Evaluation of Awareness and Knowledge Levels of Undergraduate (UGS) Dental Students About Radon

Diş Hekimliği Lisans Öğrencilerinin Radon Hakkındaki Farkındalık ve Bilgi Düzeylerinin Değerlendirilmesi

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ABSTRACT

INTRODUCTION: Radon gas, a significant natural source of ionizing radiation, is the leading cause of lung cancer in non-smokers. This highlights the need for radon protection measures and awareness among healthcare professionals. This study aimed to compare the awareness and knowledge levels of dental students at different stages of their undergraduate education regarding radon's health hazards.

MATERIAL and METHODS: 2nd- and 3rd-year dental students participated in the study. A 21-question survey assessed demographic data, general knowledge of radon, its health effects, and awareness and attitudes toward radon exposure. Data analysis was conducted using descriptive statistics, t-tests, and chi-square tests ($p<0.05$).

RESULTS: The two groups were homogeneously distributed. A significant difference in correct response rates was observed between the groups ($p<0.05$). 3rd-year students, who had received radon education, had a 55% correct response rate, compared to 11% among 2nd-year students, who had not yet received education ($p<0.05$). No significant gender-based difference was found in correct response rates ($p>0.05$).

CONCLUSION: Third-year students demonstrated higher radon knowledge and awareness levels than second-year students. Expanding radon education across all levels of dental programs through curriculum enhancements could improve awareness among future healthcare professionals.

Keywords: *Knowledge, Awareness, Radon, Radiation, Questionaire*

ÖZ

GİRİŞ: Doğal iyonizan radyasyon kaynaklarının en önemlisi olan radon gazı sigara içmeyen bireylerde akciğer kanserinin birincil etkeni olarak bilinmekte ve sağlık çalışanlarının radon hakkındaki farkındalıkları önem kazanmaktadır. Çalışmamızın amacı, diş hekimliği lisans eğitiminin farklı seviyelerindeki öğrencilerin radonun sağlık tehlikelerine ilişkin farkındalıklarını ve bilgi düzeylerini karşılaştırmalı olarak değerlendirmektir.

YÖNTEM ve GEREÇLER: Araştırmamızda, fakültemizde eğitim gören 2. sınıf ve 3. sınıf öğrencilerine hazırlanan anket formu uygulanarak demografik bilgiler, radona ilişkin genel bilgiler, sağlık üzerine olası etkileri ve radon maruziyeti hakkındaki farkındalık ve tutumlarının sorgulandığı 21 soru yöneltildi. Verilerin analizinde tanımlayıcı istatistikler, t testi ve ki-kare testi kullanılmıştır ($p<0,05$).

BULGULAR: 2 öğrenci grubunun homojen dağılım gösterdiği çalışmamızda; 2 grubun sorulara doğru yanıt verme oranları arasında istatistiksel olarak anlamlı bir fark bulundu ($p<0,05$). 3. sınıf öğrencilerinin doğru cevap oranının %55 olduğu, henüz radon eğitimi almamış 2. sınıf öğrencilerinin ise %11'lik oranla daha düşük başarı gösterdiği saptandı ($p<0.05$). Cinsiyetler arasında doğru yanıt oranı açısından istatistiksel olarak anlamlı bir fark bulunmadı ($p>0,05$).

SONUÇ: Diş hekimliği lisans programı kapsamında, temel radon eğitimi alan 3. sınıf öğrencileri ve henüz eğitim almamış 2. sınıf öğrencileri arasında bilgi düzeyleri ve farkındalık oranları açısından anlamlı fark saptanmıştır. Bu doğrultuda lisans eğitim programlarında yapılacak düzenlemeler sayesinde radon eğitimlerinin tüm öğrenim seviyelerini kapsayacak biçimde genişletilmesi, bireylerin farkındalıklarının artmasına katkı sağlayabilecektir.

Anahtar Kelimeler: *Bilgi, Farkındalık, Radon, Radyasyon, Anket çalışması*

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INTRODUCTION

From the past to present, radiation and its sources have been utilized in various aspects of daily life. Consequently, all living organisms on earth are continuously exposed to natural radiation originating from the air, water, and soil (external) and even in their own bodies (internal), as well as to the radiation of artificial radiation sources produced by humans every day.[1,2]

Radiation is divided into ionizing and non-ionizing radiation according to its interaction with matter.[1,2] Especially since ionizing radiation can have negative effects on human health, it is very important to examine the possible effects it may cause.[1,3] The main and the most important natural ionizing radiation source among natural radiation sources is radon gas.[3] Radon (222-Rn) is a byproduct of the radioactive decay chain of uranium (238-U) and radium (226-Ra) found in rocks, soil and water.[3-5] It is a colorless, odorless and tasteless gas classified as a noble gas in the periodic table.[3,6-8] It is estimated that radon gas provides up to 50% to 55% of the average annual dose from natural radiation sources.[4,9,10]

