QUANTITATIVE RESEARCH

Geographic variation in radon and associated lung cancer risk in Canada

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ABSTRACT

OBJECTIVE: Radon is an important risk factor for lung cancer. Here we use maps of the geographic variation in radon to estimate the lung cancer risk associated with living in high radon areas of Canada.

METHODS: Geographic variation in radon was estimated using two mapping methods. The first used a Health Canada survey of 14,000 residential radon measurements aggregated to health regions, and the second, radon risk areas previously estimated from geology, sediment geochemistry and aerial gamma-ray spectrometry. Lung cancer risk associated with living in these radon areas was examined using a population-based case-control study of 2,390 lung cancer cases and 3,507 controls collected from 1994-1997 in eight Canadian provinces. Residential histories over a 20-year period were used in combination with the two mapping methods to estimate ecological radon exposures. Hierarchical logistic regression analyses were used to estimate odds ratios for lung cancer incidence, after adjusting for a comprehensive set of individual and geographic covariates.

RESULTS: Across health regions in Canada, significant variation in average residential radon concentrations (range: 16-386 Bq/m^3) and in high geological-based radon areas (range: 0-100%) is present. In multivariate models, a 50 Bq/m^3 increase in average health region radon was associated with a 7% (95% CI: -6-21%) increase in the odds of lung cancer. For every 10 years that individuals lived in high radon geological areas, the odds of lung cancer increased by 11% (95% CI: 1-23%).

CONCLUSIONS: These findings provide further evidence that radon is an important risk factor for lung cancer and that risks are unevenly distributed across Canada.

KEY WORDS: Radon; lung cancer; geographic; case-control; Canada

La traduction du résumé se trouve à la fin de l'article.

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Radon is a colourless, odourless, naturally occurring gas released from the breakdown of uranium in soils. Exposure to radon occurs primarily indoors, where levels can accumulate to high concentrations. The majority of lung cancers are due to tobacco smoke; however, radon increases the risk of lung cancer for smokers as well as for individuals who have never smoked.[1-4] In Canada, approximately 16% of lung cancers (3,261 cases annually) are estimated to be attributable to residential radon exposure.[5]

While radon is recognized as being causally associated with lung cancer, national-level studies are important to estimate attributable disease burden, increase awareness and develop population health policy. To date, only one residential radon epidemiological study has been conducted in Canada. This study was in Winnipeg and reported no associations between residential radon concentrations and lung cancer.[6] Similar to most epidemiological studies of residential radon, exposure was assessed using indoor residential measurements. While this method is the gold standard for characterizing radon exposure, studies using this method typically have limited statistical power due to the difficulty in measuring residential radon for large populations. Alternatively to using individual residential measurements, two epidemiological studies conducted in the United States and Denmark used maps and spatial prediction models to estimate long-term ecological residential radon concentrations in larger population samples, the approach we follow in this analysis. For the Cancer Prevention Study II cohort in the United States, average county-level radon measurements were linked to study participants' zip codes to estimate ecological radon exposure, and a 100 Bq/m^3 increase in radon was associated with a 15% (95% CI: 1-31%) increase in lung cancer mortality.[7] In the Danish Diet, Cancer and Health cohort, information on geology and housing characteristics were used to predict radon concentrations at residential locations for 57,053 subjects (589 lung cancer cases) and a 4% (95% CI: -31-56%) increase in lung cancer risk was observed per 100 Bq/m^3 increase in predicted radon concentrations.[8]

Here we present two national radon risk maps for Canada and estimate the associated lung cancer risks by applying these maps to 20 years of residential histories using a population-based case-control study of 2,390 histological confirmed lung cancer incidence cases and 3,507 population controls. Based on the existing evidence for radon as a risk factor for lung cancer, we expect that lung cancer incidence in this population-based case-control study will be increased in individuals living in high radon risk areas.

