

Radon Awareness in Metro Vancouver

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Abstract

Background: Radon is a naturally occurring harmful radioactive gas and is the second leading cause of lung cancer (WHO, 2021). Canada gets a very high number of immigrants every year and immigrant population is increasing dramatically (Government of Canada, 2005). Assessing the immigrants' knowledge in metro Vancouver on radon gas can help identify whether education for radon gas for immigrants is needed to aid in the prevention of lung cancer.

Methods: The survey was created using Survey Monkey and distributed as an online self-administered survey through Facebook, reddit and by posted a QR code at the front desk of an immigration consultant office called Gill Immigration Consultant, Surrey, BC. The survey contained six questions that checked the general knowledge of radon gas among individuals living in the metro Vancouver. Pearson's Chi-Square test were used to analyze the data.

Results: Of the 193 respondents, 116 were living in the metro Vancouver for more than 5 years and 77 of them were living in the metro Vancouver for less than 5 years. Participants living for less than 5 years in Metro Vancouver were considered immigrants and those who were living for more than 5 years were considered Canadians. This study found that the immigrants have less knowledge of radon ($P= 0.0050$).

Conclusion: This study put emphasis on one of the most important social determinants of health which is immigration. It identified the need for more targeted and tailored radon related programs. The information can be distributed by local public health authorities, immigration organizations and other agencies such as the BC Lung Association to spread the radon gas awareness.

Keywords: *radon, survey, immigrants, BC, knowledge, lung, cancer*

Introduction

Metro Vancouver is an area where radon activity is not very high. Other parts of British Columbia such as interior has been found with high radon activity because the geological composition of rocks and soils

contains high level of uranium decay. Radon gas concentration is usually found in the indoor environment and is the second leading cause of lung cancer after smoking in Canada. From the last few years, the number of people moving from metro

Vancouver to other parts of British Columbia has increased. Thus, if a person migrates from metro Vancouver to high radon activity area, it becomes essential that a person is aware of the harmful health effects of radon. Moreover, Canada gets a very high number of immigrants every year, and immigration population has been increasing dramatically every year. Therefore, the objective of this study is to determine whether individuals living especially new immigrants in metro Vancouver have a strong background knowledge of radon gas. The findings of this study are important for local, provincial, federal government, as well as other radon awareness associations to establish educational programs for both Canadians and Immigrants.

Literature Review

A news article by BC Centre for Disease Control (BCCDC) called, “Radon testing advised for all BC homes to reduce cancer risks” highlighted the importance of radon prevention as long-term exposure can cause lung cancer (Today In BC, 2021). Dr. Parveen Bhatti, a principal investigator in Cancer Epidemiology & Prevention at BC Cancer, said, “Radon gas exposure is one of the lesser-known causes of lung cancer but

is an important risk factor” (Today In BC, 2021).. BCCDC said that the homes in lower mainland areas such as Chilliwack and Abbotsford have high levels of radon gas (Today In BC, 2021). Moreover, according to Canadian statistics, around 16% of lung cancers are associated with radon exposure (NCCEH, 2018). There are many ways that Environmental Health Officers can contribute to reduce the radon levels in BC homes. First, very few people know about radon gas and only 33% of Canadian households can correct the radon issue (NCCEH, 2018). Hence, measuring the general radon-based knowledge among the population can benefit the public health authorities to initiate targeted health promotion approaches or involve other stakeholders outside of public health to reduce the number of lung cancers.

What is Radon?

Radon is a naturally occurring harmful radioactive gas that can be found in a very high concentration in indoor environments (BCCDC, 2022). It is produced when the breakdown of the uranium element occurs i.e., it is a decay product of uranium. Radon is ubiquitous and can be found in sediment (soil), rocks, and water (WHO, 2021). Radon can get into the house with various

routes such as cracks in the foundation walls or floor slabs, pipe gaps and floor drains (WHO, 2021). Radon concentration in indoor areas varies from 10 Bq/m³ to more than 10,000 Bq/m³ (World Health Organization, n.d.).