The general effects of radon on human health are caused by its radioactivity and the resulting risk of cancer development due to ionizing radiation.[3,4,8] The main factor causing health hazards from radon exposure is not the radon itself, but the radioactive decay products (218-Po and 214-Po) which are formed during its decay and can adhere to any surface.[3,5-8,11] The accumulation of these radioactive particles in the cells lining the airways every time inhaled can lead to DNA damage and, over time, lung cancer. [3,5-7] In 1988, the International Agency for Research on Cancer (IARC) classified radon gas and its decay products under the category of 'Group 1: Substances that are definitely carcinogenic to humans'.[3,12,13]

With the understanding of the adverse effects of radon gas on health, the number of studies on radon measurements for indoor environments such as residences and workplaces has increased day by day.[14] Many national and international studies have highlighted the association between indoor radon exposure and increased risk of lung cancer.[3,4,6,9,11,15,16] While radon gas is the most important primary cause of lung cancer in non-smokers, it ranks as the second most significant cause among smokers. [3,4,6,6,8,12,17] These striking findings increase the importance of informing the public about the health risks caused by radon gas and measures to protect against radon. The literature includes numerous studies investigating the level of awareness among individuals from diverse educational and social backgrounds regarding the health risks caused by radon gas. While some of these studies targeted the general population, others included healthcare workers who are expected to have a higher level of knowledge about the health hazards of radon.[4,5,7,9–11,13,15,17–26]

In a field such as dentistry, which is an integral part of the healthcare sector and involves frequent use of radiation sources, the knowledge and attitudes of undergraduate students regarding radiation hold significant importance. Dental students undergo undergraduate training on the use of radiation sources, and upon completing this educational process, they are expected to have a basic level of knowledge and awareness in terms of professional aspects and radiation protection practices.[27] However, there is no study in the literature investigating the level of knowledge of undergraduate dental students about radon and possible health hazards.

The aim of this study is to comparatively evaluate the awareness and knowledge levels of dental students at different levels of undergraduate dental education about the potential hazards of radon on general health.

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MATERIAL AND METHODS

Ethical Approval

This study was approved by Ege University Scientific Research and Publication Ethics Committee (EGEBAYEK, Approval No: 05/07-2456) and conducted in accordance with international ethical standards.

Study Group

The study included 2nd grade and 3rd grade students studying in the undergraduate program of Ege University Faculty of Dentistry. In this voluntary survey, students who refused to participate in the study were excluded. In determining the minimum sample size of the study, the sample size approach with an unknown population was used and as a result, the minimum sample size required for a certain level of statistical significance was determined as 200 participants.

Preparation of the Questionnaire Form

In order to prepare the questions, previous survey studies on similar topics in the literature were examined. [9,18, 28-31] A questionnaire form consisting of a total of 21 questions was created to measure the level of knowledge about radon gas, its properties and awareness of its potential risks on health. The form was completed by adapting some of the questions used in these studies and adding new questions to the study under the guidance of the reports/guidelines published in the literature about radon (Table 1).[3,12,32-38]

Table 1. Questionnaire form.

SECTION 1.	
1.Gender	Female ☐ Male ☐
2.Age	15-20 ☐ 21-25 ☐ 26-30 ☐ 30< ☐
3.Education level	2nd Grade ☐ 3rd Grade ☐
4.Smoking habit	Yes ☐ No ☐
SECTION 2.	
5. Have you ever heard of radon?	Yes ☐ No ☐
6. What is radon?	
Gas ☐ Solid ☐ Fluid ☐ Not sure ☐	
7. What are the characteristics of radon? (You can select multiple options.)	
Colorless ☐ Odorless ☐ Tasteless ☐ Not sure ☐	
8. What kind of material is radon?	
Natural ☐ Artificial ☐ Not sure ☐	
9. Is radon radioactive?	
Yes ☐ No ☐ Not sure ☐	
10. Where does radon come from? (You can select multiple options.)	
Air ☐	
Water ☐	
Soil/ Rock ☐	
Nuclear power plants ☐	
Food ☐	
Building materials ☐	
Not sure ☐	
11. In which environment is radon level higher?	
Indoor ☐ Outdoor ☐ Not sure ☐	
SECTION 3.	
12. Is radon harmful to human health?	Yes ☐ No ☐ Not sure ☐
13. Which health problems can radon cause? (You can select multiple options.)	
Lung cancer ☐	
Cardiovascular diseases ☐	
DNA damage ☐	
Dermatological diseases ☐	
Allergy ☐	
Neurological diseases ☐	
Other ☐	
Not sure ☐	
14. How does smoking change the effects of radon?	
Increases ☐ Decreases ☐ Does not effect ☐ Not sure ☐	
15. Can radon level be measured?	
Yes ☐ No ☐ Not sure ☐	
16. How do you think ventilation of indoor spaces in areas with high radon levels will affect radon exposure rates?	
Increases ☐ Decreases ☐ Does not effect ☐ Not sure ☐	
SECTION 4.	
17. If you have heard of radon before, what is your source? (You can select multiple options.)	
Internet ☐ School/Class ☐ TV ☐ Newspaper/Journal ☐ Radio ☐ Health Institution/Doctor ☐ Family/Friend ☐ Other ☐	
18. Do you have information about the precautions taken regarding Radon?	
Yes ☐ No ☐	
19. Do you think you have been exposed to radon?	
Yes ☐ No ☐ Not sure ☐	
20. Do you think the authorities are taking the necessary precautions regarding radon?	
Yes ☐ No ☐ Not sure ☐	
21. Are you worried about being exposed to radon?	
Yes ☐ No ☐ Not sure ☐	

