

Radon gas—the hidden killer

What is the role of family doctors?

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Abstract

Objective To create awareness of the dangers of radon gas and to provide family physicians with updated, practical information to help educate patients.

Sources of information MEDLINE (1950 to February 2013), the Cochrane Database of Systematic Reviews (2005 to 2013), and the Cochrane Central Register of Controlled Trials (2005 to 2013) were searched using relevant terms. Guidelines, position statements, articles, and original research relevant to radon were selected.

Main message Radon is the principal cause of lung cancer in non-smokers and the second most common cause in smokers (1 in 20 and 1 in 3, respectively), and lifetime risk increases in a linear fashion with radon exposure. In outdoor air, radon is diluted and is not a health concern, but as it diffuses into houses, the gas accumulates, reaching high concentrations, and becomes a health hazard. The Canadian guideline for the maximum acceptable concentration for indoor air is 200 Bq/m³, and there are cost-effective methods available to reduce radon gas when high levels are found in dwellings.

Conclusion Family physicians play a fundamental role in the prevention of radon-related lung cancer by educating their patients, guiding them about specific preventive actions, and advocating on patients' behalf.

Le radon, ce tueur imperceptible

Quel est le rôle des médecins de famille?

Résumé

Objectif Mieux faire connaître les dangers du radon, et présenter aux médecins de famille des renseignements actuels et pratiques pour bien informer leurs patients.

Editor's key points

- ▶ Radon is the principal cause of lung cancer in non-smokers and the second most common cause in smokers, and the lifetime risk of lung cancer increases in a linear fashion with radon exposure. Radon diffuses into houses by cracks in the basement, floor drains, and sump holes, and by cracks in hollow blocks or exposed soil and rock in crawl spaces. Radon can also enter houses when it is dissolved in well water and then spread through running water from taps and showers.
- ▶ As more knowledge is obtained about this gas, many countries have decreased the permissible levels for exposure. In 2007, Health Canada decreased the national maximum acceptable exposure guideline for indoor air from 800 Bq/m³ to 200 Bq/m³. Radon meters are used to test levels in houses, and relatively cost-effective methods are available to reduce radon gas when high levels are found in dwellings.
- ▶ Patients can purchase 1-time test kits online or from hardware stores at affordable prices (\$30 to \$70). These devices collect measurements for a 90-day period and are then sent to a laboratory for analysis.

Points de repère du rédacteur

- ▶ Le radon est la principale cause du cancer du poumon chez les non-fumeurs, et la deuxième chez les fumeurs. Le risque à vie d'un cancer du poumon s'accroît de manière linéaire avec l'exposition au radon. Le radon s'insinue dans les maisons par les fissures dans le sous-sol, les drains du plancher et les trous de puisard, de même que par les crevasses dans les blocs creux ou le sol et les roches exposés dans les vides sanitaires. Le radon peut aussi pénétrer dans les maisons lorsqu'il est dissous dans l'eau de puits, puis se répandre par l'eau courante des robinets et des douches.
- ▶ À mesure que les connaissances à propos de ce gaz se sont approfondies, de nombreux pays ont révisé à la baisse les niveaux acceptables d'exposition. En 2007, Santé Canada publiait une ligne directrice nationale sur la concentration maximale acceptable de radon dans l'air intérieur, la faisant passer de 800 Bq/m³ à 200 Bq/m³. Des détecteurs de radon servent à mesurer les concentrations dans les maisons, et il existe des méthodes relativement abordables pour réduire la présence de ce gaz si des concentrations élevées sont observées.
- ▶ Les patients peuvent se procurer, en ligne ou dans une quincaillerie, des trousse de mesure à usage unique et à prix abordable (de 30 à 70 \$). Ces détecteurs recueillent des mesures pendant une période de 90 jours et sont ensuite envoyés dans un laboratoire aux fins d'analyse.