It is a colourless, odourless, tasteless gas, making it impossible to detect with human senses (CCOHS, 2018). Because of this, it is measured by the quantitative method with radon measurement devices (Health Canada, 2017). Testing of radon for homes can be done in two ways, one is that the homeowner can test their own houses by purchasing a test kit from local stores or get it tested by a radon measurement professional (CARST, n.d.). The standard unit to measure radon is, picocuries per litre (pCi/L) or becquerels per cubic meter (Bq/m³). One disintegration of radon per second is represented by one becquerel, and one picocurie per litre equals 37 Bq/m³ (CCOHS, 2018).

Health effects

In Canada, smoking is the leading cause of lung cancer and radon is second on the list (World Health Organization, n.d.). When radon is released in the open air, it gets diluted and poses a negligible human health risk (WHO, 2021). However, suppose radon

enters the indoor areas, it accumulates over time. In that case, it becomes a health hazard and poses a high health risk (CARST, n.d.). In developed countries such as Canada, it is estimated that 70% of people's time is mainly spent inside the houses (World Health Organization, n.d.) Having said that, during the current pandemic COVID-19, the indoor time spent in people may have been higher than in previous years, resulting in a high-risk of lung development for people living in areas with high levels of radon concentration. Radon gas is also considered as the primary indoor air carcinogen in Canadian settings (CAREX,2022). In 2010, worldwide, it was found that there were 98,992 deaths caused by radon gas (World Health Organization, n.d.). The risk development of lung cancer depends on three factors, concentration of radon gas, radon gas exposure span, and whether a person is a smoker or not (CARST, n.d.). People who smoke tend to be 25 times more at risk of getting lung cancer from radon exposure than non-smokers (WHO, 2021).

The sudden increase in lung cancer numbers was first detected in the uranium miners who were exposed to a very high radon concentration (WHO, 2021). Furthermore, various studies were done in Europe, North

America, and China which confirmed that even a low concentration of radon found in houses could pose a high health risk (WHO, 2021). Radon is Group 1 human carcinogenic according to International Agency for Research on Cancer (IARC) because of its harmful effects (CCOHS, 2018). In addition, it was estimated that the risk of lung cancer increases by 16 % if the person is exposed to average radon concentration, i.e., 100 Bq/m³ for a long time (WHO, 2021). When radon gas is inhaled, its particles get deposited on the lung tissue and start decaying. The decaying process of radon produces radioactive alpha particles that release radiations that can cause cell damage which may result to lung cancer over time (CARST, n.d.).

A Portugal study was performed which proved the causation of lung cancer and radon exposure. This study determined the relationship between number of people who got lung cancers due to indoor radon exposure (Veloso, 2012). It accounted for other contributing factors, such as smoking, and used two different models to study the relationship. The results from the first model indicated a close relationship and, that the combined effect of radon and smoking causes an increase in lung cancer deaths

from 18 to 28% (Veloso, 2012). Apart from this, it also suggested that approximately 90% of deaths were of smokers who were exposed to radon, and 80 % of deaths were among women (Veloso, 2012). This study consisted of many limitations, such as considering constant indoor radon concentration and assuming a constant radon exposure throughout a lifetime (Veloso, 2012). The statistical results recommended that although there are already guidelines set up, there was a need for more involvement of national and regional Portugal government to reduce radon exposure in indoor environments (Veloso, 2012).

Radon guidelines

At present, there is no Canadian regulation that oversees the radon acceptable level. However, there are guidelines in place set by Health Canada that says that the acceptable level of radon in indoor areas is 200 becquerels per cubic meter (200 Bq/m³)(12). Furthermore, it is essential to note that there is no safe radon limit; below the 200 Bq/m³ has significantly less health risk. Therefore, it comes down to the homeowners what they think is the acceptable level of radon (Health Canada, 2017).