In order to make a preliminary evaluation of the study, the questionnaire form was applied to 20 undergraduate dentistry students in the first stage and the final version of the form was formatted by rearranging it in line with the feedback received. The questionnaire form prepared after this process consisted of four sections in total. In the first section of the questionnaire, the demographic information of the participants as well as their smoking status (questions 1-4) were questioned. In the second section, after questioning whether the students had information about radon or not; there were a total of 7 questions (questions 5-11) aimed at determining the general level of knowledge about the basic characteristics of radon. In the third section, there were 5 questions (questions 12-16) measuring the level of knowledge about the possible effects of radon gas on health. In the last section of the questionnaire, a total of 5 more questions were involved to the questionnaire in order to examine the knowledge levels and attitudes of individuals towards radon gas exposure and measurements, as well as the sources of the participants' access to information about radon. Attention was paid to ensure that the questions aimed at measuring the knowledge level of the students included in the questionnaire (questions 17-21) had evidence-based correct answers (Table 1).

Data Collection

Prior to the study, three researchers (EŞ, İFK, BŞ) informed the students attending the 2nd grade and 3rd grade undergraduate programs of Ege University Faculty of Dentistry about the main purpose of the study and obtained their consent to participate. The students were reached in the classrooms where they received their education within the faculty, and the questionnaire forms were filled in face-to-face with the participants.

Statistical analyses

All statistical analyses of the data obtained from the questionnaire study were performed using IBM SPSS Statistics 20 software (SPSS Inc., Chicago, IL, USA).

The demographic data of the participants in the first section of the questionnaire form were analyzed using descriptive statistical methods. The t-test was used in the comparative analysis of the correct answer rates given to the questions measuring the knowledge levels of the participants (questions 6-16) in terms of the variables of the study (gender, education level, age, smoking). The Chi-squared test was used to calculate the distribution of the answers obtained from each question separately in terms of other survey questions. Statistical significance level was accepted as $p<0.05$.

RESULTS

A total of 332 (100%) dental students (185 female (55.7%) and 147 (44.3%) male) participated in this study. When the age distribution of the participants was analyzed, it was observed that the majority of the participants (98%) were between the ages of 18-25. Among the surveyed students, 149 (44.9%) were 2nd year students and 183 (55.1%) were 3rd grade students. It was found that 119 (35.8%) of the total students were smokers and 213 (64.2%) were non-smokers. Demographic data (gender, age, smoking, education level) of the participants are given in Table 2.

Table 2. Demographic characteristics of the participants.

Demographic Characteristics		n	%
Gender	**Female**	185	55,7
	Male	147	44,3
Age	**15-20**	109	32,8
	21-25	221	66,6
	26-30	1	0,3
	30<	1	0,3
Education Level	**2nd grade**	149	44,9
	3rd grade	183	55,1
Smoking Habit	**Yes**	119	35,8
	No	213	64,2
TOTAL		**332**	**100**

When a total of 3,652 answers given by the 332 dental students participating in the study to the questions with evidence-based definite correct answers (questions 6-16) were analyzed, it was determined that 1,385 (38%) of these answers were correct. When the rates of correct answers to the questions measuring knowledge levels were analyzed in terms of age and smoking parameters (Table 3) included in the study, no statistically significant difference was observed for both parameters ($p>0.05$). When the correct response rates to the questions measuring knowledge level were compared in terms of gender, it was observed that women (37%) were slightly more successful than men (33%), but no statistically significant difference was found between gender and correct response rates ($p>0.05$) (Table 4).

Table 3. Total numbers and percentages of correct answers given by participants to survey questions according to their smoking habits.

Question	Correct Answer		
	Yes	No	
	n (%)	n (%)	p value*
6. What is radon?	70(59)	108(51)	0,05<p
7. What are the characteristics of radon? (You can select multiple options.)	30(25)	73(34)	0,05<p
8. What kind of material is radon?	34(29)	62(29)	0,05<p
9. Is radon radioactive?	56(47)	95(45)	0,05<p
10. Where does radon come from? (You can select multiple options.)	23(19)	51(24)	0,05<p
11. In which environment is radon level higher?	41(34)	81(38)	0,05<p
12. Is radon harmful to human health?	70(59)	105(49)	0,05<p
13. Which health problems can radon cause? (You can select multiple options.)	26(22)	53(25)	0,05<p
14. How does smoking change the effects of radon?	53(45)	76(36)	0,05<p
15. Can radon level be measured?	59(50)	101(47)	0,05<p
16. How do you think ventilation of indoor spaces in areas with high radon levels will affect radon exposure rates?	45(38)	73(34)	0,05<p
TOTAL	119(100)	213(100)	

T-test*

Table 4. Total numbers and percentages of correct answers given by participants to survey questions by gender.