Sources de l'information Une recherche documentaire a été effectuée dans MEDLINE (de 1950 à février 2013), dans la base de données des revues systématiques de Cochrane (de 2005 à 2013), et dans le répertoire central des essais contrôlés de Cochrane (de 2005 à 2013), à l'aide d'expressions pertinentes. Les lignes directrices, les exposés de position, les articles et les comptes rendus de recherche originale portant sur le radon ont été retenus.

Message principal Le radon est la principale cause de cancer chez les non-fumeurs, et la deuxième la plus fréquente chez les fumeurs (1 sur 20, et 1 sur 3 respectivement). Le risque à vie augmente de manière linéaire avec l'exposition au radon. Dans l'air extérieur, le radon est dilué et ne soulève pas d'inquiétude pour la santé, mais lorsqu'il s'insinue dans les maisons, le gaz s'accumule et atteint des concentrations élevées, d'où un danger pour la santé. Selon la ligne directrice canadienne, la concentration maximale acceptable dans l'air intérieur est fixée à 200 Bq/m³. Il existe des méthodes abordables pour réduire la présence du radon si des concentrations élevées se trouvent dans une maison.

Conclusion Les médecins de famille jouent un rôle essentiel dans la prévention du cancer du poumon lié au radon en informant leurs patients, en les conseillant sur les mesures de prévention particulières à prendre, et en intervenant en leur nom.

One important role of any family physician is the prevention of disease. The 9 principles of family medicine are clearly presented in McWhinney's *Textbook of Family Medicine*,¹ and they are as relevant today as when they were written. Three of them stand as pillars of preventive duties, stating that a family physician “sees every contact with his or her patients as an opportunity for prevention of disease or promotion of health,” “views his or her practice as a ‘population at risk,’” and “is a manager of resources.”¹

One pathologic condition that has obtained much focus among the medical community and the general public is lung cancer. This type of cancer is the leading cause of death from cancer for both men and women in Canada and was estimated to represent 26% of all cancer deaths in 2017.² It is generally accepted that smoking can lead to lung cancer, and for this reason most efforts focus on educating patients and society in general about making social changes to quit smoking. Unfortunately, very little has been done to address non-smoking causes of cancer, despite the fact that 1 in 6 lung cancer patients have never smoked² and are thought to have acquired their disease owing to radon inhalation. The Canadian public and many physicians are unaware of this danger and how to prevent exposure.

Case description

A 39-year-old woman, C.M., visits you in the office. She is very anxious because her friend and next-door

neighbour read a newspaper article about the dangers of radon gas causing cancer. Her friend purchased a testing kit and found that the levels in her home were 4 times the maximum acceptable limit. As a result, C.M. is very concerned for the health of her 8-year-old twins, her husband, and herself, as she thinks radon levels could also be elevated at her house. Everybody at home is completely asymptomatic, but she wants to clarify the dangers of radon gas and is requesting guidance about what to do.

Sources of information

MEDLINE (1950 to February 2013) and the Cochrane Library, including the Cochrane Database of Systematic Reviews (2005 to 2013) and the Cochrane Central Register of Controlled Trials (2005 to 2013), were searched using relevant terms (*radon, air pollution, indoor pollution, lung cancer, lung neoplasms, carcinogens, environmental exposure*). Guidelines, position statements, articles, online publications from relevant entities, and original research relevant to radon were selected.

Main message

The family physician's role is fundamental in preventing radon-related lung cancer. Therefore, it is important that family physicians obtain a comprehensive understanding of the situation to educate their patients, guide them about specific preventive actions, and advocate on patients' behalf.

Background. Radon is a naturally occurring radioactive soil gas that is produced from the process of radioactive decay of radium, thorium, and uranium in soils and rocks throughout the world.³ Radon itself is not a problem, but its products of degradation, called *radon daughters*, are solid radioactive particles that can stick to any surface, such as dust or lung epithelium, and the α radiation emanated from them severely damages DNA, potentially leading to lung cancer. Radon is the principal cause of lung cancer in non-smokers and the second most common cause in smokers,⁴⁻⁶ and lifetime risk of lung cancer increases in a linear fashion with radon exposure.^{3,7} The risk depends on radon concentration, the duration of exposure, and smoking habits. Indeed, the risk of lung cancer in smokers is greatly potentiated by radon exposure³ (1 in 20 for non-smokers vs 1 in 3 for smokers⁵).

