Radon, an Invisible Killer in Canadian Homes: Perceptions of Ottawa-Gatineau Residents

Khan SM[1], Krewski D[2], Gomes J[3], Deonandan R[4]

[1]Population Health Program, Faculty of Health Sciences, University of Ottawa; THN 210, 25 University Private, Ottawa, ON K1N 7K4

[2]Professor, School of Epidemiology and Public Health, University of Ottawa; 600 Peter Morand Crescent, Room 216A Ottawa, Ontario CANADA K1G 5Z3
Email: dkrewski@uottawa.ca.ca; Phone: 613-562-5381

[3]Associate Professor, Interdisciplinary School of Health Sciences, Faculty of Health Sciences, University of Ottawa; THN 210, 25 University Private, Ottawa, ON K1N 7K4
Email: james.gomes@uottawa.ca; Phone: (613) 562-5800 ext. 8426.

[4] Assistant Professor, Faculty of Health Sciences, University of Ottawa
THN 209, 25 University Private, Ottawa, ON K1N 7K4
Email: raywat.Deonandan@uOttawa.ca; Phone: 613-562-5800 ext. 8377

Corresponding author:
Selim Khan
Email: skhan196@uottawa.ca
Phone: +1 819-271-7561

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Abstract

Objectives:

Canadians have reason to care about indoor air quality as they spend over 90% of the time indoors. Although indoor radon causes more deaths than any other environmental hazard, only 55% of Canadians have heard of it, and of these, 6% have taken action. The gap between residents' risk awareness and adoption of actual protective behaviour presents a challenge to public health practitioners. Residents' perception of the risk should inform health communication that targets motivation for action. In Canada, research about the public perception of radon health risk is lacking. The aim of this study was to describe residents' perceptions of radon health risks and, applying a theoretical lens, evaluate how perceptions correlate with protection behaviours.

Methods:

We conducted a mixed online and face-to-face survey ($N = 557$) with both homeowners and tenants in Ottawa-Gatineau census metropolitan area. Descriptive, correlation, and regression analyses addressed the research questions.

Results:

Compared to the gravity of the risk, public perception remained low. While 32% of residents expressed some concern about radon health risk, 12% of them tested and only 3% mitigated their homes for radon. Residents' perceptions of the probability and severity of the risk, social influence, care for children, and smoking in home correlated significantly with their intention to test; these factors also predicted their behaviours for testing and mitigation.

Conclusion:

Health risk communication programs need to consider the affective aspects of risk perception in addition to rational cognition to improve protection behaviours. A qualitative study can explore the reasons behind the gap between testing and mitigation.

Keywords: Air Pollution, Indoor, Radon, Risk, Perception, Canada.

Résumé

Objectifs:

Les Canadiens ont de bonnes raisons de se préoccuper de la qualité de l'air intérieur, car ils passent plus de 90 % de leur temps à l'intérieur. Bien que le radon domiciliaire (RD) cause plus de décès que tout autre risques environnementaux, seulement 55 % des Canadiens en ont déjà entendu parler, et d'entre eux seulement 6 % ont pris des mesures concrètes pour l'éradiquer. L'écart entre la sensibilisation aux risques et la prise de mesures de protection réelles par les résidents constitue un défi pour les professionnels de la santé publique. La perception des résidents face aux risques associés au RD devrait guider la communication en matière de santé pour cibler la motivation. Au Canada, très peu d'études portant sur les perceptions de la population face aux risques associés au RD ont été réalisées. Le but de cette étude est de décrire les perceptions qu'entretiennent les occupants de bâtiments résidentiels face aux risques pour la santé associée au RD et évaluer comment ces perceptions sont corrélées aux comportements de protection, notamment en appliquant la théorie de la motivation et de la protection.

Méthodes:

Nous avons réalisé une enquête mixte en ligne et en personne (n = 557) auprès de propriétaires et de locataires de la région d'Ottawa-Gatineau. Des analyses descriptives, corrélationnelles et des analyses de régressions ont été effectuées en fonction de nos questions de recherche.

Résultats:

En comparaison à la gravité des risques, les perceptions du public demeurent faibles. Bien que 32 % des résidents ont exprimé des préoccupations au sujet du danger que représente le radon pour la santé, seulement 12 % d'entre eux ont réalisé des tests à domicile et seulement 3 % ont pris des actions concrètes pour réduire les risques. Les perceptions des résidents quant à la probabilité et à la gravité des risques du RD sur leur santé, l'influence sociale, les soins prodigués aux enfants, ainsi que le tabagisme à la maison étaient significativement corrélées avec leur intention de réaliser un test. Ces facteurs ont également prédit leurs comportements en lien avec l'utilisation du test et les actions entreprises pour diminuer les risques.