Question	Correct Answer		
	Female	Male	
	n (%)	n (%)	p value*
6. What is radon?	105(57)	73(50)	0,05<p
7. What are the characteristics of radon? (You can select multiple options.)	65(35)	38(26)	0,05<p
8. What kind of material is radon?	50(27)	46(31)	0,05<p
9. Is radon radioactive?	91(49)	60(41)	0,05<p
10. Where does radon come from? (You can select multiple options.)	53(29)	21(14)	0,05<p
11. In which environment is radon level higher?	70(38)	52(35)	0,05<p
12. Is radon harmful to human health?	103(56)	72(49)	0,05<p
13. Which health problems can radon cause? (You can select multiple options.)	44(24)	35(24)	0,05<p
14. How does smoking change the effects of radon?	72(39)	57(39)	0,05<p
15. Can radon level be measured?	92(50)	68(46)	0,05<p
16. How do you think ventilation of indoor spaces in areas with high radon levels will affect radon exposure rates?	69(37)	49(33)	0,05<p
TOTAL	185(100)	147(100)	

T-test*

Table 5. Total numbers and percentages of correct answers given to the survey questions by all participants and their education level.

Question	Correct Answer			p value*
	2nd grade	3rd grade	Total	
	n (%)	n (%)	n (%)	
6. What is radon?	23(15)	155(85)	178(54)	p<0,05
7. What are the characteristics of radon? (You can select multiple options.)	7(5)	96(52)	103(31)	p<0,05
8. What kind of material is radon?	12(8)	84(46)	96(29)	p<0,05
9. Is radon radioactive?	21(14)	130(71)	151(45)	p<0,05
10. Where does radon come from? (You can select multiple options.)	4(3)	70(38)	74(22)	p<0,05
11. In which environment is radon level higher?	21(14)	101(55)	122(37)	p<0,05
12. Is radon harmful to human health?	30(20)	145(79)	175(53)	p<0,05
13. Which health problems can radon cause? (You can select multiple options.)	5(3)	74(40)	79(24)	p<0,05
14. How does smoking change the effects of radon?	26(17)	103(56)	129(39)	p<0,05
15. Can radon level be measured?	30(20)	130(71)	160(48)	p<0,05
16. How do you think ventilation of indoor spaces in areas with high radon levels will affect radon exposure rates?	21(14)	97(53)	118(36)	p<0,05
TOTAL	**149(100)**	**183(100)**	**332(100)**	

T-test*

When the rates of correct answers to the questions measuring knowledge level at different educational levels were evaluated comparatively, it was found that the correct answer rate of 3rd grade students was statistically significantly higher than 2nd grade students ($p = 0.01$) (Table 5). Among all participants, 9 students (3%) who answered all the questions correctly were all 3rd grade students. It was also determined that 67% of these 9 students were female and 22% of them were smokers. It was seen that the question with the highest percentage of correct answers was question 6, "What is radon?" with 54%, and the question with the lowest percentage of correct answers was question 10, "Where does radon come from?" with 22% (Table 5).

The distribution of responses to the questions in the final section of the questionnaire, designed to assess participants' knowledge levels and attitudes regarding radon gas exposure and the associated preventive measures, is presented in Table 6. When the answers given to the questions in this section were evaluated comparatively according to different education levels; it was found that the answers given by the two study groups were similar. Regardless of the level of education, it was observed that the majority of the participants did not have information about the measurements about radon and were undecided about radon exposure and the measurements taken by the authorities regarding radon (Table 6). When the findings on the sources of access to information about radon were analyzed, it was determined that while 2nd grade students showed the internet (68%) as the primary source of information, 133 (59%) of 3rd grade students accessed information about radon through school/class (Figure 1).

Table 6. Total numbers and percentages of participants' answers to questions about radon exposure according to their level of education.

Question		2nd grade	3rd grade
		n (%)	n (%)
18. Do you have information about the precautions taken regarding Radon?	**Yes**	6(4)	38(21)
	No	143(96)	145(79)
19. Do you think you have been exposed to radon?	**Yes**	20(13)	94(51)
	No	8(5)	14(8)
	Not sure	121(81)	75(41)
20. Do you think the authorities are taking the necessary precautions regarding radon?	**Yes**	2(1)	15(8)
	No	27(18)	79(43)
	Not sure	120(81)	89(49)
21. Are you worried about being exposed to radon?	**Yes**	25(17)	91(50)
	No	13(9)	30(16)
	Not sure	111(74)	62(34)

