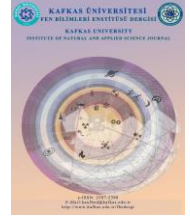




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### Measurement of Health Services Vocational School Students' Knowledge, Attitudes and Behaviors About Radon: Van Province Example

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#### Keywords:

Radon,  
Student,  
Survey.

**Abstract:** Almost 50% of the natural radiation that is constantly present in our environment is caused by radon gas and its short-lived decay products. Radon ( $^{222}\text{Rn}$ ) is a gas and can become trapped in closed spaces and rise to dangerous levels. Because  $^{222}\text{Rn}$  is colorless, odorless and tasteless, it is impossible to detect without special equipment and may not be perceived as a health risk by the public due to these properties. It is important to investigate individual risk perception in order to prevent the negative health effects of radon. In this study, which aimed to determine the knowledge and awareness of students studying in Radiotherapy and Medical Imaging Programs regarding radon gas, a survey consisting of 15 questions was applied to the participants. According to the findings, 54.2% of the participants stated that they had heard of radon and 51.1% stated that radon was harmful. The rate of those who responded that school was their source of information was 33.3%, and most of them were 2nd grade students. The rate of those who did not know the causes of radon in residences was 47%. Although the proportion of those who think that radon testing should be done in homes is high (86.3%), there are many who do not know how to test (94%). The study showed that the level of knowledge about radon among the participants is not high enough. Considering the carcinogenic effect of radon, there is a need to create more awareness among the members of the society.

### Sağlık Hizmetleri Meslek Yüksekokulu Öğrencilerinin Radonla İlgili Bilgi, Tutum ve Davranışlarının Ölçülmesi: Van İli Örneği

#### Anahtar Kelimeler:

Anket,  
Öğrenci,  
Radon.

**Özet:** Çevremizde sürekli var olan doğal radyasyonun neredeyse %50'si radon gazı ve onun kısa ömürlü bozunum ürünlerinden kaynaklanmaktadır. Radon ( $^{222}\text{Rn}$ ) bir gaz olduğundan kapalı mekanların içinde sıkışıp kalarak tehlikeli seviyelere çıkabilir.  $^{222}\text{Rn}$  renksiz, kokusuz ve tatsız olduğundan özel ekipman olmadan tespit edilmesi imkansızdır ve bu özellikleri nedeniyle halk tarafından sağlık riski algılanamayabilir. Radonun olumsuz sağlık etkilerinin önlenmesi için bireysel risk algısının araştırılması önemlidir. Radyoterapi ve Tıbbi Görüntüleme Programlarında öğrenim gören öğrencilerin radon gazına ilişkin bilgi ve farkındalıklarının belirlenmesinin amaçlandığı bu çalışmada katılımcılara 15 sorudan oluşan anket uygulanmıştır. Elde edilen bulgulara göre, katılımcıların %54.2'si radonu duyduğunu, %51.1' i radonun zararlı olduğunu belirtmiştir. Bilgi kaynağı olarak okul yanıtını verenlerin oranı %33.3 olup bunların çoğu 2. Sınıf öğrencisidir. Konutlardaki radon sebeplerini bilmeyenlerin oranı %47'dir. Evlerde radon testi yapılması gerektiğini düşünenlerin oranı yüksek (%86.3) olmasına rağmen nasıl test edileceğini bilmeyenler fazla sayıdadır (%94). Çalışma, katılımcılar arasında radona ilişkin bilgi düzeyinin yeterince yüksek olmadığını göstermiştir. Radonun kanserojen etkisi göz önüne alındığında, toplum üyeleri için daha fazla farkındalık oluşturmaya ihtiyaç vardır.

