How to Ensure That National Radon Survey Results Are Useful for Public Health Practice

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ABSTRACT

Exposure to radon gas increases the risk of lung cancer. Preliminary national survey data collected by Health Canada indicate that approximately 10% of households exceed the recommended federal long-term guideline of 200 Bq/m³. However, results to date have been reported for large geographic areas in broad measurement categories. Given that Health Canada recommends the most rapid remediation for buildings with the highest concentrations, such reporting makes it challenging for public health authorities to target interventions to communities at the highest risk. Here we use data from a survey in British Columbia to illustrate how improved spatial resolution and more refined concentration categories would be valuable for prioritizing the use of limited public health resources. We encourage Health Canada in future to provide more specific, community-level information that can be used to inform local policy and to engage building owners in radon testing and remediation.

Key words: Radon; indoor air quality; public health; geographic information systems

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Radon gas is a radioactive decay product of naturally occurring uranium. It is found in bedrock, and it enters soil and water under a variety of geological conditions. Radon penetrates indoors through building foundations, with the infiltration rate increasing as outdoor temperatures decrease (because the warmer indoor environment creates a pressure differential that draws soil gas into the building). Factors affecting the concentration of radon in a specific building include its construction (especially the design and material used for the foundation), heating and ventilation, and underlying geology and soil structure. However, there is no reliable way to assess the radon concentration in any given building without measuring it over several months.¹

Radon has a half-life of 3.8 days, with each atom emitting three alpha particles (the most damaging type of radiation for cells) as it decays into non-radioactive lead.² Occupational and residential exposure to radon gas has been associated with lung cancer,^{3,4} and estimates suggest that radon is a factor in 10-15% of all lung cancer cases in North America.⁵ As with all environmental carcinogens, there is no threshold below which radon is considered to be safe. Current estimates suggest that the risk of lung cancer increases by 8-16% for each 100 Bq/m³ increase in long-term concentration⁶ (where one Becquerel indicates one radioactive decay per second).

In Canada, the Federal-Provincial-Territorial Radiation Protection Committee first established guidelines for exposure to residential radon in 1988. In 2007, Health Canada revised the initial long-term concentration guideline of 800 Bq/m³ downward to 200 Bq/m³, with the recommendation that any dwelling over 600 Bq/m³ should be remediated to the lowest practicable concentration within one year.⁷ Furthermore, the new guidelines suggest that the most urgent action should be taken for buildings with the highest concentrations. In 2009, Health Canada began a nationwide survey of radon concentrations in 18,000 homes to better characterize the distribution of exposures in the Canadian population. Samples were

taken from 121 administrative health regions across the country, each encompassing a large geographic area and multiple distinct communities. An interim report was released to stakeholders in December 2010⁸ wherein 6,474 measurements were summarized across the health regions using three concentration categories (0<200, 200<600 and 600+ Bq/m³). The document gives a good overview of residential radon concentrations throughout Canada, but its adherence to the spatial sampling framework and its broad categorization of measured concentrations suppress the community-scale information that would be most valuable to public health authorities.

To illustrate this loss of information, we take advantage of data from a 1991-1992 survey of BC residences conducted by the British Columbia Centre for Disease Control (BCCDC) and the University of British Columbia using Alpha Track passive samplers. Although measurement technology has been updated in the past 20 years, radon concentrations are stable over time.⁹ Sampling included the main floors of 988 homes in southern BC, and was statistically designed to represent populations living in three categories of terrestrial radiation, with oversampling at the highest expected concentrations. Measured concentrations ranged from 0 to 1650 Bq/m³, and 90% were lower than the current 200 Bq/m³ guideline. In comparison, the Health Canada interim report included 433

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Table 1. Summary of Main Floor Radon Measurements From 988 Homes in the British Columbia Centre for Disease Control / University of British Columbia Survey

Health Region	Number of Homes	% Below 200 Bq/m ³	% 200 to 600 Bq/m ³	% Above 600 Bq/m ³
South Vancouver Island	62	100	0	0
Fraser South	22	100	0	0
Vancouver	19	100	0	0
Richmond	24	100	0	0
North Shore / Coast Garibaldi	94	100	0	0
Fraser North / Simon Fraser	36	100	0	0
Fraser East / Fraser Valley	3	100	0	0
Thompson / Cariboo	176	79.5	14.8	5.7
Okanagan	197	93.4	5.6	1.0
Kootenay-Boundary	207	81.7	13.0	5.3
East Kootenay	148	92.6	6.8	0.6

Note: The results have been summarized in the same format used by Health Canada for 11 of the same health regions.

samples for the same geographic area, with 91% of measurements lower than 200 Bq/m³.⁸

In the first step, we summarize the measurements by aggregating them to 11 of the 121 health regions sampled by Health Canada, and dividing them into the same three concentration categories (Table 1). In the second step, we take the data further by visualizing the values on a map of southern British Columbia (Figure 1). The spatial aggregation of measurements makes it impossible to identify which communities were sampled and, therefore, suppresses the specific locations of the high concentrations. In the third step, we address this by mapping the same concentration categories for all 22 communities included in the survey (Figure 2). Although the validity of the summary statistics has been decreased by disregarding the sampling framework, the practical value of the information has been increased because we can see which communities were sampled and where the high values were found. In

the fourth step, we add another layer of information by expanding the summary to seven concentration categories (<100, 100<200, 200<400, 400<600, 600<800, 800<1000 and 1000+ Bq/m³) that cover a fuller range of measured values (Figure 3). It is now clear that concentrations were <100 Bq/m³ throughout the coastal area, and that some parts of the interior had measurements spanning the entire distribution, with several homes greater than 1000 Bq/m³.