METHODS

Radon mapping

Two distinct approaches were used to create radon risk maps for Canada. The first (Figure 1a) and a priori best estimate of radon exposure used a recently completed residential radon survey of three-month radon measurements collected from approximately 14,000 households across Canada.[9] The sampling frame for this sur-

Table 1. Summary of the two radon mapping methods by provinces/territories

Province	Residential Radon Measurement Survey*			Radon Potential Map (% Population located in risk zones)†		
	Homes monitored	Mean (SD) radon measurement	Population weighted % >200 Bq/m³	Guarded risk zone	Moderate risk zone	High risk zone
Alberta	1124	92 (94)	5.7%	1%	1%	98%
British Columbia	1812	72 (144)	3.9%	61%	12%	28%
Manitoba	1180	150 (176)	19.4%	77%	9%	14%
New Brunswick	825	179 (319)	20.6%	16%	26%	58%
Newfoundland/Labrador	712	64 (122)	5.1%	27%	69%	4%
Nova Scotia	591	95 (232)	10.7%	51%	37%	13%
Northwest Territories	186	71 (95)	5.4%	75%	3%	23%
Nunavut	80	16 (4)	0%	8%	64%	28%
Ontario	3930	84 (150)	4.6%	10%	54%	36%
Prince Edward Island	111	49 (66)	3.5%	0%	100%	0%
Quebec	1779	82 (146)	8.2%	23%	29%	48%
Saskatchewan	1200	127 (137)	15.7%	5%	0%	95%
Yukon	225	174 (309)	19.6%	9%	69%	22%
Canada	13,755	98 (170)	6.9%	22%	32%	46%

* Results of the cross-Canada residential radon survey.[9]

† Population estimates created from 2011 Statistics Canada block points applied to the radon potential areas developed by Radon Management Corp. from geology, soil uranium geochemistry and aerial gamma ray spectrometry.[10]

vey provides geographically representative measures of residential radon concentrations by health regions (n=121) across Canada. Health regions, also called health authorities or units, are administrative boundaries in which public health activities are developed and implemented at the regional level. Participants were asked to place detectors on the lowest lived-in level of the home in which they spent a minimum of four hours per day. We averaged the resulting measurements without adjustment (i.e., we did not standardize radon measurements to basement or first floor concentrations) by health regions and hereafter refer to this map as "household-measurement-based". The grey areas of this map represent remote areas of Canada, which may not be accurately reflected in the residential radon monitoring sample.

The second approach (Figure 1b) used a map of radon risk provided by Radon Environmental Management Corp. (REMC).[10] The spatial scale of this map varies based on geological units, which were grouped into one of three risk zones according to geology, aerial gamma ray spectrometry measurements, and stream and lake sediment geochemistry. The rank classes were selected so that each of the three classes (guarded, moderate and high) contained approximately equal portions of the Canadian landmass, as this is a risk map (not an exposure map). These measurements were prioritized by data quality and type, where direct measurements were given higher weighting than extrapolated data. In addition, data used to create the United States geological radon potential map[11] were also used to calibrate predictor datasets. Hereafter we refer to this radon risk mapping approach as "geological-based".

Table 1 summarizes the results of the two mapping methods by province/territories, including the number of homes monitoring, average radon concentrations measured, and the percent of the population estimated to have radon concentrations above 200 Bq/m³ (the Canadian health standard) and living in guarded, moderate, and high radon risk zones.

Lung cancer case-control study

We used data from the lung cancer component of the National Enhanced Cancer Surveillance System (NECSS),[12] a multi-site population-based case-control study that collected 3,280 lung cancer cases, with histological classification, and 5,073 population controls from 1994-1997. Provincial cancer registries identified all lung cancer cases within 1-3 months of diagnosis and continuously sampled one in four lung cancer cases for a one-year period for inclusion in the study. Population controls were selected from a random sample of individuals within each province, frequency-matched on sex and five-year age categories to the overall collection of NECSS cancer cases. Recruitment methods for controls depended on data availability and accessibility by province and included provincial health insurance plans in five provinces (British Columbia, Saskatchewan, Manitoba, Prince Edward Island, and Nova Scotia), random digit dialing in two (Alberta and Newfoundland), and property assessment data in one (Ontario). A research questionnaire was mailed to selected cases and controls and active follow-up was conducted. The response rate for contacted lung cancer cases was 61.7% and for population controls was 67.4%.