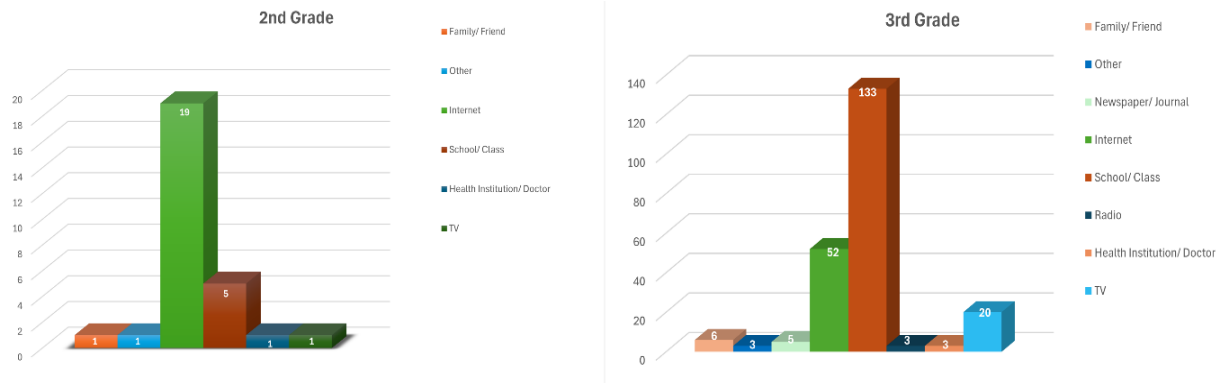


Figure 1. Distrubution of information sources about radon.

DISCUSSION

The use of radiation and its sources in dentistry and medical applications, particularly in the field of radiology, has become a routine aspect of daily practice. For this reason, it is critically important that healthcare workers, who are at high risk in terms of radiation exposure, have knowledge and awareness about radiation, its sources and protection methods. Radon gas, which has an important place among natural radiation sources, constitutes approximately 50%-55% of the average annual dose from natural radiation sources. Therefore, adverse effects of radon on human health are becoming more and more important day by day.[3,20,35,39]

In our study, aimed to comparatively evaluate the level of radon knowledge among dental students at various stages of undergraduate education, it was found that 98% of the participants were aged between 18 and 25 years. A review of similar studies assessing radon knowledge levels reveals a lack of consensus in the literature on this aspect. In some studies, it has been reported that the level of knowledge about radon increases with age, while in some other studies, the level of knowledge decreases as the participants get older.[40-42] In our study, no statistically significant difference was observed with respect to age ($p > 0.05$). We believe that the possible reason of this finding may be the homogeneity of the sample group, which comprised students of similar ages enrolled in the same undergraduate program.

A review of previous studies on radon knowledge levels reveals that, similar to the age parameter, there was also no consensus regarding the demographic factor of gender.[13,40,41] In the survey study conducted by Halpern et al., which targeted the general population, it was observed that the knowledge level of female participants was lower compared to male participants.[40] In more recent similar studies, the knowledge level about radon among the public were found to be higher in male individuals.[13,41] In our survey, in which the gender distribution of the participants was quite close to each other (56% female, 44% male), no statistically significant difference was observed between gender and radon knowledge levels. However, it was observed that the rate of correct answers of female participants (37%) was slightly higher than male participants (33%). When examining the findings regarding another parameter included in our study, "smoking status," no significant difference was found in radon knowledge levels between students who smoked and those who did not ($p > 0.05$). The differences in the number and profile of participants and educational levels in similar studies conducted on this subject prevented the formation of a common opinion in the literature and made us unable to compare some of our findings with the aforementioned studies.

In this study, although no significant difference was found between age and gender parameters and radon knowledge level, a significant difference was observed between "education level" and knowledge level about radon ($p<0.05$). In undergraduate dental education, basic education on radiation sources is given at the 3rd grade level. Our findings show that the knowledge level of 2nd grade dentistry students who have not yet been trained in this subject within their curriculum is lower than 3rd grade students who have received basic training on radiation sources. When examining similar studies where both the participant groups and the number of participants vary, it is evident that education level is positively correlated with radon knowledge levels.[9,40,42,43] This finding is further supported by studies involving healthcare professionals and students in healthcare-related fields, where the use of radiation sources is prevalent, demonstrating a similar positive correlation between education level and radon knowledge.[7,10,17,44] The findings of our study consistent with the existing literature. However, unlike other studies assessing radon knowledge levels, where participant groups and numbers exhibit significant variability, the relatively balanced and homogeneous distribution of participant groups in our study has facilitated a more robust and accurate analysis of the obtained results.

In our study, questions measuring the level of knowledge of dental students on two different basic

subjects, which are “general characteristics of radon” and “possible effects of radon on health and radon measurement”, were included. In the second section of the questionnaire, which focused on the "general characteristics of radon," the question "What is radon?" emerged as the most correctly answered question. However, a remarkable finding at this stage was that as the questions in this section became more detailed, the accuracy rates decreased. This trend was observed across both study groups with differing education levels included to the present study. In the third section of the questionnaire, the effects of radon on health were examined. Analyzing responses to the first question in this section, "Is radon harmful to human health?", 20% of 2nd-year students and 79% of 3rd-year students answered "yes." This finding suggests that education at the undergraduate level enhances knowledge about radon. However, similar to the finding obtained for the second part of the questionnaire, it was observed that the correct response rates decreased for both 2nd graders (3%) and 3rd graders (40%) as the questions about the level of knowledge were more detailed by asking which health problems radon causes. This remarkable finding is consistent with similar studies in the literature. Rafique et al. found that 80% of healthcare workers had heard of radon before, while only 30% had knowledge about radon and its hazards.[10] This finding observed in both studies raises concerns about the level of awareness of radon and its hazards in the healthcare field, where knowledge and attitudes about radon are very important, as in dentistry.

