, two-way, total costs would be US$33,040.00. Total cost of detectors transport would be US$ 46,540.00.

4.4 Logistic to distribute the detector in each country

The survey team in each city will be comprised of a project leader and five assistants. An estimation was done considering that the salary of each assistant is approximately US$ 300 per month, 3 months work to complete the detectors installations in each city and 3 months work for collecting the detectors. Five assistants for 6 months would cost US$ 9000,00 approximately for each city. Therefore, logistic of distributing and collecting detectors in 413 cities would cost US$ 3,717,000.

A summary of all costs involved in this estimation is presented in Table 4. All figures in the budget calculations are in US dollars.

Table 4: Summary of costs over four years.

Description	Cost – US$	
Radosys Unit		23,736
Detectors acquisition (434,087 units)		2,094,037
Transport of detectors		46,540
Detectors distribution logistic		3,717,000
Sub-total (all above): Direct cost	5,881,313	
Travel for team members & meetings		120,000
Training (postdocs)		160,000
Grand Total		6,161,313

5. Conclusion

The results of the survey will allow to conduct exposure assessment for the population in South America and to assess the health impact of this exposure. The results of the project will help national health authorities in developing national residential radon action levels and regulations, as well as provide public health guidance for awareness-raising and mitigation.

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