The research questionnaire collected a comprehensive set of information on individual characteristics, including residential histories. Residential histories of study subjects were geo-coded to 6-digit postal codes and are the basis of the estimation of ecological-level radon exposure. Figure 2 illustrates kernel density maps of the residential locations of lung cancer cases and population controls between 1975 and 1994. Only study participants with complete geocoded residential histories in Canada from 1975-1994 were included in the final analysis. The time-period and exclusion criteria are meant to reduce exposure assessment error and bias that may result from incomplete self-reported residential histories. These exclusion criteria reduced the study sample to 2,390 incident histologically-confirmed lung cancer cases and 3,507 population controls. No significant differences ($p<0.05$) in demographic, socioeconomic, or smoking characteristics were found between excluded and retained lung cancer cases and population controls.

Ecological radon exposure assessment

Ecological measures of radon exposure were developed using the 20 years of residential histories and the two radon maps. Given the geological stability of uranium, it was assumed that the geographic variation in radon risk was constant during the 20-year exposure period. For the primary exposure assessment approach, we assigned average health region radon measurements (Figure 1a) to all postal codes located in each health region. For each individual, we then calculated mean health region radon measures from all residences

Figure 1. Results of the cross-Canada residential radon survey[9] presented as average health region radon concentrations (a); and geological-based radon risk areas (b) developed from geology, soil uranium geochemistry and aerial gamma ray spectrometry measurements[10]

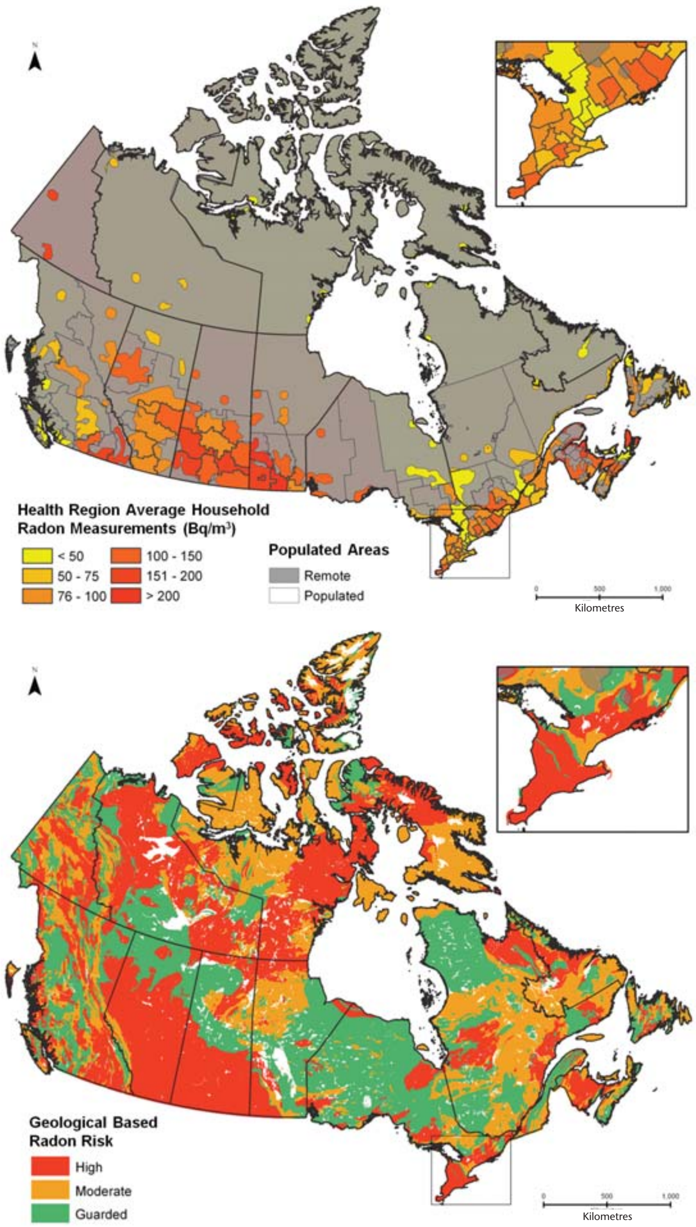


Table 2. Descriptive statistics of individual variables of lung cancer cases and population controls