Conclusion:

Les programmes de communication sur les risques du RD sur la santé doivent tenir compte des aspects affectifs associés à la perception des risques, en plus de tenir compte du niveau de connaissances pour améliorer les comportements de protection. Une recherche de nature qualitative serait nécessaire pour explorer les raisons qui expliquent l'écart entre le taux d'utilisation des tests de détection et les actions concrètes pour diminuer les risques.

Mots-clés: Pollution de l'air; Radon domiciliaire; Perceptions du risque; Canada.

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Introduction

Canadians have reason to care about indoor air quality as they spend over 90% of their time indoors.[1] Having the world's most abundant reserves of high-grade uranium (U^{238}), Canadian land emits higher levels of soil gas radon (Rn^{222}) than any other country.[2] In urban areas, those who rent poorly ventilated basements or homes that are in contact with the ground are more likely to be those with lower incomes.[3] Airtight energy efficient homes have pressure gradients between the heated indoors and chilly outdoors, which create conditions for harmful gases in the soil to enter the home.[4] Inside such dwellings, the radon concentrations can build up during the long winter months when doors and windows remain closed. Radon further degrades by emitting alpha particles which, upon inhalation, can lead to mutations in DNA in cells in the lungs that can subsequently lead to cancer.[5]

In Canada, about 7% of homes have radon gas above the federal reference level of $200Bq/m^3$.[6] Because of the long winter, construction design, urban location, and radiological anomaly in the Gatineau Park, Ottawa-Gatineau residents may experience elevated levels of exposure to radon. There is no threshold for the carcinogenic effects of radon, and most lung cancers occur from exposure to concentrations below this set level[7],.[4] Annually, at least 3,200 Canadians die from radon-induced lung cancer, accounting for 16% of all lung cancer deaths (including smokers, ex-smokers, and non-smokers), making radon the leading cause of lung cancer deaths among nonsmokers and the second leading cause among smokers.[8] Compared to the general population, children (increased breathing rate), women (passing prolonged time indoor), and smokers (synergistic effect of radon) are disproportionately affected by exposure to radon.[9] Radon lung cancer risks among smokers can be up to ten times higher among smokers

compared to non-smokers due to a synergistic effect between these two agents.[10] Children in households with less educated parents are more likely to be exposed to secondhand smoke,[11], which can enhance radon lung cancer risk.

Due to public perception of low risk, people tend not to take corrective action to reduce residential radon health risk.[12] Despite multiple efforts, the National Radon Program (NRP) has not served to stimulate radon mitigation efforts to the desired level.[8] In 2015, at least 55% of all Canadian households indicated hearing about radon, but only 6% of them tested their homes for it.[8] The gap between risk awareness and actual testing rates presents a challenge to public health practitioners. So far, practitioners have considered better-communicated information, enforced guidelines, and tax rebates to be among the best solutions for radon risk mitigation.[13] However, studies in the USA,[14] the UK,[15] and Ireland[16] showed that taking regulatory action, offering rebates, and even providing free test kits and services did not lead to significantly increased risk mitigation action by the public. The key question - how to motivate the target population individually and collectively – thus remains unanswered.[17] Even after informing (cognitive awareness) residents that their homes might have a high level of radon that it might pose a serious health threat, protective actions remained low.[18] Social science research has argued that the success of a population-level health promotion program is contingent upon the motivation of key decision makers at the household level.[19] We believe that health communication programs targeting such motivation should be informed by residents' perception of the risk. In Canada, research on public perception of radon health risk is lacking. To address this data gap, we employed theory-based tools to understand the determinants of residents' perceptions of radon health risk. Specifically, we sought to determine whether people were motivated to change their

behaviour due to cognitive awareness alone, or if there was an effect of emotional influence related to the limbic part of the brain controlling affective behaviours[19]. Such understanding can guide strategies to enhance uptake of the program. This article reports the quantitative findings of a mixed methods study conducted in the Winter of 2018.

Theoretical Framework

Exposure to a health risk communication creates a dual appraisal process, specifically a) a threat appraisal and b) a coping appraisal.[20] Within the construct of our theoretical framework, threat appraisal involves an assessment of the probability of contracting a disease (taking into account susceptibility of exposed population) and its seriousness (severity). A coping appraisal comprises response efficacy and self-efficacy. Response efficacy is the expectation that carrying out recommendations will eliminate the threat. Self-efficacy denotes the belief in an individual's ability to accomplish suggested actions without failure.[20] Thus, the stronger a threat appraisal, the more an individual engages with the coping behaviour.