Exposure to inhaled radon was first identified as a cause of lung cancer by epidemiologic studies of uranium among miners,⁸⁻¹⁰ and current evidence strongly indicates that exposure to high levels found in homes and workplaces provides an increased risk of developing lung cancer.¹¹⁻¹³ Elevated risk of other types of cancer was not identified when a pooled analysis of miner cohorts exposed to radon was performed.¹² Radon is odourless, colourless, and tasteless, making it difficult to detect. In nature, radon ascends through small spaces in the soil reaching the surface and atmosphere. In outdoor air, radon is diluted and

is not a health concern. When a house is heated, air rises within the house producing a negative pressure, which draws radon from the ground; the gas accumulates, reaching high concentrations, and becomes a health hazard. This is especially evident during winter months when houses are less ventilated to retain heat. Radon diffuses into houses by cracks in the basement, floor drains, and sump holes, and by cracks in hollow blocks or exposed soil and rock in crawl spaces. Radon can also enter houses when it is dissolved in well water and then spread through running water from taps and showers.¹⁴

Some genes might modulate the carcinogenic pathway of radon radiation. A hospital-based case-control study involving 792 patients found that the absence of genes *GSTM1* and *GSTT1* increased the risk of lung cancer when exposed to radon.¹⁵ The absence of these genes results in decreased production of protective enzymes (eg, glutathione S-transferases) for cellular detoxification processes.¹⁶ The *GSTM1* and *GSTT1* genes can be deleted in up to 50% and 20% of white patients, respectively.¹⁷

As more knowledge is obtained about this gas, many countries have decreased the permissible levels for exposure. In 2007, Health Canada decreased the national maximum acceptable guideline for indoor air from 800 Bq/m³ to 200 Bq/m³.¹⁸ However, the recommendation for the maximum acceptable radon exposure by the World Health Organization is 100 Bq/m³,⁴ and entities such as the International Commission on Radiological Protection and the International Atomic Energy Agency recommend reducing radon concentrations to as low as reasonably possible below the set standards.¹⁹⁻²¹

Radon meters are used to test levels in houses, and cost-effective methods are available to reduce radon gas when high levels are found in dwellings. Radon meters are used to test levels in houses. If elevated, increasing ventilation in basements, sealing floors and walls, and depressurizing subslabs are effective measures.⁵ Ventilation alone can sometimes increase radon levels, as radon can be sucked in owing to relative negative pressure built inside the house.

Role of family physicians. It is estimated that 21 100 Canadian deaths due to lung cancer occurred in 2017² (an increased number of deaths per year from previous estimations³), and 16% of them were due to radon exposure.^{6,22} There are no areas in Canada that are radon free,²² and it has been found that 7% of Canadian houses have radon levels above the recommended Canadian maximum.¹³ For these reasons, patient education, health prevention, promotion of health, and health advocacy need to be undertaken by family physicians.

Family doctors screen for and educate patients about different types of cancer on a daily basis (cervical, colon, prostate, breast, skin) and also counsel against smoking to prevent lung cancer. Thus, family physicians are in the perfect position to disseminate radon

prevention education to prevent further lung cancer in both patients who smoke and those who do not, and such education should therefore be included in routine screening activities. A short educational sentence during the periodic health review appointment can provide the needed information. Providing handouts and website educational links can allow for more structured instruction (**Table 1**). The only way to determine if a home has elevated radon levels is to measure those levels in the home.¹³ The physician can provide further guidance based on that measured radon level.