Variables	**Cases* (n=2390)**	**Controls* (n=3507)**
Individual variables		
Age; Mean (SD)	63.5 (8.2)	59.0 (12.6)
Sex		
Female	1152 (48%)	1719 (49%)
Male	1238 (52%)	1788 (51%)
Median household income		
>$100,000	47 (2%)	137 (4%)
$50,000-$99,999	283 (12%)	630 (18%)
$30,000-$49,999	474 (20%)	840 (24%)
$20,000-$29,999	398 (17%)	548 (16%)
$10,000-$19,999	366 (15%)	363 (10%)
<$10,000	133 (6%)	100 (3%)
Prefer not to report	689 (29%)	889 (25%)
Education		
>High school	590 (25%)	1373 (39%)
High school	406 (17%)	607 (17%)
<High school	1379 (58%)	1514 (43%)
Smoking status		
Never-smoker	130 (6%)	1337 (38%)
Former smoker	969 (41%)	1446 (41%)
Current smoker	1288 (54%)	718 (2%)
Smoking pack years; mean (SD)	34.9 (21.0)	12.7 (17.5)
Years since quit smoking; mean (SD)	6.2 (8.9)	10.3 (13.2)
Residential SHS exposure; mean (SD)	56.7 (44.1)	36.1 (37.9)
Occupational SHS exposure; mean (SD)	74.0 (83.2)	56.7 (74.2)
Years working with dust/odours; mean (SD)	12.9 (16.8)	10.3 (15.4)
Years working with hazardous substances; mean (SD)	12.2 (27.8)	9.4 (26.0)
Geographic variables		
Urban size category†		
≥500,000	783 (33%)	1139 (33%)
100,000-499,999	376 (16%)	516 (15%)
30,000-99,999	217 (9%)	316 (9%)
1000-29,999	441 (19%)	688 (20%)
<1000	573 (24%)	848 (24%)
$PM_{2.5}$ (μg/m^3); mean (SD)	11.9 (2.9)	11.9 (3.1)
NO_2 (ppb); mean (SD)	15.6 (8.9)	15.3 (9.1)
O_3 (ppb); mean (SD)	20.2 (5.0)	20.3 (4.9)
Ecological radon estimates		
Average health region radon measurements (Bq/m^3); mean (SD)	81.3 (40.8)	78.6 (39.5)
Years in high radon risk area; mean (SD)	9.0 (9.5)	7.9 (9.5)

* Descriptive statistics for lung cancer cases and population controls with 20 years of complete residential histories between 1975-1994.
† Based on the longest-term residential location between 1975-1994.
SHS = Second-hand smoke.

in the 20-year exposure period. The secondary exposure assessment used the geological-based radon risk zones (Figure 1b) and for each individual the number of years living in guarded, moderate and high radon zones was calculated.