Protection Motivation Theory (PMT) specifies how these two perception processes lead an individual to either adopt an active adaptive or maladaptive coping mechanism in response to a health risk.[21] These, in turn, are fortified by observational learning (someone died from radon-induced lung cancer), internal persuasions (lifestyle, smoking), intrapersonal traits (caring for family') and external environment ('social influence') leading to fear arousal and developing the intention to take action. These perceptions, combined with multiple other influences, shape protection motivation and lead to the actual adoption of coping behaviours.[22] Maladaptive responses place people at additional risk, as they miss the opportunity to take preventive actions. Therefore, the PMT has four dynamics: a) perceived probability (likelihood of an adverse health effect due to exposure to radon); b) perceived severity of a threatening event (lung cancer); c)

response efficacy of the recommended intervention (testing and mitigation can eliminate the threat); and d) self-efficacy (confidently taking action). Thus, protection motivation is the result of informed threat and coping appraisal, which facilitates protective health behaviour and generates a broader perception ('worldview') about radon risk management[22] (Figure 1).

Appraising homeowners' perceptions within the fundamental logic of the PMT might help to enhance understanding of the motivation dynamics, and identify strategies to encourage protection behaviours. To inform this issue, this study examined the PMT components in a Canadian context to provide insight into homeowners' perceptions of radon health risk. The PMT has been previously applied in health research to influence and predict various health-related behaviours related to reducing alcohol consumption, enhancing healthy lifestyles, improving diagnostic health behaviours, and preventing disease.[22] A thorough understanding of homeowners' perception of radon health risk through this theoretical lens can advance the PMT research agenda to promote awareness of radon health risks and encourage innovative approaches by policymakers and professionals to address the issue.

Research Questions/Hypothesis

The primary research question considered in this work is: How do Ottawa-Gatineau residents perceive and act in response to awareness of radon health risks? In addition to enquiring the risk perception phenomena and related worldviews, we sought to answer the following sub-questions:

i) Are residents' intention to test for radon associated with any of the following variables: Perceived radon health risk susceptibility, severity, synergistic risk of radon with smoking, smoking in home, care for children and social influence?

ii) How do these variables predict residents' efficacy in adopting protection behaviours (testing and mitigation of homes for radon)?

We hypothesize that there would be significant associations between perceived radon health risk susceptibility, severity, synergistic risk perception, smoking in the home, care for children, social influence with residents' intention to test for radon. Likewise, we hypothesize these variables will predict residents' adoption of protective behaviours.

MethodS

Sampling and Data Collection Protocol. We surveyed homeowners and tenants (included for the first time in such a study as a control group) of Ottawa and Gatineau CMA who were residents in a home with a basement or a home in contact with the ground for over one year. Participants were randomly selected from the Qualtrics residents' panel, a platform frequently used in studies of public opinion,[23, 24] with a target sample size of 560 respondents Participants received email invitations, along with a link to the online survey, in both French and English. We conducted an equivalent, face-to-face version of the survey using iPads. Some participants filled out the survey and returned it by email, and others completed the face-to-face version in community settings to include respondents who could not take the interview online. The University of Ottawa's Institutional Review Board approved the study and data collection protocols (file number: H10-17-03). Participation was voluntary and anonymous. All participants reviewed the informed consent form before confirming their willingness to go ahead with the survey.

Instrument and Measures. The 41- item survey instrument included a mix of closed and open-ended questions. We measured the independent variables such as residents' 'perception of probability' (do you think radon may present in your home?) and 'perception of severity' (how

seriously does radon affect our health?) of the risk across homeowners and tenants. We also measured internal factors such as 'smoking in home' (does anybody smoke cigarette in your home?) and 'synergistic risk perception' (does smoking enhance the risk of radon for lung cancer?). Intrapersonal factors included 'care for children' (does at least one child live or spend over four hours in the basement or ground floor?) and external persuasion such as 'social influence' (how many people you know who have tested their homes for radon?). Although the last three variables were measured in previous research in different settings,[25, 26] our qualitative pilot study conducted in the Winter of 2017 helped to shape the questionnaire in a Canadian context. We employed an anchored relative scale rather than a Likert scale, as previous research has identified the former to be more sensitive than the latter.[27] The anchored relative scale quantified grading points with specific narratives rather than with inexplicit ranges. The open-ended questions explored residents' depth of knowledge and points of view regarding various aspects of radon health risk. The outcome (dependent) variables included 'intention to test' (have you the intention to test your home for radon?); 'tested home for radon' (have you ever tested your home for radon?); and 'mitigated home for radon' (did you fix or mitigate your home after testing?). Efficacy was explored by asking about repeated action (did you test after mitigation?). The open-ended questions explored residents' general awareness (what do you know about radon?) and point of views regarding risk management (is it an individual or overall societal problem?) followed by, who should be responsible for fixing it?).