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## 1. INTRODUCTION

Almost 50% of the natural radiation that is constantly present in our environment is caused by radon gas and its short-lived decay products. Radon is formed by the decay of the  $^{226}\text{Ra}$  (Radium) nucleus in the  $^{238}\text{U}$  (Uranium) radioactive series found in nature. Since uranium is found in all rocks and soils, radon gas is also present everywhere. Radon ( $^{222}\text{Rn}$ ) has a half-life of 3.82 days and is found at very low levels in open air. Since  $^{222}\text{Rn}$  is a gas, it can pass from rocks into both water and ambient air and become trapped inside homes and other closed spaces, reaching unsafe levels. Since  $^{222}\text{Rn}$  is colorless, odorless and tasteless, it is impossible to detect without special equipment (Polat and Sarıtaş., 2016). Exposure to radon can increase the risk of lung cancer, making it a significant public health problem. High levels of radon exposure are the second leading cause of lung cancer after smoking. Pooled studies in the United States, Europe, and China have identified radon as an independent risk factor for lung cancer, regardless of smoking status (Neri et al., 2018). The decay products of radon,  $^{218}\text{Po}$  (Polonium) and  $^{214}\text{Po}$ , emit alpha particles that disrupt cellular DNA and can lead to the development of lung cancer. The International Commission on Radiation Protection (ICRP) has set a reference level for indoor radon ranging from 100-300  $\text{Bqm}^{-3}$  (Cronin et al., 2020). The World Health Organization (WHO) estimates that radon exposure causes 3-14% of lung cancer deaths worldwide, and the limit value for indoor radon is 100  $\text{Bqm}^{-3}$  (Pacella et al., 2023). The United States Environmental Protection Agency (EPA) has recommended that homeowners with indoor radon levels above 4pCi/L take mitigation measures. Radon reduction is a preventive health behavior (Esan et al., 2020); Kennedy et al., 1991). In 1988, the International Agency for Research on Cancer (IARC) stated that radon and its decay products are classified as Group 1 carcinogens. Radon is not widely known and due to its specific properties, the health risk is perceived by the public as uncertain and is easily underestimated. The health risk from radon is cumulative and the risk of developing lung cancer can be mitigated by reducing exposure (Cori et al., 2022).

In order to prevent the effects of radon on health, it is of great importance to investigate individual risk perception. In this respect, determining and developing the awareness levels of individuals towards radon, which can also occur as a result of the geological structure of the city they live in, ensures the formation of positive attitudes and behaviors towards the environment. Individuals who are aware of the risks are better equipped to protect themselves and others from harm. Literature information reveals that although many people have “heard” of radon, many segments of society, especially those under the age of thirty and less educated, do not know what radon is (Vogeltanz-Holm and Schwartz., 2018).

This research is a cognitive study aimed at determining the knowledge and awareness of radon gas among university students who are candidates to work in radiation fields. Another aim is to determine the gains of the participants in radiation-related courses they have taken during their university education and to reveal their contribution to the level of awareness.

## 2. MATERIAL AND METHODS

### 2.1. Type of Research

The research is a descriptive type of study.

### 2.2. Place and Time of Study

The survey form prepared in line with the purpose of the study was conducted between April and May 2024 with 1st and 2nd year students studying in the Radiotherapy and Medical Imaging departments of Van Yuzuncu Yil University Health Services Vocational School using the face-to-face interview technique.

### 2.3. Universe and Sample of the Study

A sample was not taken from the population, and a total of 168 volunteer students studying in the Radiotherapy and Medical Imaging departments who agreed to participate in the study were included.

### 2.4. Data Collection Tools

Those who agreed to participate in the study were informed about the study and a 15-question survey form was filled out face to face. 5 of the questions included socio-demographic characteristics and 10 included radon information. The prepared questionnaire included questions about age, gender, class, department, high school graduation and radon awareness level.

### 2.5. Statical Analysis

While some descriptive statistics are given for the continuous variable of age, frequency distributions are given for categorical variables. Chi-square test was used to determine the relationship between categorical variables. SPSS statistical software version 19.0 (SPSS Inc, Chicago, III, USA) package and excel program were used in the calculations.