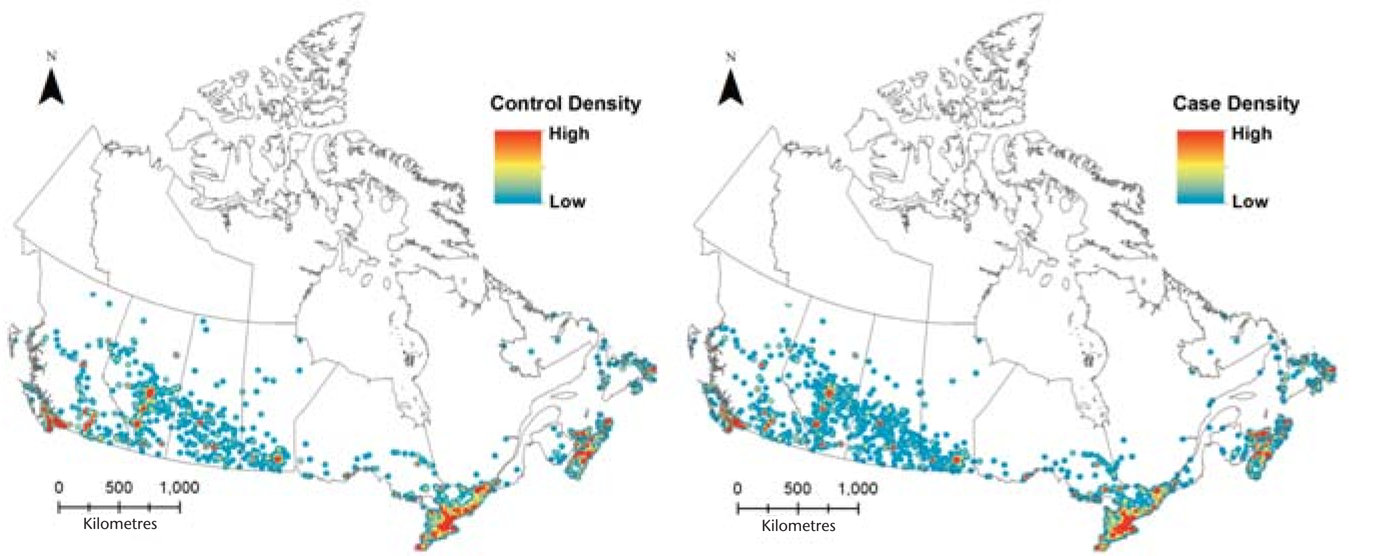
Covariates

A comprehensive set of individual and geographic variables were available for inclusion in the multivariate models. Individual variables included in the final analyses were age, sex, educational attainment, household income, smoking pack-years, years since quit smoking, residential second-hand smoke exposure (defined by the number of smokers in the home multiplied by number of residential years), occupational second-hand smoke exposure (defined by the number of smokers in the immediate work environment multiplied by number of occupational years), average weekly alcohol serving, average weekly meat servings, and years working with dust/odours and hazardous substances. Geographic variables included study province; long-term fine particulate matter ($PM_{2.5}$), nitrogen dioxide (NO_2) and ozone (O_3) air pollution exposure estimates;[13] an urban population size category based on where individuals had lived the longest during the exposure period; and a long-term neighbourhood socio-economic status indicator.[14]

Statistical analyses

We conducted statistical analyses using hierarchical logistic regression models (GLIMMIX, SAS version 9.3; SAS Institute, Inc., Cary, NC). Random intercepts were defined from Statistics Canada census division (CD) boundaries (which are the second-largest census administrative area after provinces) and assigned to individuals' longest-term residential location to account for residual clustering of study participant characteristics and/or geographic-related biases. Individuals with missing covariates (cases=236, controls=243) were excluded from the final multivariate models. We report odds ratios (ORs) and 95% confidence intervals (95% CI) for 50 Bq/m^3

Figure 2. Kernel density maps (radius=25 km) of residential locations between 1975-1994 for population controls and lung cancer cases



increases in health region radon concentrations (approximate interquartile range) as well as exposure quartiles for unadjusted, individual and individual+geographic adjusted models. For the geological-based radon risk exposure model, we report ORs for 10-year increases in residing within high radon risk zones as well as categorized residential years. Models were also stratified by major lung cancer histological subtypes.

RESULTS

Selected individual and geographic descriptive statistics for study participants are provided in Table 2 as well as ecological radon estimates. Six percent of lung cancer cases were never-smokers compared to 38% in the population control group. Lung cancer cases had much higher smoking pack-years than controls and had quit smoking more recently. There were also differences between cases and controls in terms of socio-economic and individual health behaviours as well as occupational exposures. No differences were found for years living in an urban area or ambient air pollution exposures in unadjusted analyses. Cases had higher ecological radon exposures for all measures: the mean (±SD) health region radon concentration for cases was 81.3 (40.8) Bq/m^3 compared to 78.6 (39.5) Bq/m^3 for controls, and lung cancer cases lived an average of 9.0 years in high radon risk zones compared to 7.9 years for controls.