We collected sociodemographic (control) variables such as age, gender, race/ethnicity, education level, total household income and home ownership or tenancy to compare how risk perceptions may vary in accordance with these characteristics. We followed the criteria used in the National Households and the Environment Survey[10] to classify gender, age group,

race/ethnicity, education and income groups. Participants voluntarily identified themselves and chose their groups. We conducted reliability analysis of our perception scales (susceptibility and severity of the risk) and obtained an internal consistency score of .74 (Cronbach's alpha) with a 2-item adapted scale.

Analysis

Respondents completing <80% of the survey accounted for less than 10% of the total sample, and were excluded data from further analysis. Because our focus was on Ottawa-Gatineau residents, we eliminated all participants who completed the survey from outside this area. Our final sample (N=557) included 394 (71%) homeowners and 163 (29%) tenants.

We conducted descriptive and inferential analyses using IBM SPSS 24, setting the confidence intervals at 95% and alpha at 0.05 (two-tailed) overall. Descriptive statistics included frequency distributions to summarize the data. We conducted univariate analyses for the entire sample, subgroups (homeowners and tenants), and outcome variables. In addition to these baseline analyses, we also conducted sensitivity analyses to test the robustness of the findings to the analytic methods used. We used Pearson's Chi-square to test for associations among the variables monitored and likelihood ratio test to determine whether the risk related perception variables were associated with residents' intention and actual performance of protection behaviours (testing and mitigation). Data quality management was done to ensure that all relevant assumptions related to multicollinearity, outliers, normality, homoscedasticity, and independence of residuals were satisfied.[28] We conducted ordinal and binary logistic regression analyses to identify predictors of *intention to test* and actual *testing* and *mitigating* behaviours (both dichotomized as 'yes' and 'no'). We examined the fit of our proposed model, and controlled for age, gender, race/ethnicity, education, total household income, and home

ownership. Regression models were constructed both by entering all variables simultaneously and by using the forward conditional variable selection (both models gave similar results).

Results

Sample Characteristics: Our sample proportionately represented the sociodemographic features of Ottawa-Gatineau CMA residents. Table 1 presents these characteristics and their associations with residents' intention to test their homes for radon. We found significant associations ($p<.001$) of residents' homeownership, gender and age with their intention to test for radon. Homeowners, females and older adults had greater intention to test than tenants, males, and young adults, respectively. Although European Canadians, university educated and lower-middle-income residents showed a higher level of intention to test their homes for radon, these associations were not statistically significant. When it comes to taking actual protective action, males and young adults exceeded their counterparts in testing. University educated and those in the upper-middle-income group were most likely to report taking radon mitigation action (Table 2).

Regarding indoor air quality, more people expressed concern about dust/dust mites (29%) and mold (27%) than radon (20%). Among the residents concerned about radon, 39% described it as a radioactive gas. Their primary sources of information were the media (46%), Health Canada (13%) and internet browsing 8.5%.

(<Figure 2 >)

Figure 2 shows that only 32% of residents expressed concern about radon health risks, 12% tested for radon, and just 3% took radon mitigation action in their homes. Among those who mitigated, 94% re-tested after mitigation ($p<.001$) showing the efficacy of adopting protection behaviours. Although 3% of tenants also tested their residences, none of them

mitigated their homes for radon. Our analysis showed that 93% of homeowners and 85% of tenants spent more than four hours either in the basement or on the ground floor. This variable had a significant correlation with testing for homeowners ($p<.01$) but not for tenants ($p<.904$). Both smoking in the home and synergistic risk perception were significantly associated with the intention to test by homeowners ($\chi^2=107.12, 172.42$; $p<.001, <.001$) and tenants ($\chi^2=42.17, 88.22$; $p<.001, <.001$). Our data showed that 21.8% of homeowners and 5% of tenants had at least one child living in the basement or on the ground floor that (having a child live in the basement) had strong associations with the intention to test for both homeowners' ($\chi^2=81.82$, $p<.001$) and tenant's ($\chi^2=13.08$, $p<.001$). Similar strong associations were found between social influence and intention to test for both homeowners ($\chi^2=41.66$; $p<.001$) and tenants ($\chi^2=4.54$, $p<.03$).

When asked about their worldview about radon, the majority (28%) of respondents said that they are concerned about their health since radon exposure affects everybody. Over 26% said that radon affects individual persons, so they (homeowners) are responsible for risk mitigation. About 25% said that property owners and tenants should get a tax rebate according to their income level for mitigating their homes. Nearly 21% said that as this is a population health problem, so the government is responsible for fixing it. These opinions did vary significantly by residents' gender ($\chi^2=35.20$, $p <.001$), age ($\chi^2=29.24$, $p<.01$), education ($\chi^2=32.36$, $p<.001$) and income levels ($\chi^2=27.49$, $p<.02$), but not with homeownership and race/ethnicity.

