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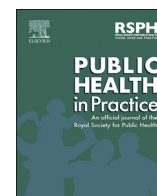
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## Original Research

## Radon risk perception and barriers for residential radon testing in Southwestern Nigeria



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## ABSTRACT

**Objectives:** The seriousness and long-term health effects of radon exposure are often underestimated due to inaccurate perceptions of radon risk. The aim of this study was to assess radon risk perception and barriers for residential radon levels testing among Obafemi Awolowo University faculty.

**Study design:** A quantitative cross-sectional design was used for this study.

**Methods:** Lecturers' residents of the Obafemi Awolowo University participated in the study. A semi-structured questionnaire was administered to 296 residents to assess their knowledge about radon and determine their perceived susceptibility to radon health risks. Data were analysed and summarised using descriptive and inferential statistics.

**Results:** The respondents' mean age was  $43 \pm 8.5$  years and 71% were male. The study revealed that awareness of radon was low (46%), while 61% of respondents had poor knowledge. Only a fifth (19.5%) of the respondents had a high perceived risk of radon, and 70% were not aware of measures to detect radon in their respective homes. A majority (74%) of the respondents reported not knowing where to get a radon testing kit as a barrier to radon testing. Professional background ( $p < 0.001$ ), academic qualification ( $p < 0.05$ ) and designation/cadre ( $p < 0.001$ ) were the major determinants of radon knowledge among residents. Moreover, religion and profession were statistically significantly related to the perception of residents about radon risk ( $p < 0.05$ ).

**Conclusion:** Despite having a high level of education, knowledge/awareness about radon health risks is low in the Obafemi Awolowo University faculty members; furthermore, lack of knowledge about house testing supplies are a significant barrier to residential testing.

## 1. Introduction

Lung cancer risk is increased by exposure to radon in the indoor air; however, evidences indicate that radon testing and home remediation is generally low in developing nations. Radon is not widely known, and it is often not perceived as a health risk by the public. Hence, radon risk communication faces serious challenges [1]. Radon is a foremost environmental carcinogen, second to smoking in the causality of lung cancer [1]. The main source of indoor radon is infiltration from soil gas into buildings. Other sources include building materials (such as concrete, stone, brick), and tap water [1]. The seriousness and long-term health

effects of radon exposure are often underestimated due to low perceptions of the risk from radon. Even though radon levels in homes can be easily tested for and homes remediated to reduce the associated risks; literature revealed populace inaction towards radon testing and home remediation. This is not exclusively due to cost but rather due to the individual's perception of radon's health risks [2].

Risk perception is defined as "attitudes, judgments; people's beliefs and dispositions; towards hazard" [3]. Risk perception is further viewed as a psychological process in which people are subject to unconscious emotional biases. About radon exposure, risk perception is both an emotional and cognitive response that operates within a social context.

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Most people, particularly in Nigeria, often perceive the threat from radon as distal and uncertain [4]. If risk perception of radon is low in the populace, there will be no motivation by the public to keep exposure levels low through individual actions such as home testing and remediation measures. Moreover, whether individuals perceive radon as a risk or not, will determine their action or inaction towards safeguarding their lives and families against hazard from it. Therefore, it is necessary to assess individuals risk perception of radon and their perceived susceptibility to radon risk with the aim of minimising biases associated with radon exposure in a bid to further overcome challenges/constraints faced by non-testers particularly in areas where radon levels have been reported to be high. Laws and regulation could also influence whether or not people will take action against radon risk.

Several researches have investigated populace awareness and perception about radon as a public health issue in the last two decades [5]. Most of these studies and research were conducted in developed countries, whereas, only a few studies have been documented in Nigeria. A thorough literature search revealed that the few studies conducted in Nigeria focused on knowledge assessment and awareness, and to the best of our knowledge, none has investigated individual/public risk perception about radon exposure.

Three major components are involved when evaluating risk communication. These are risk assessment, risk perception, and risk management [6]. The perception of risk encompasses more than just public perception but also takes into account both political and economic factors. Through gaining knowledge and accumulation of information, public perception can change over time.

Perceived risk of radon is often associated with intentions to test as well as actual radon test ordering [7]. The way people view the risk from radon will determine whether or not, they will be willing to conduct radon testing and remediation in their homes [8].