Table 3 presents unadjusted ORs (95% CI) as well as individual and individual+geographic adjusted ORs for lung cancer incidence using both ecological radon exposure measures. In the fully-adjusted model (individual+geographic), a 50 Bq/m^3 increase in health region average radon concentrations was associated with a non-significant increase in the odds of all lung cancer incidence (OR 1.07, 95% CI: 0.94-1.21). A significant increase in the odds of adenocarcinoma (OR 1.23, 95% CI: 1.04-1.45) was observed. For every 10 years residing in a high radon potential zone, the odds of lung cancer also increased (OR 1.11, 95% CI: 1.01-1.23) and the largest risks were observed for large cell and squamous cell carcinoma. No statistically significant interactions were observed for any smoking variables and ecological radon exposures. For example, the ORs for a 50 Bq/m^3 increase in average health region radon stratified by never- (130 lung cancer cases), former (969 cases) and current smokers (1,288 cases) were 0.83 (95% CI: 0.55-1.23), 1.11 (95% CI: 0.93-1.31) and 1.05 (95% CI: 0.86-1.27), respectively.

DISCUSSION

Substantial geographic variation in radon was observed across Canada and increased odds of lung cancer were found for individuals living in high-risk areas. These findings provide further evidence that radon is an important risk factor for lung cancer and that risks are unevenly distributed across Canada.

Geographic variation in radon and population health prevention

The geographic variation in radon risk across Canada (Figure 1) has important population health implications, although it is important to differentiate the individual- and population-level utility of the radon maps presented here. The radon maps illustrate large variations in mean radon concentrations by health regions (range:16-370 Bq/m^3); however, all areas of Canada had homes with high radon concentrations (even in the health region with the lowest mean radon concentration, there were still homes that tested over the Health Canada guideline of 200 Bq/m^3). This supports Health Canada's policy that all individuals should get their homes tested for radon.[15]

From a population health perspective, areas of Canada that have much greater radon risk could be the target of focused radon awareness and prevention programs. In Canada, less than 30% of the population are able to describe radon as a health hazard, and only 5% of individuals have tested their homes for radon.[16] Currently, there are no official radon maps for Canada, despite most developed countries having published radon risk maps that indicate high/low areas based on radon measurements or geological information.[17] Geographical targeting would also increase the cost-effectiveness of radon prevention options, which are often criticized for being too costly.[18] The health region household-measurement map is recommended for informing population health prevention,

Table 3. Association between ecological radon exposures and lung cancer incidence, by histological subtype

Exposures	Cases	Controls	Unadjusted* OR (95% CI)	Individual covariate† Adjusted OR (95% CI)	Individual + geographic covariate‡ Adjusted OR (95% CI)
Average health region radon measurements					
All lung cancer (per 50 Bq/m³)	2154	3264	1.12 (1.03-1.22)	1.05 (0.94-1.17)	1.07 (0.94-1.21)
Categorized Bq/m³ (Quartiles)					
Q1 (<51)	496	808	1	1	1
Q2 (51-75)	525	894	1.06 (0.88-1.27)	1.08 (0.86-1.37)	1.04 (0.81-1.34)
Q3 (76-102)	567	792	1.23 (1.01-1.49)	1.09 (0.85-1.41)	1.11 (0.84-1.45)
Q4 (>102)	566	770	1.26 (1.03-1.54)	1.19 (0.92-1.54)	1.18 (0.89-1.56)
Histological subtype (per 50 Bq/m³)					
Squamous cell	605	3264	1.07 (0.93-1.22)	0.96 (0.81-1.15)	0.92 (0.76-1.11)
Adenocarcinoma	756	3264	1.15 (1.02-1.30)	1.14 (1.00-1.28)	1.23 (1.04-1.45)
Small cell	358	3264	1.17 (1.00-1.37)	1.08 (0.88-1.33)	1.09 (0.85-1.41)
Large cell	213	3264	1.06 (0.87-1.29)	1.05 (0.82-1.35)	1.08 (0.77-1.51)
Residing in high radon risk zone					
All lung cancer (per 10 years)	2154	3264	1.10 (1.03-1.18)	1.12 (1.02-1.22)	1.11 (1.01-1.23)
Categorized Years					
0	1025	1743	1	1	1
1-9	135	209	1.18 (0.93-1.49)	1.18 (0.88-1.59)	1.20 (0.89-1.55)
10-19	134	184	1.32 (1.04-1.68)	1.27 (0.93-1.73)	1.30 (0.95-1.78)
20	860	1128	1.24 (1.07-1.44)	1.27 (1.05-1.53)	1.25 (1.01-1.62)
Histological subtype (per 10 years)					
Squamous cell	605	3264	1.14 (1.02-1.27)	1.16 (1.01-1.34)	1.14 (0.97-1.34)
Adenocarcinoma	756	3264	1.07 (0.97-1.18)	1.05 (0.93-1.18)	1.05 (0.91-1.21)
Small cell	358	3264	1.07 (0.93-1.23)	1.11 (0.93-1.33)	1.13 (0.92-1.40)
Large cell	213	3264	1.18 (0.99-1.40)	1.21 (0.99-1.49)	1.21 (0.94-1.56)