Mitigation measures

The radon level can only be reduced if firstly radon tests are performed. The most recent survey done by Health Canada in 2011 suggests that 42% of Canadian households got to hear about radon. However, only 5 % of these households have tested their houses for radon (CAREX, 2022) . Because radon level varies over time, it is recommended that radon test should be performed for a minimum of three months duration (Health Canada, 2017). Prevention of radon exposure is essential to reduce the number of people who gets lung cancers. The Canadian Cancer Society predicted that by 2042, 3569 cancer cases due to radon in homes can be prevented if the mitigation measures of radon levels above 100 Bq/m³ to 50 Bq/m³ are met (Government of Canada, 2020) .

It is suggested that people should take corrective actions whenever radon concentration for indoor areas is found above the acceptable level. If the results are between 200-600 Bq/m³, corrective actions should be taken within two years. If the results are above 600 Bq/m³, these actions should be taken within one year (Health Canada, 2017). A study performed by Health Canada in 2018 looked at the rates of radon mitigation and found that 29 % of

households with radon levels above 200 Bq/m³ performed mitigations steps to reduce radon exposure (Government of British Columbia, 2014). Rest of the 39 % of survey participants radon tests came above 800 Bq/m³, and 43 % of participants tests were above 1000 Bq/m³. All these participants performed mitigation steps to reduce radon exposure (Government of British Columbia, 2014).

According to the Radon reduction guide for Canadians, remedial actions for old buildings are increased mechanical ventilation of the home, use of sealant products to seal cracks, holes on floors and walls, and creating a blockage between the basement and rest of the house (BC Lung Foundation, 2022). For newer buildings, the National Building Code of 2010 recommended mitigation methods such as sealing expansion joints in basements, installing special traps in floor drains that only drains water and prevent radon entry into the house (BC Lung Foundation, 2022). As shown in figure 1, British Columbia is divided into three zones. Zone 1 is considered a high-risk radon area versus Zone 2 and Zone 3, respectively (BC Lung Foundation, 2022).

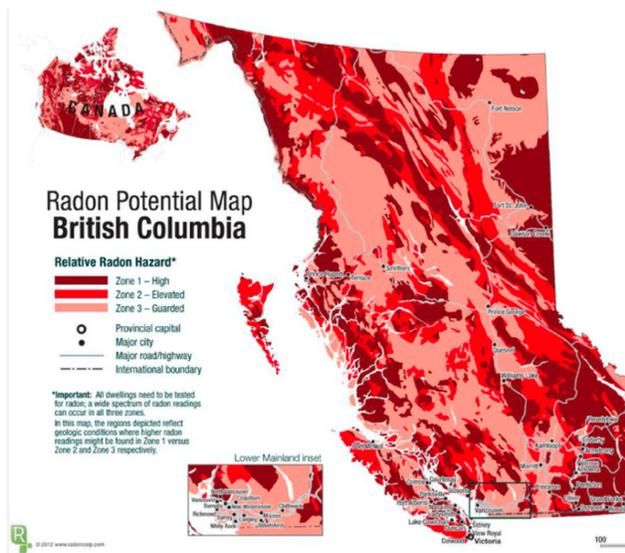


Figure 1. Radon Potential Map for the Province of BC. (Radon and BC Building Code. 2015)

For houses in Zone 1 areas, BC Building Code requires to have a subfloor depressurization system consisting of a gas pipe and 100 mm granular material (BC Lung Foundation, 2022). A gas pipe installed in the subfloor basement is extended to the outside of house with fan that exhaust radon (CCOHS, 2018). However, BC Building Code does not require to have the fan installed during construction but for efficient removal of radon the designers should consider installing it (Government of British Columbia, 2014). One more method to reduce the radon level from indoor environments for newer buildings is using

non-permeable membranes, such as plastic sheets. These sheets can be placed over the sand or gravel base before pouring the concrete foundation (Government of British Columbia, 2014).