The final section of the questionnaire focused on participants' sources of information about radon, as well as their knowledge and attitudes toward radon gas exposure. When asked about their sources of information on radon and its effects, notable differences were observed between the two study groups. While the majority of 2nd-year students (68%) selected "Internet," over half of 3rd-year students (59%) chose "School/ Class." Among 3rd-year students—who had received basic education on radon—"Internet" was the second most common response after "School/Class". When the findings of similar studies conducted with the general population are reviewed, it was found that the highest rate of response to this question differed.[13,15] However, a distinguishing factor in these studies is the older average age of participants compared to our study. Another notable observation is that, consistent with our findings, younger individuals in these studies were more likely to select "Social Media/Internet" as a primary source of information, with this trend being evident across both genders.[13] The fact that younger individuals use the internet/social media more could be the possible reason for the answer given in favor of the “Internet” option as the age decreases both in our study and in similar studies in the past.

The sources from which the participants received information about radon and their awareness and attitudes towards radon gas exposure were another parameter questioned in our study. In this regard, only 13% of the 2nd grade students answered “Yes” to the question “Do you think you have been exposed to radon?”, while this rate was 51% among the 3rd grade students. It is noteworthy that the answers given by two different study groups to another question asked in the last section of the questionnaire as “Are you worried about being exposed to radon?” are similar. 17% of 2nd grade students and 50% of 3rd grade students stated that they were concerned about radon exposure. The fact that 3rd grade students have a higher rate of concern about radon exposure compared to 2nd grade students coincides with their higher level of knowledge about radon. However, it is noteworthy that only 51% of 3rd grade students think that they have been exposed to radon despite having received radon education. This finding raises doubts about the adequacy of the education on radiation sources and radon, although it has increased the knowledge level of the 3rd graders.

In the literature, there are many studies evaluating the level of knowledge and awareness of radon and its potential effects.[7,9,12,12,18,23,26,29,45,46] These studies mostly included individuals from different educational and social levels of the population. In the limited number of studies conducted on healthcare professionals, it is noteworthy that most of them belong to different groups such as nurses/physicians and healthcare staff.[7,10,17,44] Similar to our study, only two studies in the literature specifically evaluate the impact of radon gas on students pursuing education in healthcare-related fields.[7,10] However, no prior research has been identified that specifically targets dental students in undergraduate programs. In this regard, our study is the first to assess the knowledge levels of dental students about radon and its potential health hazards within the scope of a dental undergraduate curriculum.

CONCLUSION

In this study, we investigated the level of knowledge of dental students at different levels of undergraduate dental education about radon and its potential health hazards. As a consequence, a significant difference was found between 3rd year students who received basic education about radon and 2nd year students who had not yet received any education in terms of knowledge levels and awareness rates. However, the low overall accuracy rate (38%) in responses to the knowledge-based questions among all participants highlights the insufficient level of knowledge about radon, even among those who had received basic education. In light of these findings, incorporating curriculum revisions within dental undergraduate programs to expand radon-related education may contribute significantly to increasing

students' knowledge and awareness. Although our study is the first study to evaluate the knowledge levels about radon and possible health hazards in the dental field with all parameters, it includes only two different grades of students in the dentistry undergraduate program. Future studies with larger participant populations encompassing all levels of undergraduate education would provide a clearer understanding of the need for curriculum updates and allow for more accurate conclusions. This could ultimately facilitate more effective integration of radon-related education into dental training programs.