### 2.6. Etichal Aspects of Research

In order to conduct the research, the necessary permissions were obtained from the Van Yuzuncu Yil University Non-Interventional Clinical Research Ethics Committee (Decision no: 2024/03-05, Date: 08.03.2024) and the School Directorate. In addition, informed consent was obtained from the participants before starting the study.

## 3. RESULTS AND DISCUSSION

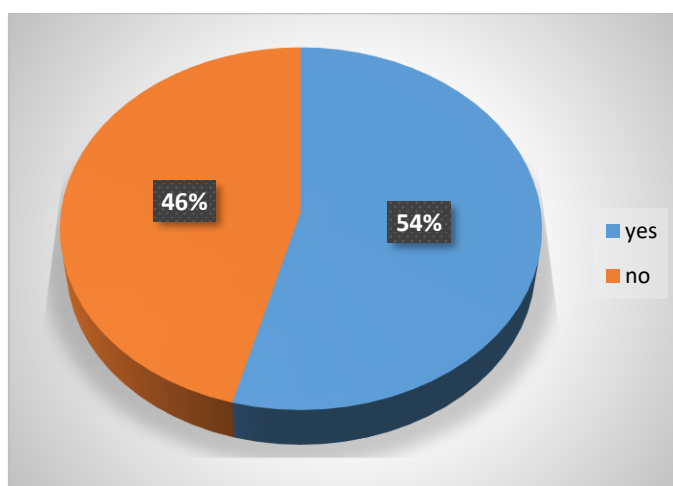
Since the age variable among socio-demographic characteristics is continuous, some descriptive statistics of this variable are presented in Table 1. When Table 1 is examined, it is seen that the ages of the participants ranged from 18 to 37 and the average age was approximately 21. In addition, the standard error for age was found to be 0.1583 and the standard deviation was 2.0517. The socio-demographic characteristics of the participants and their responses to the survey questions are given in Table 2.

**Table 1.** Descriptive statistics for the age variable.

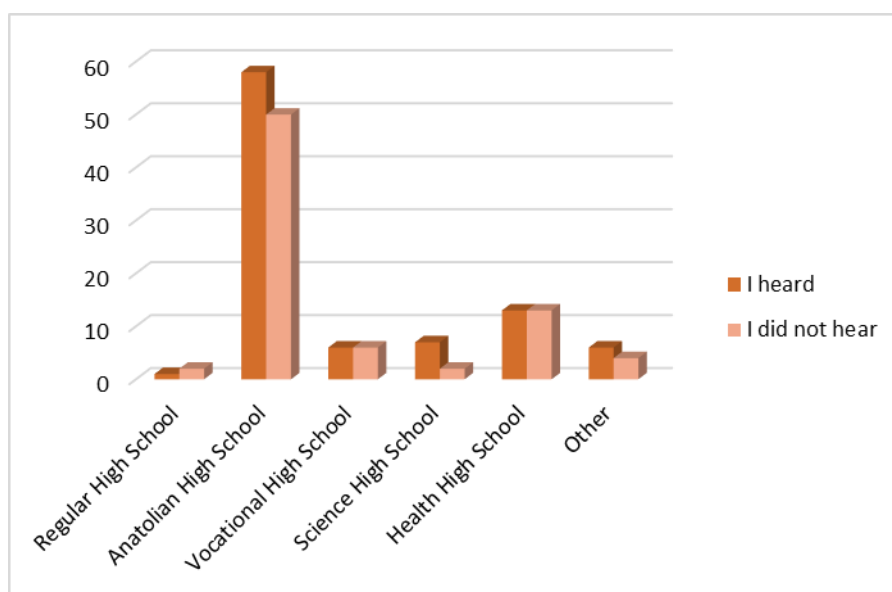
	<b>N</b>	<b>Range</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Mean</b>	<b>Std. Error</b>	<b>Std. Deviation</b>
Age	168	19.00	18.00	37.00	21.0060	0.1583	2.0517