Awareness of Radon around Canada

Throughout Canada, radon is ubiquitous i.e., no place in Canada is “Radon-free”, but its concentration is highly dependent on the composition of bedrock and sediment (CARST, n.d.). According to Statistics Canada, 7 % of homes in Canada are approximated to have high radon levels (Statistics Canada, 2016). Canadian places such as Yukon Territory, Saskatchewan, Manitoba, and Nova Scotia exceeded the acceptable radon concentration, 200 Bq/m³ (Statistics Canada, 2016). Cross country survey conducted by Health Canada from 2009 to 2011 showed that 6.9 % among 14,000 homes tested for indoor radon levels and results were also above current Canadian guidelines of 200 Bq/m³ (CAREX, 2022).

Awareness of Radon around British Columbia

Radon measurement study was performed in the interior of BC in 2007 by BCCDC in which Lower mainland of BC is considered

to have very less radon gas concentration (BCCDC, 2021). High radon levels are usually found in the regions of the east coast mountains, including Kootenays, the Okanagan Valley, Northern Interior, North Thompson, and Peach River (BCCDC, 2021). In these high radon levels areas, 5 to 40% of homes are above the acceptable Canadian radon guidelines (Government of Canada, 2021). A high radon level is found in the winter when the walls and doors are closed (CAREX, 2022). Moreover, when a building is sealed to conserve the energy level, it can also result in high radon levels (CAREX, 2022).

Purpose of the study

The purpose of this study is to determine whether individuals living in lower mainland of British Columbia have strong background knowledge regarding radon gas. Lower mainland of British Columbia has radon levels below the acceptable Canadian guidelines (BCCDC, 2021). However, regardless of meeting the Canadian guidelines, it is essential to understand the radon knowledge level among individuals in lower mainland because of two reasons. First, it is found that migration within the province has accelerated for various reasons (BCBC, 2020). According to Statistics

Canada, a very high number of people migrate from outside of lower mainland (BCBC, 2020). From the last few years, the number of people flowing from lower mainland to other parts of BC has increased from 2,700 to 10,300 (BCBC, 2020). Therefore, if a person migrates from lower mainland to high radon level areas, it becomes essential that a person is aware of the harmful health effects of radon. Secondly, Canada gets a very high number of immigrants every year. According to the recent 2001 Census, 738,600 immigrants live in Vancouver (Government of Canada, 2005). The immigrant population has increased dramatically by 88% from 1986 to 2001 (Government of Canada, 2005). Thus, it is conceivable that the individuals who are new to Canada as immigrants may not have heard about the radon. Therefore, with increasing immigrants into Canada, there is a greater need to have targeted and tailored radon related health promotion approaches. Furthermore, the radon knowledge survey results can help the governments and radon-related agencies to develop policies and establish cost-effective radon knowledge education programs across lower mainland of British Columbia to reduce the number of lung cancers.

Materials and Methodology

The survey was distributed as an online self-administered survey on the platform SurveyMonkey and was open for three weeks from January 18th, 2022, to February 9th, 2022. The survey was posted by the front desk of an immigration consultant office called Gill Immigration Consultant in Surrey with QR code for individuals to scan and participate. Furthermore, the surveys were distributed on other platforms such as Reddit-sub reddit: Take My Survey, and Facebook pages such as Canada Immigration & Citizenship, Lower mainland, and Canada Immigration.

There were six questions in the survey that checked the general knowledge of radon gas among individuals living in the metro Vancouver to target both Canadians and Immigrants. Survey questions had closed-ended questions, and there was an option of “prefer not to answer” for all the questions. In this way, the participants’ privacy was protected, and if they were not comfortable answering any question, they had an option not to answer. At the end of the survey, there was an option to enter their contact information to win a prize draw.

Inclusion and Exclusion

Individuals who are currently living in the metro Vancouver, British Columbia, and who are 19 years of age or older was included in this study. Any individuals who did not meet the inclusion criteria above was excluded from the study. Moreover, classmates, friends and family members were excluded from the study.

Ethics

To ensure the ethics of this research study the method, cover letter, consent form and survey questions were sent to, and approved by, the BCIT Research Ethics Board before the survey was distributed to people.