Patients can purchase 1-time test kits online or from hardware stores at affordable prices (\$30 to \$70). These devices collect measurements for a 90-day period and are then sent to a laboratory for analysis. Another option is to obtain electronic radon monitors (about \$260), which provide daily, weekly, and monthly average concentrations. If high levels are found (≥ 200 Bq/m³), prompt actions to decrease radon levels are required, and standard steps to assess for lung cancer should be followed. The patient's clinical assessment can include a complete history, focusing in particular on smoking habits, family history of cancer, and previous exposure to pollution and environmental pollutants, and a focused physical examination. Unfortunately, no guidelines exist to inform further steps. If no abnormalities are found, long-term surveillance and periodic reassessment is prudent, and evaluation of other people who live in the same household should be ensured.

Investigations could include, in some cases, chest radiographs or computed tomography scans for patients with prolonged exposure to high levels of radon and positive physical findings, but once again, there are no recommendations or guidelines as to how to study this in patients. If any abnormality is found during clinical or radiological assessment, referral to a lung specialist could be necessary for cases that require further investigation, such as bronchoscopy-guided biopsy or open lung biopsy. If cancer is encountered, referral to an oncologist is clearly necessary.

There is evidence that exposure to radon in childhood increases lifetime risk of developing lung cancer²³; if a child was exposed to very high levels of radon at home for only a few years, his or her risk of developing lung cancer as an adult could be equivalent to that following lifetime exposure to moderate levels of radon.²³ For this reason, the higher the concentration of radon, the sooner remedial action should be taken.²⁴ Besides medical assessment, if patients identify elevated radon levels through home self-testing, recommend that they contact certified professionals in radon mitigation to manage or reduce concentration of radon at home (**Table 1**). The average cost for house mitigation is between \$1500 and \$3000, depending on the precise engineering details of the residence.⁶

Physicians across Canada can influence the determinants of health through requests to government entities to create requirements to meet the national guideline for

Table 1. Resources to assist family physicians in educating patients about radon

TOPIC (SOURCE)	MATERIAL TYPE	RESOURCE LINK
Brief information about radon for patients		
• What is radon? (Health Canada)	Downloadable brochure	www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/radiation/radon_brochure/radon-brochure-eng.pdf
• Radon: increased risk for smokers (Health Canada)	Pamphlet for smokers	www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/radiation/radon_smokers-fumeurs/radon_smokers-fumeurs-eng.pdf
• How to mitigate your house (BC Lung Association)	Downloadable brochure	www.radonaware.ca/database/files/library/BROCHURE_TESTING_MITIGATION.pdf
• Radon reduction guide (Health Canada)	Downloadable booklet	www.hc-sc.gc.ca/ewh-semt/alt_formats/pdf/pubs/radiation/radon_canadians-canadiens/radon_canadians-canadien-eng.pdf
Videos you can use to teach your patients		
• What radon is and how to test your house (BC Lung Association)	Video	www.radonaware.ca/radon-resources/videos#radon-testing
• What is a radon reduction system? (Ontario Lung Association)	Video	www.on.lung.ca/radon
Patient self-education		
• Radon presentation: what you need to know about radon (McMaster University)	Online presentation	https://machealth.ca/programs/radon/m/mediagallery/1743
How to test for radon		
• Ordering a radon test kit (BC Lung Association)	Website	www.radonaware.ca/radon-resources/order-a-radon-test-kit
What to do if radon levels are high		
• Reducing radon in your home (McMaster University)	Video	https://machealth.ca/programs/radon/m/mediagallery/1804
• Ordering a mitigation book guide (BC Lung Association)	Website	www.radonaware.ca/radon-resources/order-a-radon-mitigation-book
• Finding a mitigation professional (Canadian National Radon Proficiency Program)	Website	http://c-nrpp.ca/find-a-professional
• Finding a mitigation professional (Health Canada)	Website	www.takeactiononradon.ca/test
Maps		
• Mapping the geologic radon potential in Canada (Radon Environmental Management Corporation)	Online information	www.radonaware.ca/database/files/library/Canada_Radon_Potential_Map.pdf
Further information for patients		
• Written radon summary (World Health Organization)	Website fact sheet	www.who.int/mediacentre/factsheets/fs291/en
• Radon summary and further resources (Health Canada)	Downloadable fact sheet	English: www.hc-sc.gc.ca/hl-vs/alt_formats/pacrb-dgapcr/pdf/iyh-vsv/environ/radon-eng.pdf French: www.hc-sc.gc.ca/hl-vs/alt_formats/pacrb-dgapcr/pdf/iyh-vsv/environ/radon-fra.pdf
Poster		
• Radon: have you tested your home? (BC Lung Association)	Downloadable poster	www.radonaware.ca/database/files/library/MIKE_HOLMES_RADON_POSTER.pdf
Specific answers for patients' questions		
• Health Canada	Website	www.hc-sc.gc.ca/ewh-semt/radiation/radon/faq_fq-eng.php
• Radon Aware (BC Lung Association)	Online fact sheet	www.radonaware.ca/database/files/library/RadonAware_Radon_QA_.pdf