**Table 2.** Socio-demographic characteristics and radon awareness of the participants.

		<b>Number</b>	<b>%</b>
Sex	Woman	118	70.2
	Man	50	29.8
Department	Radiotherapy	76	45.2
	Radiology	92	54.8
Class	1 <sup>st</sup> Grade	89	53
	2 <sup>nd</sup> Grade	79	47
	Regular High School	3	1.8
	Anatolian High School	108	64.3
Graduated from high school	Vocational High School	12	7.1
	Science High School	9	5.4
	Health High School	26	15.5
	Other	10	6
Have you heard of radon, a naturally occurring radioactive gas?	Yes	93	55.4
	No	75	44.6
If your answer to the previous question is yes, from which source did you get the information about radon gas?	TV	6	5.3
	Internet	37	32.7
	Family Members	1	0.9
	School	56	49.6
Is radon gas harmful?	Friends, Neighbours	2	1.8
	Other	11	9.7
	I don't know	80	47.6
	Yes	86	51.2
Do you think radon is carcinogenic?	No	2	1.2
	I don't know	74	44
	Yes	85	50.6
	No	9	5.4
Is there a history of lung cancer in your family?	I don't know	8	4.8
	Yes	16	9.5
	No	144	85.7
	Building materials	33	19.6
What are the causes of radon in homes?	Water	7	4.2
	Heating Systems	14	8.3
	Outdoors	6	3.6
	All	29	17.3
Should radon measurements be made in homes?	I don't know	79	47
	I don't know	12	7.1
	Yes	145	86.3
	No	11	6.5
Has the air in your home been tested for the presence of radon gas?	I don't know	31	18.5
	Yes	2	1.2
	No	135	80.4
Do you know how to test your home for the presence of radon gas?	I don't know	89	53
	Yes	10	6
	No	69	41
Do you or anyone in your household plan to have the air in your home tested for radon within the next year?	I don't know	85	50.6
	Yes	14	8.3
	No	69	41.1



**Figure 1.** Do you know about radon?



**Figure 2.** Distribution of radon knowledge level according to high school graduation.

70.2% of the students were female and 29.8% were male. 45.2% of the participants were studying in the Radiotherapy Program and 54.8% in the Medical Imaging (Radiology) Program. Most of the students (64.3%) graduated from Anatolian high schools. When asked if they had ever heard of radon, 54.2% of the students answered yes, and most of those who knew were Anatolian high school graduates (Figure 1 and Figure 2). No statistically significant difference was found between the participants' knowledge level and the high school they graduated from.

Have you heard of radon, a naturally occurring radioactive gas? 93 people who answered yes to the question were asked what their sensory sources were. Answers; When the participants' sources of information were questioned, it was determined that 49.6% responded "school", 32.7% "internet", 5.3% "television", 1.8% "friends and neighbors", 0.9% "family members" and 9.7% "other". The distribution of sources of information by grade is given in Figure 3. Accordingly, most of those who answered school were 2nd grade students. While 51.2% of the participants thought radon was harmful, 47.6% did not know whether radon was harmful

or not. Similarly, the rate of those who stated that radon had a carcinogenic effect was 50.6%, while the rate of those who did not know was 44%. When the participants were asked about their family history of lung cancer, the rate of those who said yes was 9.5%, while the rate of those who said no was 85.7%.

The answers to the question "What are the causes of radon in homes?" are given in Figure 4. As can be seen from Table 2 and Figure 4, the rate of those who do not know the causes of radon in homes is higher than the other options (47%). The rate of those who think that radon testing should be done in homes is 86.3%, while the rate of those who do not know and no how to test is 94%. Very few of the participants (1.2%) have had radon measurements done in their homes, and the rate of those who plan to have it done in the future is also low (8.3%).

It was found that the number of people who heard radon was higher in the Radiotherapy program, while the number of people who did not hear it was higher in the Medical Imaging program (Figure 5).

