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Issue Dedication:
This issue of the JRCD is dedicated to Cheryl Williams who passed away suddenly in 2010. She was in the first semester of her PhD program in Nursing at the University of Saskatchewan at the time of her death. Her co-authored paper in this issue is based on her master's thesis research. Pammla Petrucka was Cheryl's advisor. It was Pammla's wish to publish this peer-reviewed article in honour of Cheryl's work and her family.

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Concerning Knowledge: Assessing Radon Knowledge and Concern in Rural Nova Scotia

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Abstract

A homeowner survey (n=152), designed to assess knowledge of radon health effects, concern regarding radon exposure in the home, and interest in radon testing, was conducted in a small university town in uranium-rich Nova Scotia, Canada. Although approximately 10% of lung cancer deaths in Canada are attributable to residential radon exposure, most respondents indicated that they had little knowledge of and little concern about radon and its health effects. There was a significant positive relationship between knowledge and concern but even when knowledge is high, levels of concern remain relatively low. Unless government policies address residential radon testing and mitigation, families will remain at risk of radon exposure in their homes.

Keywords: Public health, family health, health policy, radon, risk perception

1.0 Introduction

Prolonged radon exposure is the second leading cause of lung cancer after smoking (Canadian Cancer Society, 2010; 2011). Radon Rn^{222}, created through decay of uranium U^{238}, is a colorless, odorless, highly mobile radioactive noble gas. Although uranium is stationary, radon moves through the soil with ease, diffusing into the groundwater and through cracks in the walls of house foundations. Radon is classified as a human carcinogen by the World Health Organization, the International Agency for Research on Cancer, and the US National Toxicology Program.

The relationship between a heightened risk of lung cancer and radon inhalation is well documented in multiple case studies on uranium miners around the world (Tirmarche, Raphalen, Allin, Chameaud, & Bredon, 1993; Lubin et al., 1995;). Cancer risk for the public is evaluated by studies on characteristics of low annual exposure compared to residential radon gas concentrations of 500-1000 Bq/m^3

(Tirmarche et al., 1993) and extrapolated to the general population (Lubin et al., 1995). The largest aggregation of data—4081 cases and 5281 controls—on residential radon and lung cancer conducted to date (Krewski et al., 2006) provides direct evidence of an association between residential radon and lung cancer risk, and confirms the previous extrapolation of results from occupational studies of radon-exposed underground miners. The age of cancer diagnosis is a strong predictor of excess relative risk per working-level month of radon exposure, falling from Odds Ratio (OR) = 0.025 for those aged less than 50 years to OR = 0.002 for those 70 years or older (Morrison, Villeneuve, Lubin & Shaubel, 1998). For equal total exposure, a low exposure rate over a long duration is more harmful than a short duration, high exposure rate (Morrison et al., 1998).

Public concern in Canada about indoor radon levels began in the mid-1970s, and independent studies have confirmed that the lung cancer risk from radon extends downward to radon levels as low as 200 Bq/m^3 (5.4 pCi/L) (Brand, Zielinski, & Krewski, 2005; Canada Mortgage and Housing Corporation & Health Canada, 2007). An estimated 1,400-2,000 Canadian deaths annually are attributable to radon exposure in homes (Brand et al., 2005). Approximately 10% of lung cancer deaths in Canada have been related to residential radon exposure (Canadian Cancer Society, 2010). For Nova Scotia, this fraction may be higher given that the province is rich in deposits of uranium (Jackson, 1992).

Why do people fear certain health risks and not others? The public is much less concerned about radon exposure in the home than they are of radiation emitted from nuclear plants; yet, 1000 times more radiation is emitted from radon in the home than from nuclear plants (Cohen, 1995). Research has shown that the public resists radon home testing (Gagnon et al., 2008; Poortinga, Bronstering, & Lannon, 2011). The reasons offered include: the substantial costs of having one's home tested, lack of acceptance that radon poses serious health risks lack of media attention on radon and related health issues, distrust of home testers, impact of negative test results on home values, and lack of government policies regulating radon levels in the home (Doyle, McClelland, Schulze, Elliott, & Russell, 1991; Golding, Krimsky, & Plough 1992; Field, Kross & Vust, 1993; Cohen 1995). Factors that influenced the uptake of radon mitigation and testing also include socioeconomic factors (Wang, Ju, Stark, & Teresi, 1999; Hill, Butterfield, & Larson, 2006), householder status (Larson, Hill, Odom-Maryon, & Yu, 2009), and those with higher incomes. Those who were homeowners were more likely to undertake home testing and, if needed, remediation.