Findings regarding the research questions: Ordinal logistic regression showed, as we hypothesized significant associations between residents' intention to test for radon and their

perceived radon health risk susceptibility, severity, synergistic risk perception, smoking in home, care for children, and social influence. Similarly, binary logistic regression demonstrated that these variables are predictors of residents' testing and mitigation of homes for radon. Table 3 presents the outcomes of ordinal and binary logistic regressions that show the perception variables are significantly associated with residents' intention to test for radon as well as predicted residents' efficacy in actually adopting the protection behaviours.

(<Table 3>)

Discussion

Our purpose in this study was to describe residents' perceptions of radon health risks and to evaluate how perceptions correlated with protection behaviours applying the protection motivation theoretical lens. We examined the perception of radon health risk of an illustrative sample of Ottawa-Gatineau residents. In doing so, we compared the observed measures of the perception variables of interest with residents' sociodemographic features and identified mixed associations with their intention to test and actual protection behaviours. Our analyses showed significant associations of perception variables with residents' intention to test for radon. The same variables meaningfully predicted residents' actual protection behaviours, thus confirmed our research hypotheses. These findings correspond with the results of studies conducted by Hahn at al.[29] in the USA and Butler et al.[25] in the UK.

A few quantitative studies in Canada have assessed public perception of environmental health risks in general. Krewski et al.[30] conducted a national survey on health risk perception and looked into thirty common health hazards. A more focused study by Spiegel and Krewski[13] evaluated health risk perception of radon along with three other health hazards affecting

residents of high radon areas in Canada. They examined residents' compliance with the radon guideline and concluded that the Canadian radon guideline is not effectively prompting homeowners to reduce radon exposure.[13] Our findings support this conclusion, in that compared to the gravity of the risk, residents' perception level still remains low. Although those studies credibly supported the federal government initiative to develop a radon guideline, no follow-up study purposefully focused on radon health risk perception to support the National Radon Program of Health Canada. This study fills that scholarly gap in the literature.

Although few (29%) in number, the inclusion of tenants in our sample, led to some notable findings. Like homeowners, tenants also tested their homes for radon due to having concern for their children living in the basement. However, none of them mitigated their homes. An apparent reason for this is the lack of authority to do so; nonetheless, there presently exists no law that gives tenants the right to hold property owners responsible for such mitigation. Homeowners who mitigated their homes also tended to have children sleeping in the basement. Homeowners had also observed others taking such mitigation action, or had heard of people who had radon-induced lung cancer. Perception of radon health risk documented in this study may create apprehension among tenants and occupants of public buildings, as building owners are not currently required to measure and mitigate radon. Understanding perception of radon health risk can also help to dissipate the ambiguity in radon health communication and deliver appropriate message to the right audiences in the right manner; thus, opening up new pathways for preventive interventions to enhance public health.

Again, the significant correlation between having children live in the basement or on the ground floor with taking actual protective behaviours might have biological plausibility. To elaborate, a targeted health communication message that can stir the affection part relating to the

inner cortex or limbic brain would yield better outcome compared to those emphasizing only the rational cognitive part pertaining to the neocortex. These findings warrant further exploration of social influence through an in-depth qualitative study to test whether motivation works under the affective familial or social influence that can open the way to make protective behaviours a norm in our society.

Although our study targeted one metropolitan area, the Ottawa-Gatineau CMA spans two provinces in the capital region and covers both English and French-speaking populations. Finally, a systematic understanding of homeowners' perceptions through the protection motivation theoretical lens advances the PMT research agenda and puts forward evidence for innovative approaches to be considered by policymakers and professionals in addressing radon as an important public health issue.

Limitations

Our study is limited in demographic scope. We may have overlooked demographic diversities and cultural subtleties in selecting the sample online that could have skewed our results. Our sample did include tenants, but the lack of variability in the scores may have affected the relationship between them. Furthermore, residents who took the survey did so voluntarily and included those who have access to the internet; therefore, we collected proportional responses offline using iPad to include the rest 10% of residents having no access to the internet. Our study included only residents in Ottawa-Gatineau and should be understood in the context of this population. Though the sample was in proportion to the demographic features of the Canadian population, we cannot claim it to be representative of the whole Canadian demography. A future study with a national representative sample would provide stronger evidence base to support the design of national health communication programs focusing on residential radon risk mitigation.

Conclusion

In this study, we tested the hypothesis that those with the higher levels of perceived susceptibility, severity, synergistic risk perception, smoking in home, care for children and social influence would be more likely to have the intention to test as well as to demonstrate protection behaviours regarding testing and mitigating their homes. Statistical analyses of our survey data confirmed this hypothesis in a Canadian context. Variables reflecting public perception of radon health risk did not always convert into the protection behaviours that could be explained by biological plausibility. Nonetheless, through the protection motivation theoretical lens, we have now understood that residents' perceptions of the health risks of radon are a marker of intention to test their homes for radon, and are a clear predictor of actual risk mitigation behaviours.