The Surgeon General Office in the United States stated that it is a concerted effort of individuals to safeguard themselves from indoor radon gas, which poses a threat to human health. Most persons will not decline to take action on preventing the dangers of radon if they are cognizant of the adverse effects [8]. In the United States, there is an increase in radon levels among millions of homes and the solution to the issue is simple such as sealing cracks in foundations and improving the ventilation in houses [1]. In 2015, Afolabi et al. [9] reported measurable quantities of radon in sites and locations within the academic core of the study area [9]. Furthermore, Esan et al., 2020 [10], reported possibility of the sampled populace being exposed to high radon concentration due to faults across the underlying bedrock on which buildings in the study area have been cited.

Currently, in Nigeria, there is low public awareness about radon and vast number of the populace lack requisite knowledge about radon risk. Furthermore, Nigeria does not have regulatory limits for radon levels in building/residences and there are no campaigns to raise population awareness about radon, despite the fact that some studies have documented elevated radon levels in houses in parts of the country [9,11]. Also, radon testing for homes is not a requirement for house sales in Nigeria, which could be, if the population had been adequately sensitized about radon risk. The present study evaluates the radon risk perception and radon awareness level of the residents of a University campus in Nigeria and also assesses barriers to non-testing among the sampled populace.

## 2. Methods

The study was conducted at the Campus of Obafemi Awolowo University, situated at Ile-Ife in Osun state. Ile-Ife is located at Longitude 4° 28'30"E and Latitude 7° 28'30"N. The town is situated in the south-western region of Nigeria, a typical rain forest in the tropical region. The temperature can peak at 39°C and seldom drops below 25°C daily.

A cross-section design was utilised on the respondents who were lecturers in the university. The total sample size used was 296

**Table 1**  
Socio-demographic characteristics of Respondents.

Variable	Frequency N = 248	Percentage
<b>Age (years)</b>		
20–29	9	3.6
30–39	70	28.2
40–49	96	38.7
50–59	52	21.0
60 and above	12	4.8
Missing data	9	3.6
<b>Mean age (S.D)</b>	43.3(8.5) years	
<b>Sex</b>		
Male	177	71.4
Female	71	28.6
<b>Religion</b>		
Christianity	213	85.9
Islam	32	12.9
Traditional	1	0.4
Missing	2	0.8
<b>Highest Education Level</b>		
Bachelors	10	4.1
Masters	73	29.7
Ph.D	156	63.4
Others	7	2.8
<b>Designation/Cadre</b>		
Lecturer II and below	73	29.4
Lecturer I/Senior Lecturer	142	57.2
Reader/Professor	30	12.1
Missing	3	1.2

respondents. This was computed using the Fisher's exact formula at 95% confidence level and precision of 0.05 with 26% prevalence attribute representing the portion of individuals with the knowledge of the subject matter of radon based in a study conducted by Afolabi et al. [2].

All the faculty members were stratified into Core Science Background, Socio-Science Background and Health Science background based on the professional background of employees. Strata sampling technique (stratified random) was used to determine eligible respondents from each stratum using sampling proportionate to size. The sampling frame was the office numbers, and the occupants of selected offices were recruited. A semi-structured, adapted questionnaire [12], was self-administered in order to assess respondents' level of knowledge about radon and their perceived susceptibility to radon health risk. The questionnaire consists of four sections which include; socio-demographic information of respondents; awareness of radon and its health risks; perceived susceptibility to radon risk; and barriers to radon testing. A total of 296 pretested and validated questionnaires were self-administered to study participants. However, only 246 respondents returned their questionnaire yielding a response rate of 83%. Data collection lasted for six weeks.

Data collected were entered and analysed using IBM-SPSS (Statistical Product for Service Solution) version 20 at both univariate and bivariate levels. The knowledge score was graded on a 3-point scale (Good knowledge, Fair knowledge and Poor knowledge). Thirteen questions were used to determine the knowledge levels of respondents with the maximum score obtainable as 13 and minimum to as zero. Points 10–13 graded as good, 5–9 points as fair, and scores below 5 graded as poor. The results were presented in charts and tables. Chi-square was used to compare the knowledge level across professional groups, academic qualification and designation/cadre of respondents. Variables association was determined using Chi-square (respondent's perception and certain socio-demographic variable).