A substantial number of homes in Nova Scotia have high levels of radioactivity due to radon (Jackson, 1992). In 2006, sample radon tests in Nova Scotia homes in the Annapolis Valley showed radon levels up to 24 times greater than the current recommended acceptable level of 200 Bq/m^3 (Barkanova, 2007, p.63). Informal interviews, conducted by Barkanova while testing for radon in homes, showed that most homeowners knew nothing or very little about radon or its effects on health. To further examine this finding, we conducted a formal survey of Wolfville, Nova Scotia homeowners to examine not only the extent of their knowledge and concern about radon in their community, but also whether knowledge and concern translate into radon home-testing and mitigating actions, such as minimizing basement-use.

2.0 Method

Wolfville is a small town in western Nova Scotia, Canada, with a population, at the time of this study, of 3,770. It is the home of Acadia University, a small university. Compared to other rural communities in Nova Scotia, the population of Wolfville on average has higher levels of education and income (Wolfville Community Fund & Community Foundation of Nova Scotia, 2009). Based on these demographics, we anticipated that residents would not only be knowledgeable of radon (Schnittkeron, 2004), as the prevalence of radon in Nova Scotia has been known for several decades, but also be concerned about its human health effects.

A questionnaire was administered between 2008 and 2009 to Wolfville residents who own and live in their home, to determine the level of their knowledge of and concern about radon in their community. The sample of surveys (n=152) was drawn from a number of sources. We posted an online survey at Acadia University, which was sent to the university community of over 500 faculty and staff, we randomly approached approximately 120 people at the local farmers market (An estimated 600-800 people visit the market each Saturday.) over three consecutive Saturdays, and we distributed 350 surveys at the local elementary school, where each child was given a survey to take home to their parents. We were particularly interested in surveying homes with children, as children are, "at a distinct disadvantage for health consequences from environment exposures" (Hill et al., 2006, p. 392). Of the 151 surveys completed, 41 were from Acadia University, 40 from the farmers market and 71 were from the local elementary school. Ethics approval was received by the University's Research Ethics Board.

3.0 Results

Using SPSS for data analyses, the survey results (n=152) showed that the average education level (Grade 1 equals 1 year of education) was 17.3 years (sd = 3.576). Needless to say, this sample is skewed to individuals with tertiary education. The Wolfville community is not representative of Nova Scotia in terms of education and income, as it is highly educated and predominantly middle class (Wolfville Community Fund, 2009).

One third of the respondents surveyed had no children living at home, 18.7% had one child, 35.3% had two children, and 12.8% had 3 or more children. Household incomes (Canadian dollars) were represented by five categories (less than $25,000; $25,000 - $49,000; $50,000-74,000; $75,000-$99,999; and $100,000 plus). The median household income category was between $50,000 and $74,000. Whereas 26.5% of respondents reported a family income of greater than $100,000, 7.4% had an income less than $25,000.

Using a Likert scale (0 to 10), respondents were asked to rate their level of radon knowledge (0 = no knowledge; 10 = substantial knowledge) and their level of concern (0 = no concern; 10 = substantial concern). The average knowledge rating and level of concern was 3.66 (sd=2.43) and 3.48 (sd=2.97), respectively.

The variable "radon concern" was regrouped into four broad categories of concern and analyzed by explanation offered for concern (Table 1). Chi square analysis was done and significance was reached at the .01 level. Those with high and moderate concern expressed concern over the effect of radon on health (66.7%) and the environment (45.5%). Those who indicated little concern either did not have enough knowledge (20.6%), or did not know that radon is a potential problem in the

Wolfville area (28.6%). Those who reported some concern did so because they did not have enough knowledge (19.2%) or were concerned about the effect on health and environment (23.1%). Of note, only 5.5% of the respondents reported effect on children as a concern. This is somewhat surprising as two-thirds of the sample had at least one child living at home.