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Compliance with ethical standards:

The University of Ottawa's Institutional Review Board approved the study and data collection protocols (file number: H10-17-03).

Conflict of interest:

The authors declare no conflict of interest.

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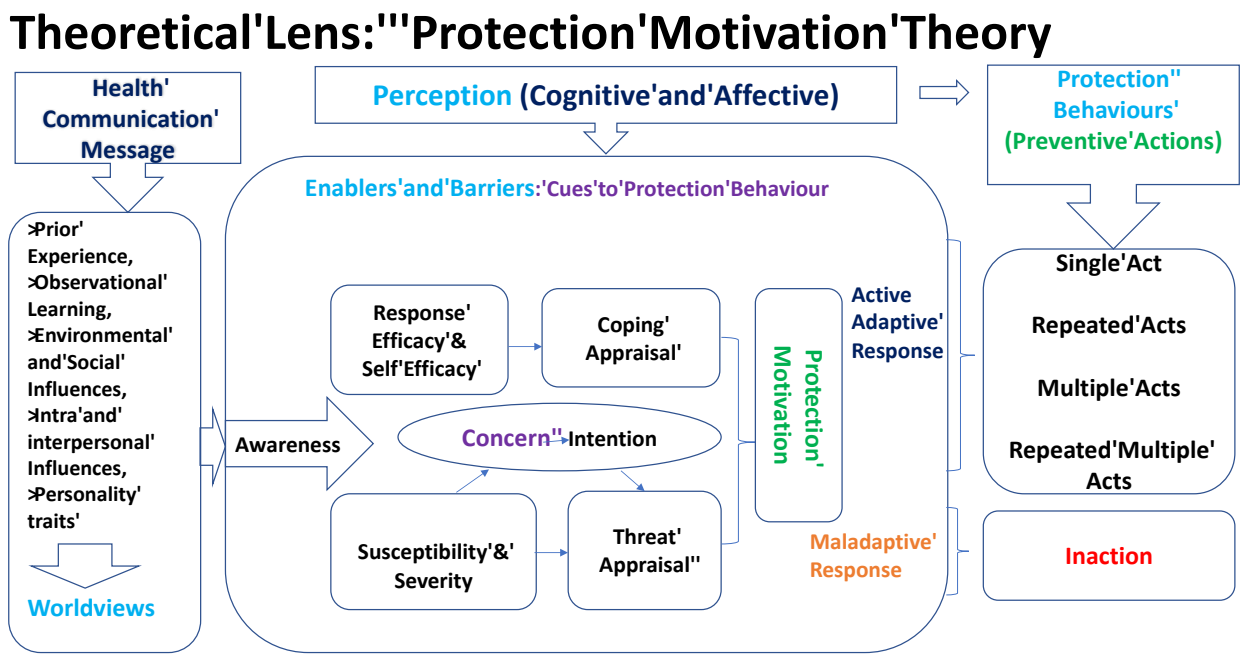
Appendices:



Figure'1:'Developed'with'ideas'from'the'Protection'Motivation'Theory'of'Rogers'(1983)'

Table 1: Associations of sociodemographic characteristics with residents' intention to test homes for radon

Characteristics	Total Sample (N=557)		Residents' Intention to Test Homes for Radon: Yes		No		Associations (Significance)
	N	%	N	%	N	%	X^2 (p)‡
Homeownership							
Owners	394	71	*179*	*80*	215	65	14.2* (.000§)
Tenants	163	29	46	20	117	35	
Gender							
Male	291	52	88	39	203	61	29.8* (.000§)
Female	224	40	*121*	*54*	103	31	
No willing to identify	42	8	16	7	26	8	
Age groups							
18-24 year	83	15	46	20	37	11	
25-34 year	58	10	35	16	23	7	
35-44 year	59	11	33	15	26	8	85.8* (.000§)
45-54 year	85	15	50	22	35	11	
55-64 year	106	19	9	4	97	29	
65 and above	166	30	*52*	*23*	114	34	
Race/Ethnicity							
European Canadian	375	67	*146*	*65*	229	69	
First Nations	14	2.5	5	2	9	3	1.9* (.583)
Visible Minorities	120	21	55	24	65	20	
Prefer not to answer	48	9	19	8	29	9	
Education							
High School or less	70	13	25	11	45	14	
College	135	24	54	24	81	24	7.3† (.062)
University	346	62	*146*	*65*	200	60	
Prefer not to answer	6	1	0	0	6	2	
Income groups							
Lowest subsistence	60	11	28	12	32	10	
Lower middle, non-skilled	147	26	*60*	*27*	87	26	
Skilled working class	94	17	36	16	58	17	2.1* (.836)
Middle class	106	19	44	20	62	19	
Upper middle	68	12	28	12	40	12	
Prefer not to answer	82	15	29	13	53	16	