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TOPIC (SOURCE)	MATERIAL TYPE	RESOURCE LINK
Information for physicians		
• Radon: information for health professionals (Health Canada)	Website	www.hc-sc.gc.ca/ewh-semt/pubs/radiation/radon_brochure_profession/index-eng.php
	Downloadable version	lung.healthdiary.ca/Guest/Product.aspx?IDS=Y05Eir5037ngD27nQnAWdw%3d%3d
• Report of cross-Canada survey of radon concentration (Health Canada)	Website	English: www.hc-sc.gc.ca/ewh-semt/radiation/radon/survey-sondage-eng.php#a1 French: www.hc-sc.gc.ca/ewh-semt/pubs/radiation/survey-sondage/index-fra.php
	Downloadable version	www.hc-sc.gc.ca/ewh-semt/alt_formats/pdf/radiation/radon/survey-sondage-eng.pdf
• Ionizing radiation: quantities and units (Government of Canada, Canadian Centre for Occupational Health and Safety)	Website	www.ccohs.ca/oshanswers/phys_agents/ionizing.html
• Radiation dose information (Canadian Nuclear Safety Commission, Government of Canada)	Website	http://nuclearsafety.gc.ca/eng/resources/radiation/introduction-to-radiation/radiation-doses.cfm

radon in indoor air,²¹ to reduce the maximum permissible indoor levels to 100 Bq/m³, to request actions to achieve levels as low as reasonably possible below this level,²¹ and to provide specific community-level information to inform local policies to guide testing and remediation.²⁵ Recommendations for preventive actions that are being introduced in Ontario and Quebec, including testing and mitigation for houses, day-care centres, schools, workplaces, and public-access buildings, should be implemented across Canada. To further encourage health prevention actions, tax deduction incentives or subsidies could be offered to citizens with low income to facilitate measurement of radon levels in their dwellings.^{3,21}

Case resolution

After obtaining a pertinent clinical history and performing a focused physical examination, you provide C.M. with information you have available at your office (a short explanative video, official website links, and informative pamphlets) and answer her questions. She follows the plan suggested. She buys a radon testing kit and contacts a licensed technician who tests her house during winter. Her house radon levels are 280 Bq/m³. Radiographic findings are normal. You offer a spiral computed tomography scan for further assessment, but C.M. declines when you explain the levels of radiation exposure from this examination. You counsel C.M. that she, her husband, and their children should never smoke. Radon mitigation measures are undertaken at her house by a certified professional. The patient is reassured, and long-term surveillance during periodic physical assessments of her and her family is proposed.

Conclusion

An increasing number of people are becoming aware of the dangers of radon exposure; however, most Canadians

remain unaware or have not taken steps to determine if they are at risk of developing radon-related lung cancer. Non-smokers could have a relatively false sense of security if radon levels have not been measured at home or at work, and smokers are at a very high risk of developing this kind of cancer if exposed to radon. For this reason, the role of family physicians is fundamental to educating patients about this threat and to preventing the development of lung cancer in Canadians. As with other types of cancer, the family doctor's intervention to assess radon exposure could avoid the development of lung neoplasms, offer the opportunity to provide treatment in early stages of the disease, and decrease the number of deaths. 🌿

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Competing interests
None declared

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