* Adjusted for age, sex and study province (to account for study design).
† Adjusted for age, sex, study province, cigarette smoking pack years, years since quit smoking, educational attainment, household income, average weekly alcohol and meat consumption, residential and occupational second-hand smoke exposure, years working in occupations with dust or odours from industry, years working with lung hazards.
‡ Adjusted for all individual variables as well as ambient $PM_{2.5}$, NO_2, and O_3 air pollution exposures, urban size category of longest-duration residences, and years living in the lowest quintile of median household income, percent residence without a high school diploma, and percent rental dwellings.

as it incorporates actual indoor radon measurements and corresponds to the administrative boundaries in which public health activities are developed and implemented at the regional level. Importantly, targeted prevention efforts are only one component of a comprehensive radon strategy, as prevention measures in *all* new buildings[19] and incorporation of radon prevention with smoking cessation programs[20] are likely the most effective ways to reduce radon-related lung cancers at the population level.

Epidemiological results

We found positive associations between exposures derived from the two radon maps and lung cancer incidence in this population-based case-control study, and although most measures were not statistically significant, the effect sizes correspond closely to the existing literature on residential radon exposure and lung cancer risk. For example, combined analysis including seven North American studies found an 11% (95% CI: 0-28%) increase in lung cancer risk per 100 Bq/m³, which rose to 18% (95% CI: 2-43%) with improved exposure assessment.[21] The analysis of 13 European studies found an 8.4% (95% CI: 3-15.8%) increase in risk per 100 Bq/m³, and after correction for exposure error this rose to 16% (95% CI: 5-31%).[1] In our study, a 100 Bq/m³ increase in average health region level radon concentrations was associated with a 13% (95% CI: -12-46%) increase in the odds of lung cancer incidence. The lack of statistical significance is not unexpected given the large errors associated with assigning individual radon exposures from aggregated radon measurements; however, the epidemiological analysis served to evaluate the radon risk maps and demonstrated for the first time an association between residential radon exposure and lung cancer incidence in Canada. In addition, we found ORs per 50 Bq/m³ increase in average health region level radon concentrations of 1.23 (95% CI: 1.04-1.45) for adenocarcinoma, the lung cancer subtype most common in non-smokers. While higher radon risks are typically seen in smokers, we did not observe statistically significant effect modification for any smoking-related variable. For a detailed description of radon risks by smoking status, estimates of the number of lung cancer deaths in Ontario attributable to radon in smokers and non-smokers, and associated public health implications, we refer readers to Peterson et al.[22]

Limitations

The principal limitation of this study is the use of ecological radon measures to estimate individual-level radon exposures. Random error in exposure assessment is certainly present, due to large variability in radon concentrations between homes in the same health region, which likely attenuated the ORs towards the null.[23] Nevertheless, there is substantial radon variability between health regions in Canada that was captured by the household radon survey. We conducted a sensitivity analysis to examine how results changed if radon exposure was assigned based on average town/city measurements (if >5 measurements existed). Results showed slightly reduced ORs, with a 100 Bq/m³ increase in town/city radon associated with an 8% (-10-30%) increase in the odds of lung cancer incidence. This exposure approach uses a small sample of radon measurements to represent average city measurements even though the data are not representative at this scale (representing a trade-off between spatial scale and data representativeness); however, the similarity in results to the health region estimates suggests that geographic confounding or bias is limited. The geological-based map was also used as an independent exposure method that was thought to have increased specificity, although the use of three categories makes this ecological exposure model more susceptible to potential geographic confounding due to large homogenous areas in some parts of Canada, particularly Alberta and Saskatchewan (see Table 1). There were differences between the geological-based and household-measurement-based results, particularly for histological subtype analyses, but the overall conclusions from the two approaches are consistent in demonstrating that the odds of lung cancer were increased for individuals residing in high radon risk areas of Canada. Both mapping methods captured the very high radon locations in Canada; however, the correlation between the exposures was only 0.24. This low correlation is not surprising given the known difficulties in predicting individual residential radon concentrations,[24] which depend predominantly on individual housing characteristics. A detailed comparison of these two approaches for estimating ecologic classification of radon exposure is available elsewhere.[25] While we estimated exposure from long-term residential locations, no information was available for housing characteristics that may influence radon exposures. This is especially important for apartments and high-rise buildings, which typically have low radon concentrations compared to detached homes. This would have incorporated further exposure misclassification into the ecological radon estimates.