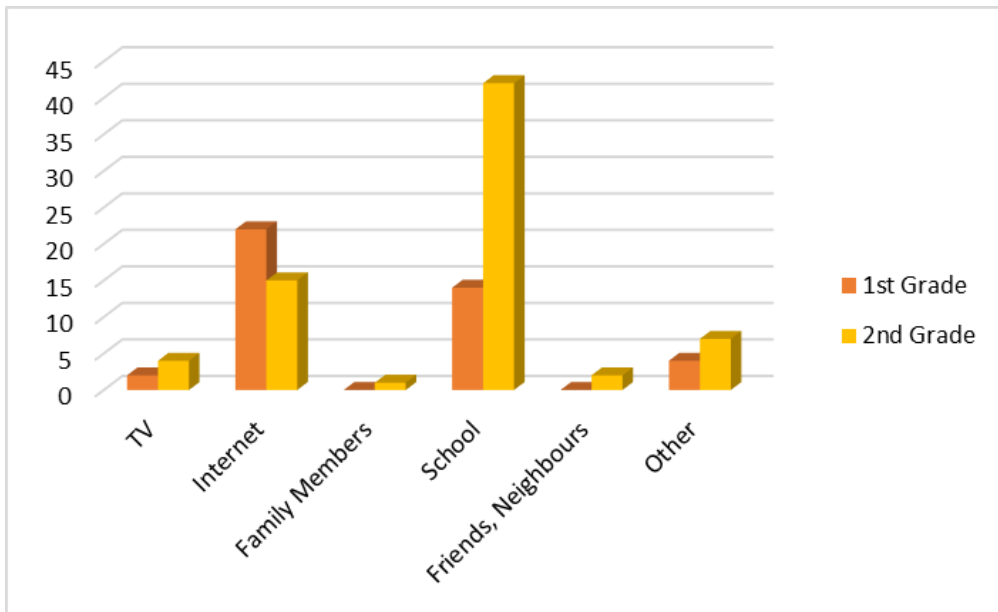


Figure 3. Distribution of radon information sources by class.

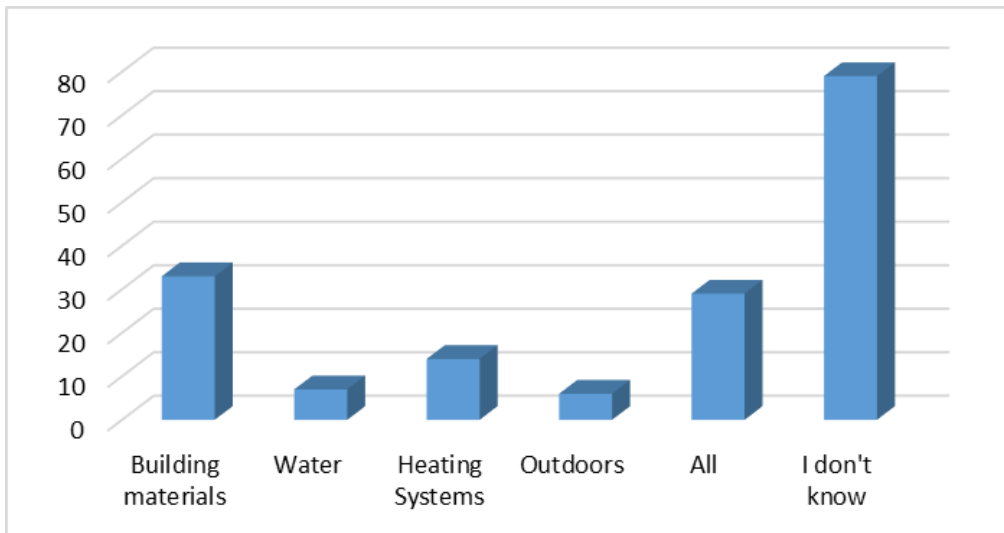


Figure 4. Causes of radon in residences.