Table 1. *Level of Radon Concern by Reason for Concern (%)*

	Radon Concern				
Why radon concern?	Little concern	Some concern	Moderate concern	High concern	Total
Not enough knowledge	20.6	19.2	9.1	11.1	18.3
Not a problem in this area	28.6	15.4	18.2	0.0	22.0
Did not know there was a problem	28.6	19.2	0.0	0.0	21.1
Don't want to know	1.6	7.7	0.0	0.0	2.8
Link to health/ environment concern	3.2	23.1	45.5	66.7	17.4
Effect on children	3.2	7.7	9.1	11.1	5.5
Other	14.3	7.7	18.2	11.1	12.8
Total (n=109) Missing = 43	100.0	100.0	100.0	100.0	100.0

X^2 =41.68
p<.001

Table 2 presents a regression analysis of the effect of level of knowledge and education on radon concern. In Model 1, the regression equation shows that with each additional one-unit increase in radon knowledge, concern about radon increases by 0.235 units. That is to say, should an individual offer a score of "10" in radon knowledge, this model predicts that the accompanying level of concern would be 4.89 (out of 10). Although knowledge of radon positively affects concern about radon, the level of concern is substantially less than what would be expected given the serious long-term health effects associated with radon exposure. When controlling for education (Model 2), knowledge continues to have a positive effect on levels of concern, but there is a weak inverse relationship (significance was not reached) between concern and education.

Table 2. *Regression Estimates of Radon Knowledge and Education on Radon Concern*

	Model 1 B	Model 2 B
Radon Knowledge	0.235*	0.219*
	(0.112)	(0.113)
Education		-0.055
		(0.076)
Constant	2.542	4.972
N	126	124
R^2	0.034	0.033

*p<.05

Because radon is a heavy gas and settles in the basement level of homes, basement use was examined to determine whether there is a difference in use between households with and without children. Less than half the sample (45.4%) indicated use of their basement solely for furnace, electric panels and storage; the remaining 54.7% indicated use of their basement either as a living and/or play area in combination with use for furnace, electric panels and storage. In homes where there are no children, 62.8% of families use their basement solely for storage and furnace whereas the converse is true for families with one or more children: 63.2% use their basement as living space.

The relationships between basement use for living and/or play areas, and the variables of radon knowledge, radon concern and children in the home, were examined using logistic regression analysis (See Table 3). The likelihood of basement use for living and/or play areas is almost 3.7 times greater should there be children in the household than when there are no children. There is an (marginal) inverse relationship between basement use for living and playroom use and radon knowledge (OR=.899) and radon concern (OR=.935), but significance was not reached. Basement use by families with children appears to be more a matter of having extra living and play space for children rather than either concern about or knowledge of radon.

Table 3: *Logistic Regression of Radon Concern, Children in the Home, and Radon Knowledge on Basement Use for Living Space*

	B	se	Odds Ratio
Radon Concern	-.052	.081	.935
Children in the home	.911	.537	3.702*
Radon Knowledge	-.028	.113	.899

n=67
missing cases=16
*p<.069

The survey respondents were asked if they wanted their homes tested; only 56.6% answered they did. Those who answered “no” were then asked to indicate why they did not want their homes tested. Nearly half (43.1%) of those who answered “no” said there was “no need to test”, and 17.6% felt they “need more information”.

4.0 Discussion

A survey on radon knowledge and concern was administered in Wolfville, Nova Scotia – a rural community with higher than average levels of education and income. The findings overall revealed that Wolfville residents who completed the survey had little knowledge of and little concern about radon, even though uranium concentrations are high in many parts of Nova Scotia. There was a significant positive relationship between knowledge and concern, but even when knowledge is high, levels of concern remain relatively low. Consequently, only 57% of the respondents wanted their homes tested.

This study supports research that has found that the decisions to mitigate are based on either lack of information or denial that the problem exists (Gagnon et al., 2008; Golding et al., 1992; Field et al., 1993; Poortinga et al., 2011). Contrary to previous

findings (Wang et al., 1999), income was not a factor in terms of knowledge and desire to have one's home tested. The lack of knowledge of radon given the high level of education of respondents is puzzling. The presence of radon in Nova Scotia and its negative effects on health have been known for almost 30 years. Furthermore, when the survey was first administered (summer of 2008), news stories of radon health risks were ubiquitous either in newspaper articles or on radio shows. Yet, the respondents demonstrated a general lack of concern and interest about radon in their homes, with more than 20% of the respondents believing that radon is not a problem in their area.