Results

Description of Data

The collected data for the radon awareness survey was nominal and ordinal which included demographics, years of living in metro Vancouver and knowledge level. For the purpose of this study, the knowledge categories were: (i) Not knowledgeable, (ii) some knowledgeable, (iii) very knowledgeable. Not knowledgeable basically tells that the person has not heard about the radon gas in their life and some knowledgeable category is defined that the person has some basic knowledge of radon such as what is radon? How is it tested? And

very knowledgeable category defines people who knows the radon exceeding limits, legislation behind radon gas etc. Participants living for less than 5 years in Metro Vancouver were considered immigrants and those who were living for more than 5 years were considered Canadians.

Descriptive Statistics

The collected data was presented as number of respondents in a pie chart. Real data was run for the first hypothesis, and among 193 respondents, 116 were living in the metro Vancouver for more than 5 years and 77 of them were living in the metro Vancouver for less than 5 years (Figure 2)

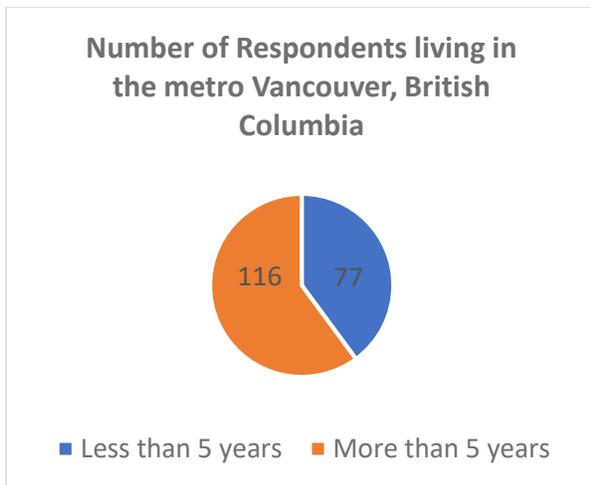


Figure 2 Years of living in metro Vancouver Profile of Respondents

Figure 3 displays the radon knowledge level of participants versus years of living in metro Vancouver. Among 193 respondents,

116 respondents were living in metro Vancouver for more than 5 years, and among these respondents, 10 said they are not knowledgeable, 54 have some knowledge and 52 respondents are very knowledgeable about radon. Another group consisted of 73 respondents (those who had been living in metro Vancouver for less than 5 years). Among this group, 7 respondents were not knowledgeable, 45 of them had some knowledge about the radon, and only 21 respondents were very knowledgeable about radon.

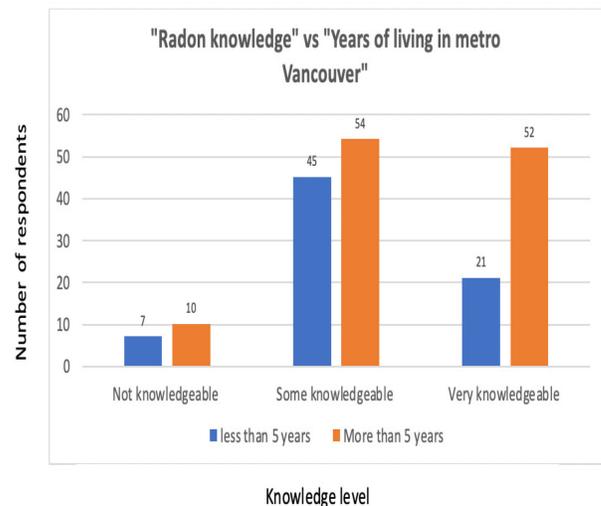


Figure 3 Radon knowledge level of Respondents versus years of living in metro Vancouver

Figure 4 displays the radon knowledge of participants versus level of education. In “Not knowledgeable” category 7

respondents have Diploma or certificate, 7 have bachelor's degree and 4 holds master's degree, PhD. In "Some knowledgeable" category 9 respondents have high school education, 22 have Diploma or certificate, 39 have bachelor's degree and 20 have master's degree, PhD. In "very knowledgeable" category 3 respondents have high school education level, 14 have Diploma or certificate, 34 have bachelor's degree and 23 have master's degree, PhD.