There are two principal approaches to lowering radon exposures across Canada. The first is to lower the population exposure through construction practices that reduce indoor radon concentrations. This objective is already reflected in the 2010 revision of the National Building Code of Canada, which recommends measures that limit soil gas intrusion into new homes, schools and workplaces. However, each province and territory legislates its own building code, adopting specific sections of the national code (with

Figure 1. Data from Table 1 mapped onto the health regions

Pie charts are scaled to indicate the number of measurements taken in each region, and are placed at the geographic centre of the region.

Figure 2. Data from Table 1 and Figure 1 mapped by community rather than by health region

Pie charts are scaled to indicate the number of measurements taken in each community, and are roughly placed at the geographic location of the community.

Figure 3. Data from Figure 2 expanded from three concentration categories into seven concentration categories

Pie charts are scaled to indicate the number of measurements taken in each community, and are roughly placed at the geographic location of the community.

the flexibility to specify regional exemptions) as deemed appropriate. Provincial and regional authorities need spatially explicit information about high radon concentrations to help identify areas where adoption of the new provisions should be prioritized, especially where they may be facing pressure from stakeholders to implement exemptions. Conversely, those regions where existing concentrations are well below the guideline values can also be identified. For example, Figure 3 indicates that coastal areas of southern British Columbia would remain a low priority even if Health Canada revised its guideline value to the World Health Organization minimum recommendation of 100 Bq/m³.¹⁰ The second approach is to identify and remediate buildings with high radon concentrations, which requires long-term measurements in at-risk communities. Local health authorities have direct contact with their constituents and, therefore, the opportunity to actively encourage and pursue testing in homes, schools and workplaces. Although Health Canada recommends that all homes should be tested, practicality dictates that limited resources should be used to target areas where the highest concentrations are expected. Any spatially explicit information from existing surveys can inform such initiatives.

The latter is especially important because building owners bear the cost of radon remediation in Canada, meaning that we must ultimately rely on them to achieve national reduction objectives. It is easier for public health authorities to encourage testing (and subsequent remediation) if building owners believe that their property and its inhabitants are at elevated risk. A 2001 study in Winnipeg reported that homeowners were unlikely to act on radon concentrations less than 1100 Bq/m³.¹¹ However, the same group was willing to pay an average of \$221 per each 100 Bq/m³ reduction of concentrations greater than 702 Bq/m³ (the guideline value was 800 Bq/m³ at the time) after receiving information about the health risks. Although no similar study has been conducted since the implementation of the 200 Bq/m³ guideline, we should assume that building owners will continue to use relevant risk information when making decisions about radon testing and remediation.

We have demonstrated how the spatial aggregation and broad categorization of household radon measurements suppress the community-level information that public health authorities need to help lower radon exposures in Canada. We strongly encourage Health Canada to release more spatially explicit maps (similar to Figure 3) of the national radon survey results. Although the validity of the summary statistics will be somewhat decreased, the practical value of information from this rich dataset will be markedly increased.

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RÉSUMÉ

L'exposition au radon accroît le risque de cancer du poumon. Selon les données préliminaires d'une enquête nationale de Santé Canada, environ 10 % des ménages dépassent les lignes directrices fédérales recommandées à long terme pour le radon, qui sont de 200 Bq/m³. Cependant, les données recueillies jusqu'à maintenant concernent de vastes zones géographiques et de grandes catégories de mesure. Comme Santé Canada recommande que l'on assainisse le plus rapidement possible les bâtiments qui présentent les plus fortes concentrations de radon, des données aussi générales n'aident pas les autorités de santé publique à concentrer leurs interventions sur les communautés les plus à risque. Nous utilisons ici les données d'une enquête menée en Colombie-Britannique pour montrer que la résolution spatiale améliorée et des catégories plus étroitement définies seraient utiles pour prioriser l'utilisation des ressources de santé publique limitées. Nous encourageons Santé Canada à fournir à l'avenir des données plus précises, recueillies à l'échelle communautaire; ces données pourraient étayer les politiques locales et inciter les propriétaires de bâtiments à effectuer des tests de radon et à prendre des mesures d'assainissement.

Mots clés : radon; qualité de l'air à l'intérieur; santé publique; systèmes d'information géographique