**Pearson Chi-Square (x^2); †Likelihood ratio; ‡Asymptotic significance (2 sided); §Significant association*

Figure 2: Residents' concern about radon health risk; actual testing and mitigation behaviours

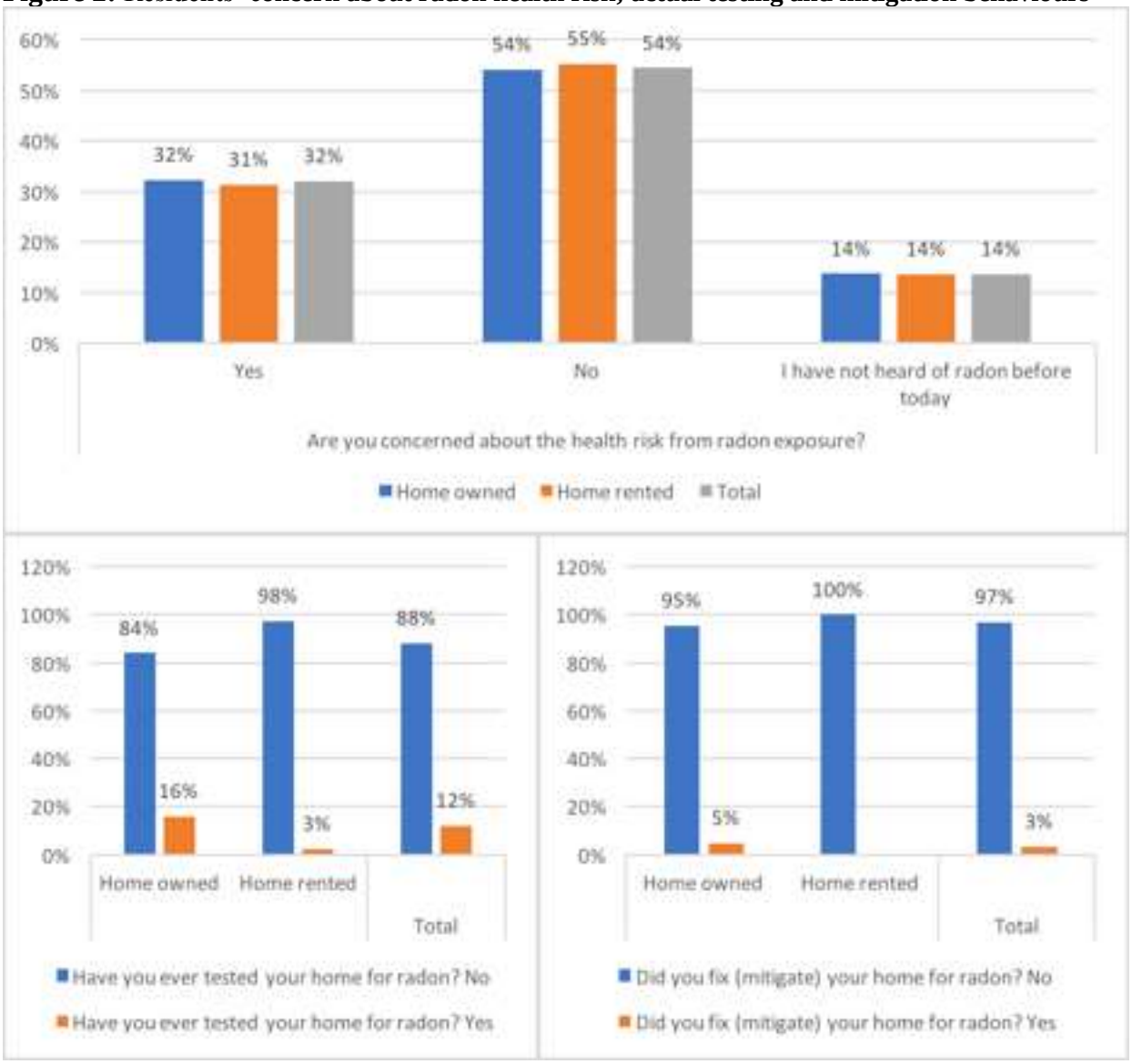


Table 2: Associations of sociodemographic characteristics with residents' actual testing and mitigation of homes for radon