Inferential Statistics

Two hypotheses were analyzed and determined if there was a statistically significant association for both hypotheses using a Pearson's Chi-square test with statistical software NCSS 2022.

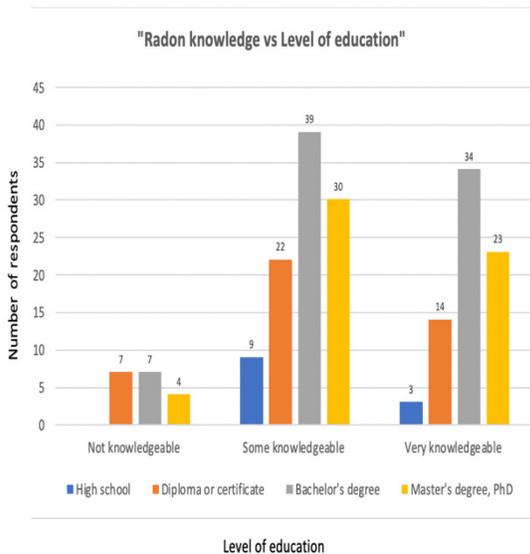


Figure 4 Radon knowledge of respondents versus level of education

#	H0 and Ha	Test Used	Result	Conclusion (alpha or beta error, if relevant), power if provided
1	H01: There is no association between knowledge of radon and years of living in the metro Vancouver. Ha1: There is an association between knowledge of radon and years of living in the metro Vancouver	Chi-Square test	P = 0.0050	Reject the null hypothesis and conclude that there is a statistically significant association between knowledge of the radon and years of living in metro Vancouver.
2	H02: There is no association between knowledge of radon and education level of respondents. Ha2: There is an association between knowledge of radon and education level of respondents.	Chi-Square test	P = 0.6797	Do not reject the null hypothesis and conclude that there is no association between knowledge of radon and education level of respondents.

Discussion

Hypothesis 1

The results of the Chi-square test showed that there was statistically significant association between knowledge of the radon and years of living in metro Vancouver. Results from the table showed that immigrants have less knowledge about the radon gas when compared to Canadians. There could be various reasons: (i) immigrants are coming

from a country where there is less knowledge about radon gas or the radon activity is not present at all, (ii) there is language barrier i.e., immigrants cannot understand the information provided to them about radon in English, (iii) metro Vancouver is low-hazard zone according to the Radon Potential Map in BC, and as such there are less radon education programs especially those whose target population is immigrants and, (iv) low

level of education among immigrant population.

The survey done by Health Canada in 2011 suggests that 42% of Canadian households had heard about radon (CAREX, 2012). Statistics Canada in 2015 conducted a survey which showed that only 55 % of all Canadians households had heard about radon, and only 59 % were able to correctly identify radon gas when they were presented with a list of possible descriptions. Conclusively, British Columbia households were most likely to have chosen an incorrect description for radon when asked in the survey (Statistics Canada, 2016). However, no previous radon awareness surveys that target immigrants were found which implies that there are very less resources to study the immigrant's knowledge on radon. The result of the radon awareness in metro Vancouver survey extrapolates the public's radon knowledge especially immigrants. With low knowledge level among immigrants from metro Vancouver, it can be implied that there is a need for more targeted approach.

Hypothesis 2

Because low level of education is the potential reason of less knowledge regarding radon gas, the question whether the education

level of respondents (both Canadians and Immigrants) is related to the radon knowledge level arose. As per the results there is no association between knowledge of radon and education level of respondents. For the purpose of this study, the education level categories were: (i) high school, (ii) Diploma or certificate, (iii) Bachelor's degree, and (iv) Master's degree, PhD. The result of this test indicates no significant difference in radon knowledge based on education. It implies that there was an overall lack of awareness among respondents living in the metro Vancouver area despite the years of living in metro Vancouver and their education level. This result was expected because metro Vancouver is a low-hazard region for radon gas compared to the other areas of province, and perhaps people residing outside of metro Vancouver have stronger awareness because those areas may have more radon education awareness programs. Moreover, because the survey questions were not translated into different languages there is a chance that some immigrant populations or low literacy population was missed and conceivably in reality there is an association between low education level and radon knowledge level.