A number of limitations related to the case-control study design also need to be highlighted. First, while this study has relatively high response rates for cases (61.7%) and population controls (67.4%), response and recall bias cannot be ruled out. In addition, there may be geographic variation in the case/control participation ratio across Canada; however, provincial and regional stratified results supported the national analyses. Second, different recruitment methods for population controls were conducted in each province that could incorporate bias into the study, but it is unlikely that any recruitment differences would be related to radon exposures and stratified analyses by the three recruitment methods produced similar results. Third, no information was available for other environments, such as work locations, where radon exposure may occur.

CONCLUSIONS

We used two national radon maps to examine the geographic variation in radon across Canada and observed increased odds of lung cancer for individuals residing in high radon areas after adjusting for a wide range of individual risk factors, including smoking histories. Effect sizes corresponded closely with those reported in recent meta-analyses of residential radon exposure and lung cancer risk. Due to the geographic variations in radon across Canada, national radon maps could be used as one component of a comprehensive radon strategy to geographically target awareness and prevention efforts to high-risk areas.

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RÉSUMÉ

OBJECTIF : Le radon est un important facteur de risque du cancer du poumon. Nous utilisons ici des cartes de variation spatiale du radon pour estimer le risque de cancer du poumon associé au fait de vivre dans les régions du Canada fortement exposées au radon.

MÉTHODE : Nous avons estimé la variation spatiale du radon à l'aide de deux méthodes de cartographie. La première a fait appel à une enquête de Santé Canada regroupant 14 000 mesures du radon dans les habitations par région sanitaire, et la deuxième, à des estimations antérieures des régions exposées au radon par la géologie, la géochimie sédimentaire et la spectrométrie gamma aéroportée. Nous avons examiné le risque de cancer du poumon associé au fait de vivre dans ces zones exposées au radon à l'aide d'une étude populationnelle cas-témoins menée entre 1994 et 1997 auprès de 2 390 cas de cancer du poumon et de 3 507 témoins dans huit provinces canadiennes. Nous avons combiné les lieux de résidence des sujets au cours des 20 années précédentes avec les deux méthodes de cartographie pour estimer les expositions écologiques au radon. Des analyses de régression logistique hiérarchiques ont permis d'estimer les rapports de cotes de l'incidence du cancer du poumon, après avoir tenu compte d'un ensemble exhaustif de covariables individuelles et géographiques.

RÉSULTATS : Les régions sanitaires du Canada diffèrent considérablement en ce qui a trait à leurs concentrations moyennes en radon dans les habitations (intervalle : 16-386 Bq/m3) et aux zones géologiques fortement exposées au radon (intervalle : 0-100 %). Dans les modèles multivariés, une hausse de 50 Bq/m3 du radon dans une région sanitaire moyenne était associée à une hausse de 7 % (IC de 95 % : -6-21 %) de la probabilité de cancer du poumon. Pour chaque tranche de 10 ans pendant laquelle les sujets avaient vécu dans des zones géologiques fortement exposées au radon, la probabilité du cancer du poumon augmentait de 11 % (IC de 95 % : 1-23 %).

CONCLUSIONS : Ces constatations sont des preuves supplémentaires que le radon est un important facteur de risque du cancer du poumon, et que les risques sont inégalement répartis au Canada.

MOTS CLÉS : radon; tumeurs du poumon; régions géographiques; études cas-témoins; Canada