	Residents Ever Tested Homes for Radon							Mitigated homes for radon						
Characteristics	**Total Sample (N=557)**		**Yes**		**No**		**Associations (Significance)**	**Total Sample (N=557)**		**Yes**		**No**		**Associations (Significance)**
	N	**%**	**N**	**%**	**N**	**%**	**X^2 (p‡)**	**N**	**%**	**N**	**%**	**N**	**%**	**X^2 (p‡)**
Homeownership														
Owners	394	71	63	94	331	68		394	71	**17**	**100**	377	70	7.7*
Tenants	163	29	4	6	159	32	19.9* (.000§)	163	29	0	0	163	30	(.006§)
Gender														
Male	291	52	*34*	*51*	257	52		291	52	*10*	*56*	281	52	
Female	224	40	31	46	193	40	2.8* (.244)	224	40	8	44	216	40	1.5*
No willing to identify	42	8	2	3	40	8		42	8	0	0	42	8	(.467)
Age groups														
18-24 year	83	15	*19*	*28*	64	13		83	15	*6*	*35*	77	14	
25-34 year	58	10	11	16	47	10		58	10	3	18	55	10	
35-44 year	59	11	10	15	49	10	18.6† (.000§)	59	11	5	29	54	10	17.4†
45-54 year	85	15	9	13	76	15		85	15	2	12	83	15	(.004§)
55-64 year	106	19	5	8	101	21		106	19	0	0	106	20	
65 and above	166	30	13	19	153	31		166	30	2	*6*	164	31	
Race/Ethnicity														
European Canadian	375	67	*36*	*54*	339	69		375	67	**1***0*	*56*	365	68	2.5†
First Nations	14	3	2	3	12	3	6.6* (.08)	14	3	0	0	14	3	(.479)
Visible Minorities	120	21	20	30	100	20		120	21	6	33	114	21	
Prefer not to answer	48	9	9	3	39	8		48	9	2	11	46	8	
Education														
High School or less	70	13	7	10	63	13		70	13	1	6	69	13	
College	135	24	17	25	118	24	.4* (.932)	135	24	4	22	131	24	1.6†
University	346	62	*42*	*63*	304	62		346	62	*13*	*72*	333	62	(.652)
Prefer not to answer	6	1	1	1	5	1		6	1	0	0	6	1	
Income groups														
Lowest subsistence	60	11	11	16	49	10		60	11	3	18	57	11	
Lower middle, non-skilled	147	26	*19*	*28*	128	26	5.73* (.333)	*147*	*26*	4	23	143	26	5.24†
Skilled working class	94	17	10	15	84	17		94	17	1	6	93	17	(.387)
Middle class	106	19	9	13	97	20		106	19	3	18	103	19	
Upper middle	68	12	12	18	56	12		68	12	**5**	*29*	63	12	
Prefer not to answer	82	15	7	10	75	15		82	15	1	6	81	15	

**Pearson Chi-Square (x^2); †Likelihood ratio; ‡Asymptotic significance (2 sided); §Significant association*

Table 3: Ordinal and binary regression modeling: Residents' perception of radon health risk predicting their intention to test; actual testing and mitigating homes for radon

Variables	Intention to test				Tested home for radon				Mitigated home for radon			
	Estimate/ β	SE	Wald/ Std. β	p	Estimate/ β	SE	Wald/ Std. β	p	Estimate/ β	SE	Wald/ Std. β	P
Perceived susceptibility of radon risk*	2.0	.65	10.3	.001§	18.8	.36	2762.3	.000§	18.5	.66	787.5	.000§
Perceived severity of radon risk†	2.5	.42	36.8	.000§	2.4	.62	15.5	.000§	20.3	.66	936.9	.000§
Synergistic risk perception‡	-3.6	.37	97.7	.000§	-3.4	.41	67.9	.000§	-2.5	.64	15.7	.000§
Smoke in home‡	-2.0	.35	35.7	.000§	-3.5	.39	81.7	.000§	-4.0	1.03	15.1	.000§
Care for children‡	-2.0	.49	17.7	.000§	-5.4	.55	98.9	.000§	-4.6	1.04	19.9	.000§
Social influence[c]	2.3	.60	14.7	.000§	-6.5	.60	118.8	.000§	-4.9	1.04	22.8	.000§

**Ordinal regression model fit statistics for intention to test are Likelihood = 21.47, $p < 0.001$, and $X^2 = 100.43$, df=4.*

†Ordinal regression model fit statistics for intention to test are Likelihood = 20.09, $p < 0.001$, and $X^2 = 75.04$, df=3.

‡Binary regression model, Hosmer and Lemeshow test's $X^2 = 47.42$, $p<0.001$, df=4.

§Values refer to the predictors that are significant in the model. SE=standard error of β; Std. β=standardized beta, X^2= Chi-Square statistic, df=degree of freedom.

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