Basement use was perhaps the most interesting finding in that, controlling for radon knowledge and concern, basement use for living or play areas was linked to whether there were children living at home. The day-to-day challenges of managing a household with children, which includes addressing space demands, perhaps pale in comparison to risks that appear to be "far removed".

The low levels of concern about radiation emitted from radon are especially puzzling in light of deep concerns the public holds over radiation from nuclear power plants. In Canada, the public's exposure to radiation from nuclear power plants is significantly less than the average exposure to radiation (such as coming from radon) occurring naturally in the environment. (The problem with nuclear power plants, of course, is public concern over widespread and intense radiation when there is an accident such as the one in Chernobyl, and more recently Fukushima.) The irony here is that people who are afraid of having a nuclear plant nearby their homes appear to have little concern about exposure to radiation due to radon in their homes. Perhaps, because radon is invisible and occurs "naturally" in the environment, it is not perceived as harmful (Doyle et al., 1991) in the same way as radiation from nuclear power plants. It appears that risk perception and willingness to act to reduce risk is not simply a matter of education or access to accurate information on radon.

This study raises many questions and concerns. Given the prevalence of radon in Nova Scotia, the levels of radon knowledge (i.e. health risks) are substantially lower than we anticipated. What is the most effective way of disseminating radon information and increasing the concern of homeowners? How do we explain the relatively low levels of radon concern, controlling for knowledge level? Why did most respondents not want their home tested? Should home testing be mandatory? If so, who is responsible for remediation, when levels exceed recommended concentrations?

The answers to many of the above questions are most likely an outcome of financial rather than health concerns. Should there be high levels of radon in one's home, this may mean spending thousands of dollars for remediation. And, should radon be a problem in the home or neighborhood, the concern is, as Golding, Krimsky and Plough (1992) found, that home sales are likely to be adversely affected. Homeowners may prefer to turn a blind eye to radon as a health concern, thus explaining the low level of concern reported in this study.

The survival rate for lung cancer is dismally low; the 5-year relative survival rate (2006-2008 estimates) is 17% (males 14%, females 20%), and the 10-year rate is 13% (Canadian Cancer Society, 2014). Reducing lung cancer deaths by reducing exposure to radon will result in savings to the health care system. In 2004, the estimated lifetime cost of lung cancer care in Canada was estimated at between $25,000 and $30,000 per patient (Public Health Agency of Canada (PHAC), 2004).

Lung cancer deaths due to radon are preventable. To do so, however, requires a major effort to educate the public on the health effects of radiation due to radon and to develop and implement governmental policies on radon testing and mitigation. Public education through health promotion programs has had some success; the anti-smoking campaign is one example of an effective health strategy (PHAC, 2008). Clearly, national studies and dissemination of information on the health issues associated with radon, and the options for mitigation, are needed.

Under the guidance of the World Health Organization (WHO), governments in 30 countries formed a network (International Radon Project) in 2005 to examine ways in which to reduce the risks of radon exposure, including the enforcement of government regulations where testing/mitigation is required, and provision of full or partial funding to homeowners to address the costs of testing and mitigation (WHO, 2009a). Even though Canada has one of the richest deposits of uranium in the world, and is the number one uranium producer, the Canadian government, surprisingly, has taken little action in developing policies on radon testing and mitigation in homes, although there are programs in place for testing government buildings and schools. It is our viewpoint that a stronger position would be more beneficial, one that follows the recommendations in the WHO Handbook on Indoor Radon (2009b).

The survey we conducted examined radon knowledge and concern among an educated and middle-income community in Nova Scotia. Should these findings be true of the larger population, knowledge of radon does not translate into concern about radon in one's home and its potential health impact on family members, especially children. In the absence of government policies on residential radon testing and mitigation, it is unlikely that individuals will voluntarily test their homes, as was demonstrated in this study. This indeed is a concern.

5.0 Acknowledgements

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