REFERENCES

1. Çoşkun Ö. İyonize Radyasyonun Biyolojik Etkileri. *SDÜ Tek Bil Der* 2011; 1(2): 13–17.
2. Gökoğlan E, Ekinci M, Özgenç E, İlem-Özdemir D, Aşıkoğlu M. Radyasyon ve İnsan Sağlığı Üzerindeki Etkileri. *Anadolu Kliniği Tıp Bilimleri Dergisi* 2020; 25(3): 289–294. doi: 10.21673/anadoluklin.709434
3. World Health Organization. WHO Handbook on Indoor Radon: a Public Health Perspective (WHO), Geneva, Switzerland, 2009. Available at: https://iris.who.int/bitstream/handle/10665/44149/9789241547673_eng.pdf?sequence=1. Accessed on 10 October 2024.
4. Alaamer AS. Radon Awareness among Saudi People in Riyadh, Saudi Arabia. *World J Nuclear Science and Technology* 2012; 2(4): 165–168. doi: http://dx.doi.org/10.4236/wjnst.2012.24025
5. Loffredo F, Savino F, Serra M, Tafuri D, Quarto M. Cognitive investigation on the knowledge of the risk deriving from radon exposure: Preliminary results. *Acta Medica Mediterranea* 2020; 2(36): 1265–1267. doi: 10.19193/0393-6384_2020_2_198
6. Garcia- Rodriguez JA. Radon gas—the hidden killer What is the role of family doctors? *Can Fam Physician* 2018; 64: 496–501.
7. Nwodo NK, Ezenma IC, Luntsi G, Abubakar MG, Nwodo MC, Uche CH, et al. Radon Gas Potential Hazards Awareness among Undergraduate Students and Staff of a College of Health Sciences in South-East, Nigeria. *Int J Radiol Imaging Technol* 2023; 11: 73-85. doi: 10.23937/2572-3235.1510106
8. Degu Belete G, Alemu Anteneh Y. General Overview of Radon Studies in Health Hazard Perspectives. *J Oncol.* 2021; 1: 6659795. doi: 10.1155/2021/6659795
9. Rahman S, Faheem M, Rehman S, Matiullah. Radon awareness survey in Pakistan. *Radiat Prot Dosimetry* 2006; 121(3): 333–336. doi:10.1093/rpd/ncl021
10. Rafique M, Jabeen S, Shahzad MI. General public's and physicians' perception of health risk associated with radon exposure in the state of Azad Jammu and Kashmir. *Public Health Nurs* 2008; 25(4): 327–335. doi: 10.1111/j.1525-1446.2008.00713.x
11. Coppola F, La Verde G, Loffredo F, Quarto M, Roca V, Pugliese M. Preliminary results of the risk perception of radon exposure. *Nuovo Cimento della Societa Italiana di Fisica* C 2018; 41(6): 221-226. doi: 10.1393/ncc/i2018-18221-6
12. Cori L, Curzio O, Donzelli G, Bustaffa E, Bianchi F. A Systematic Review of Radon Risk Perception, Awareness, and Knowledge: Risk Communication Options. *Sustainability.* 2022; 14(17): 10505. doi: 10.3390/su141710505
13. Cholowsky NL, Irvine JL, Simms JA, Pearson DD, Jacques WR, Peters CE, et al. The efficacy of public health information for encouraging radon gas awareness and testing varies by audience age, sex and profession. *Sci Rep* 2021; 11(1): 11906. doi: 10.1038/s41598-021-91479-7
14. Reste J, Pavlovska I, Martinsone Z, Romans A, Martinsone I, Vanadzins I. Indoor Air Radon Concentration in Premises of Public Companies and Workplaces in Latvia. *Int J Environ Res Public Health* 2022; 19(4): 1993. doi: 10.3390/ijerph19041993
15. Esan DT, Obed RI, Afolabi OT, Sridhar MK, Olubodun BB, Ramos C. Radon risk perception and barriers for residential radon testing in Southwestern Nigeria. *Public Health in Practice* 2020; 1: 100036. doi: 10.1016/j.puhip.2020.100036
16. Celebi N, Ataksor B, Taskin H, Albayrak Bingoldag N. Indoor radon measurements in Turkey dwellings. *Radiat Prot Dosimetry* 2015; 167(4): 626–632. doi: 10.1093/rpd/ncu329
17. Hazar N, Karbakhsh M, Yunesian M, Nedjat S, Naddafi K. Perceived risk of exposure to indoor residential radon and its relationship to willingness to test among health care providers in Tehran. *J Environ Health Sci Eng* 2014; 12(1): 118. doi: 10.1186/s40201-014-0118-2
18. Pacella D, Loffredo F, Quarto M. Knowledge, risk perception and awareness of radon risks: A Campania region survey. *J Radiat Res Appl Sci* 2023; 16(4): 100721. doi: 10.1016/j.jrras.2023.100721
19. Clifford S, Hevey D, Menezes G. An investigation into the knowledge and attitudes towards radon testing among residents in a high radon area. *J Radiol Prot* 2012; 32(4): 141-147. doi: 10.1088/0952-4746/32/4/N141
20. Khan SM, Gomes J, Chreim S. A Mixed Methods Population Health Approach to Explore Radon-Induced Lung Cancer Risk Perception in Canada. *Cancer Control* 2021; 28: 1-15. doi: 10.1177/10732748211039764
21. Cronin C, Trush M, Bellamy W, Russell J, Locke P. An examination of radon awareness, risk communication, and radon risk reduction in a Hispanic community. *Int J Radiat Biol* 2020; 96(6): 803–813. doi: 10.1080/09553002.2020.1730013