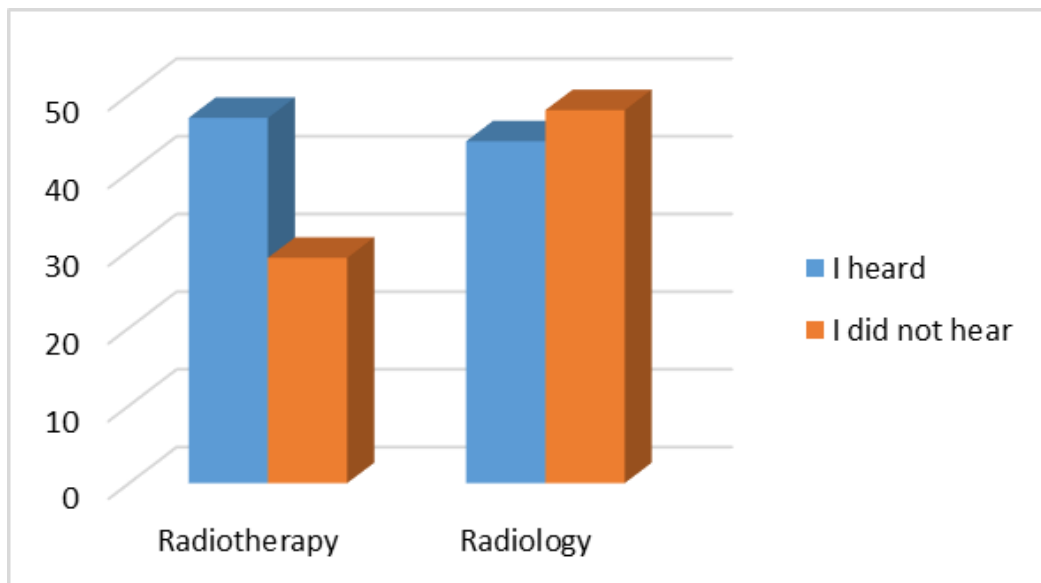


Figure 5. Distribution of radon awareness by departments

**Table 3.** Comparison results between lung cancer history and radon being carcinogenic.

		Family history of lung cancer			p
		I don't know	Yes	No	
Is radon carcinogenic?	I don't know	5 62.5%	3 18.8%	66 45.8%	0.871
	Yes	3 37.5%	13 81.3%	69 47.9%	
	No	0 0.0%	0 0.0%	9 6.3%	

The relationship between the answers to the question “Is radon carcinogenic?” and “Is there a family history of lung cancer?” is given in Table 3. According to the table, although this relationship is not statistically significant, 81.3% of those with a positive family history of lung cancer know that radon is carcinogenic.

There is radon exposure in all closed areas (housing, school, subway station, shopping mall, mines). In this study examining the level of awareness regarding radon, more than half of the students stated that they had heard of radon. Those who know about radon are mostly Anatolian high school graduates. In high school education in Turkey, radon information is given under various titles in courses such as physics, chemistry, biology, and geography. Especially in chemistry courses, it is expressed as “radon gas” as a noble gas. However, in addition to this information, radon gas is a source of environmental pollution. In a study investigating radon awareness among high school students, it was found that the vast majority of students had never heard of radon and that there was no significant difference between those who knew about radon and the type of school (Polat and Sarıtaş, 2016). In the current study, no correlation was found between the type of school and radon information.