Based on previous studies, it could be simplified that the radon gas is worldwide problematic and, effective awareness and mitigation campaigns need to be executed. A Portugal study was performed which proved the causation of lung cancer and radon exposure. This study determined the relationship between number of people who got lung cancers due to indoor radon exposure (Veloso, 2012). The study recommended that although there are already guidelines set up, there was a need for more involvement of national and regional Portugal government to reduce radon exposure in indoor environments (Veloso, 2012). Similarly, even in Canada there are guidelines setup, but based on the results from this radon awareness study there is need for more involvement from various local public health authorities for metro Vancouver population especially immigrants. Because regardless there is guideline setup, but most of the population do not have general knowledge of radon, and therefore cannot mitigate the risk.

Limitations

There were some limitations throughout the duration of the study. One major difficulty encountered involved methodology and conducting the online survey. The link to the

survey could not be shared with friends, family, or colleagues, nor be posted on personal social media websites due to ethical considerations. The survey was distributed on Reddit and Facebook pages, and this was challenge because many subreddits and Facebook pages had rules in terms of what can be posted, therefore limiting the response rates. Survey poster was also posted in immigration consultant office that had increased the response rates; nevertheless, it was difficult to differentiate the responses that had come from people scanning the QR code from those that came through subreddit and Facebook pages.

Some respondents especially immigrants may also have difficulty in understanding the English language. This limitation could have been reduced by translating the survey questions into different languages. This way the survey response validity could have been increased as it lowers the probabilities of respondents answering the questions without fully understanding the meaning of the questions. Translating the surveys into different language could have benefited the study's result by giving the actualities of whether immigrants have less knowledge of radon. Because the survey was not translated into different languages and immigrants in

Canada come from all different countries where first language is not English, there are high chances that responses of significant immigrant populations were missed.

Knowledge Translation

According to the 2016 Census, 7.5 million immigrants live in Canada which represents over one-fifth (21.9%) of Canada's total population (Government of Canada, 2005). The projections from 2017 Statistics Canada's stated that the proportion of immigrants could reach between 24.5% and 30.0% by 2036 (Government of Canada, 2005). This study provides a greater awareness that firstly as per the literature review the immigration population is expected to be increased in the coming years and secondly results of the study shows that immigrants are less knowledgeable about radon gas. Thus, this demographic in the population requires more focus by the various local public health authorities in metro Vancouver and other health related agencies such as Health Canada, BCCDC etc. Results of this study can be used to initiate a dedicated program in the health authorities that covers areas such as education seminars, radon workshops and working with other agencies to create new policies. For example, immigrants can be

given a radon testing as a package and incorporating the radon testing in housing policy is another way to spread the radon awareness. Thus, the immigrants dedicated programs by the local authorities will bring opportunity to have targeted and tailored radon related health promotion approaches.

Future Research

Based on this research project, future students' projects can be established to further investigate people's knowledge level of radon gas in metro Vancouver. Those projects may include but are not limited to:

- Assessing the general radon knowledge of people living in metro Vancouver in the future to compare with the findings from this project. A difference in findings may imply the effectiveness of (if any) newly implemented awareness programs
- Assessing the radon knowledge of immigrants living in BC to see if the immigrants living in the high-hazard region has more radon knowledge compared to those who live in the low-hazard region, for example metro Vancouver.

Conclusion

Radon gas is the second leading cause of lung cancer in Canada but still many people are not aware of its health consequences. This study tried to put emphasis on one of the most important social determinants of health which is immigration. The immigrant population has consistently been affected negatively by social determinants of health such as lack of educational attainment (Chang, 2019). This study demonstrated that new immigrants showed little to no background knowledge about radon gas. It implies that there are very less education or awareness programs for immigrants and that is why it is very important that there should be radon awareness programs by collaborating with various immigration organizations and other agencies such as the BC Lung Association.

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Competing Interest

The author declares that they have no competing interests.

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