22. Hill WG, Butterfield P, Larsson LS. Rural parents' perceptions of risks associated with their children's exposure to radon. *Public Health Nurs* 2006; 23(5): 392–399. doi: 10.1111/j.1525-1446.2006.00578.x
23. Martin K, Ryan R, Delaney T, Kaminsky DA, Neary SJ, Witt EE, et al. Radon From the Ground into Our Schools: Parent and Guardian Awareness of Radon. *Sage Open* 2020; 10(1): 215824402091454. doi: 10.1177/2158244020914545
24. Neri A, McNaughton C, Momin B, Puckett M, Gallaway MS. Measuring public knowledge, attitudes, and behaviors related to radon to inform cancer control activities and practices. *Indoor Air* 2018; 28(4): 604–610. doi: 10.1111/ina.12468
25. Petrescu DC, Petrescu-Mag RM. Setting the scene for a healthier indoor living environment: Citizens' knowledge, awareness, and habits related to residential radon exposure in Romania. *Sustainability* 2017; 9(11): 2081. doi: 10.3390/su9112081
26. Poortinga W, Bronstering K, Lannon S. Awareness and perceptions of the risks of exposure to indoor radon: A population-based approach to evaluate a radon awareness and testing campaign in England and Wales. *Risk Analysis* 2011; 31(11): 1800–1812. doi: 10.1111/j.1539-6924.2011.01613.x
27. Yüksek Öğretim Kurumu (YÖK). Mezuniyet Öncesi Diş Hekimliği Ulusal Çekirdek Eğitim Programı 2024. Available at: https://www.yok.gov.tr/Documents/Kurumsal/egitim_ogretim_dairesi/Ulusal-cekirdek-egitimi-programlari/dis-hekimligi.pdf. Accesed on:15.11.2024.
28. Riesenfeld EP, Marcy TW, Reinier K, Mongeon JA, Trumbo CW, Wemple BE, et al. Radon Awareness And Mıtıgatıon In Vermont: A Publıc Health Survey. *Health Physics* 2007; 92: 425-431.
29. Wang Y, Ju C, Stark AD, Teresi N. Radon Awareness, Testıng, And Remedıatıon Survey Among New York State Resıdents. *Health Physics* 2000; 78: 641-647.
30. Djounova JN, Ivanova KG. Bulgarian public opinion survey for risk perception including radon and suggestions for communication. *J Radiat Res Appl Sci* 2023; 16(2): 100559. doi: 10.1016/j.jrras.2023.100559
31. Davies C, Grange S, Trevor MM. Radiation protection practices and related continuing professional education in dental radiography: A survey of practitioners in the North-east of England. *Radiography* 2005; 11(4): 255–261. doi: 10.1016/j.radi.2005.07.009
32. Khan SM, Gomes J, Krewski DR. Radon interventions around the globe: A systematic review. *Heliyon*. 2019; 5(5): e01737. doi: 10.1016/j.heliyon.2019.e01737
33. Cheng ES, Egger S, Hughes S, Weber M, Steinberg J, Rahman B, et al. Systematic review and meta-analysis of residential radon and lung cancer in never-smokers. European Respiratory Review. *European Respiratory Society* 2021; 159(30): 200230. doi: 10.1183/16000617.0230-2020
34. Nunes LJR, Curado A, da Graça LCC, Soares S, Lopes SI. Impacts of Indoor Radon on Health: A Comprehensive Review on Causes, Assessment and Remediation Strategies. *Int J of Environ Res Public Health*. 2022; 19(7): 3929. doi: 10.3390/ijerph19073929
35. Grzywa-Celińska A, Krusiński A, Mazur J, Szewczyk K, Kozak K. Radon—the element of risk. The impact of radon exposure on human health. *Toxics* 2020; 8(4): 1–20. doi: 10.3390/toxics8040120
36. Ćujić M, Ljiljana &, Mandić J, Petrović J, Dragović R, Đorđević M, et al. Radon-222: environmental behavior and impact to (human and non-human) biota. *Intl J Biometeorol.* 2021; 65: 69-83.
37. UK National Radon Action Plan. Public Health England. Available at: https://assets.publishing.service.gov.uk/media/5c1917e7ed915d0b753d1568/UK_National_Radon_Action_Plan.pdf. Accessed on 30 October 2024.
38. Mc Laughlin J. An historical overview of radon and its progeny: Applications and health effects. *Radiat Prot Dosimetry* 2012; 152: 2–8. doi: 10.1093/rpd/ncs189
39. Lantz PM, Mendez D, Philbert MA. Radon, smoking, and lung cancer: the need to refocus radon control policy. *Am J Public Health* 2013; 103(3): 443–447. doi: 10.2105/AJPH.2012.300926
40. Halpern MT, Warner KE. Radon Risk Perception and Testing: Sociodemographic correlates. *J Environ Health*. 1994; 56: 31-35.
41. Beck F, Richard JB, Deutsch A, Benmarhnia T, Pirard P, Roudier C, et al. Knowledge about radon and its associated risk perception in France. *Cancer/Radiothérapie* 2013; 17(8): 744–749. doi: 10.1016/J.CANRAD.2013.06.044
42. Vogeltanz-Holm N, Schwartz GG. Radon and lung cancer: What does the public really know? *J Environ Radioact.* 2018; 192: 26–31. doi: 10.1016/j.jenvrad.2018.05.017
43. Reed Johnson F, FisheI A. Conventional Wisdom on Risk Communication and Evidence from a Field Experiment. *Risk Analysis* 1989; 9: 209-213.
44. Schmitz D, Klug MG, Schwartz GG. Radon knowledge and practices among family physicians in a high radon state. *J Am Board Fam Med.* 2021; 34(3): 602–607. doi: 10.3122/JABFM.2021.03.200553
45. Radon awareness in Canada by Environment Energy and Transportation Statistics Division. Environment Fact Sheets. *Statistics Canada*, 2016. Available at: https://www150.statcan.gc.ca/n1/pub/16-508-x/16-508-x2016002-eng.pdf. Accessed on 2 November 2024.
46. Polat M, Sarıtaş D. Examination of High School Teachers' Radon Awareness in Terms of Some Variables, *ECJSE* 2017; 4: 165-176.