The average age of the participants was 21, and most of them were female. No correlation was found between the level of radon knowledge and gender and age. Most of the participants stated that they received their radon knowledge from school. Radiotherapy students had more knowledge about radon compared to Medical Imaging. This may be because radioactivity is explained more in the Radiotherapy department. Students in both departments take both theoretical and practical radiation-related courses, and radon gas is explained in theoretical courses. It is expected that most of the participants who had knowledge were sophomores. Since the current study was conducted in April-May, sophomores are in a period close to graduation. Cronin et al. (2020) reported that the most frequently reported source of information among those who stated that they had heard of radon was TV commercials (31%). 51.2% of the students know that radon is harmful and 50.6% know that radon is carcinogenic. Radon and its decay products can remain in the lungs when inhaled, undergo radioactive decay, and emit alpha particles, causing lung damage (lung cancer in cumulative dose exposure) (Appleton, 2012; Kang et al., 2019). Since it was thought that the participants may have heard of radon gas during their research on the causes of lung cancer, they were asked whether they had a family history of lung cancer. Radon gas is known to be the primary cause of lung cancer in non-smokers and the secondary cause in

smokers. In addition, indoor radon exposure and cigarette consumption have a synergistic effect on the formation of lung cancer. Lung cancer, an aggressive cancer, is the most common cause of cancer-related deaths worldwide (Park et al., 2020). In Turkey, among all cancer cases, lung cancer ranks first in men (55.5%) and fifth in women (10.9%) (General Directorate of Public Health, 2023). In the current study, although 81.3% of the participants with a positive family history of lung cancer knew that radon was carcinogenic, no statistical significance was found. According to the results of a survey conducted among faculty members working at Obafemi Awolowo University in Nigeria, radon awareness was low (Esan et al., 2020).

Radon can enter buildings through cracks in the building structure after being released from rocks into the soil and water. For this reason, building materials, natural gas, external atmosphere, consumed water can leak into the building due to the difference in internal and external pressure in houses and cause radon pollution in the house (Skeppström and Olofsson, 2007). The rate of participants who do not know the cause of radon in houses was found to be higher than other options. Considering that radon is an indoor air pollutant, a high level of awareness about radon leads individuals to correct attitudes and behaviors over time. For example, knowing indoor radon sources can lead a person to learn reduction strategies. Studies show that a high level of awareness strengthens the attitude-behavior relationship (Polat and Sarıtaş, 2016).

Although the proportion of participants who think that radon testing should be done in their homes is high, most do not know how to do it and very few people plan to do it in the future. Radon testing and reduction are among the preventive health behaviors (Kennedy et al., 1991). Laflamme and Van Derslice (2004) reported that less than one-third of the participants in their study knew how to test for radon and the proportion of households planning to test for radon gas was also low. Some states in the United States have existing radon notification policies that require buyers, sellers and real estate agents involved in the purchase of single-family homes to receive an informative brochure about radon (Neri et al., 2018). Since radon is odorless, colorless and tasteless, the only way to know if the levels are safe is to test the air quality using commercially available test kits or to work with a radon testing professional (Cronin et al., 2020). The level of awareness of the indoor radon hazard in Turkey is low. If the public's perception of radon risk is low, there will be no motivation to keep exposure levels low through individual actions such as home testing and remediation measures. Digital radon detectors that provide short- and long-term radon measurements in real time (i.e., do not require sending

a test kit to a laboratory and waiting for results) are available at prices that are affordable to most homeowners (Mainous and Hagen, 1993).

#### 4. CONCLUSION

The study showed that the level of knowledge about radon among the participants was not high enough. Increasing the level of knowledge about radon, which is an important risk factor for lung cancer, especially among non-smokers, may lead to increased radon testing, mitigation of radon and ultimately a decrease in lung cancer deaths.

Some strategies to improve risk awareness and management include: Providing education and training to individuals can help them prepare for the risks they face. Effective communication can raise public awareness of how to reduce potential risks and respond in an emergency. Public institutions can help the public develop appropriate strategies to manage radon-related risks. Even collaboration between individuals, government agencies, and civil society can help improve risk management. Therefore, there is a need to raise awareness among community members through media, public lectures, and mass campaigns to help them make informed decisions about indoor radon exposure and to encourage them to have their homes tested for radon. Additionally, installing radon detectors in homes that produce visible or audible alarms to signal high radon levels can support remediation.

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