The researchers obtained ethical clearance to conduct the study from UI/UCH Joint Ethical Review Board (UI/EC/16/0352). Respondents were informed before questionnaire administration on the purpose of the research and were given adequate information ensuring that they understand the research purpose and protocols.

**Table 2**  
Awareness of respondents on radon and its health risks.

Variable	Yes	No
Proportion of respondents who have heard about radon (N=248)	113 (45.6)	135 (54.4)
Aware of health risk of radon (N=113)	77 (68.1)	36 (31.9)

**3. Results**

Table 1 showed the socio-demographic variables of the participants. The age (mean) of the sampled participants was 43 years. The majority (71.4%) of the respondents were male and Christian (85.9%). Respondents were faculty members (lecturers) divided by ranks: Lecturer

grade II and below is composed of 29% of the sample, middle cadre (Senior lecturers and lecturer I) 57%, and senior cadre (Reader and Professor) 12%. Fig. 1 showed that about 8% of participants were from Arts and Humanities faculty, 17% from Sciences, 10% from Environmental Design, and Management, 12% from Engineering and Technology, 13% from Health Sciences and 3% from Pharmacy. The majority (63%) were PhD holders.

Participant awareness was 45.6% (113 of total respondents) before the survey out of which 77 (68.1%) were aware of radon health-risk Table 2. Their source of information revealed that (57.8%) of respondents read about radon from books, (19.3%) from internet, newspaper (3.7%), television (3.7%) while 19.3% of the respondents stated other sources which included training, lectures, classroom and conferences (Fig. 2). Four-fifth (83.1%) of the respondents are aware that

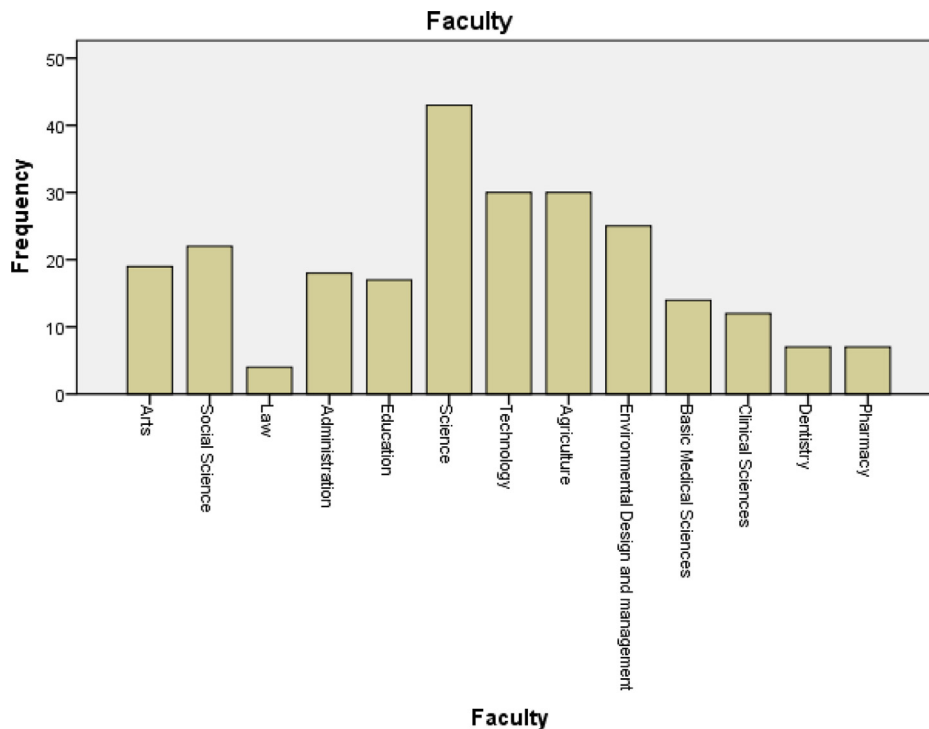


Fig. 1. Faculties of respondents.

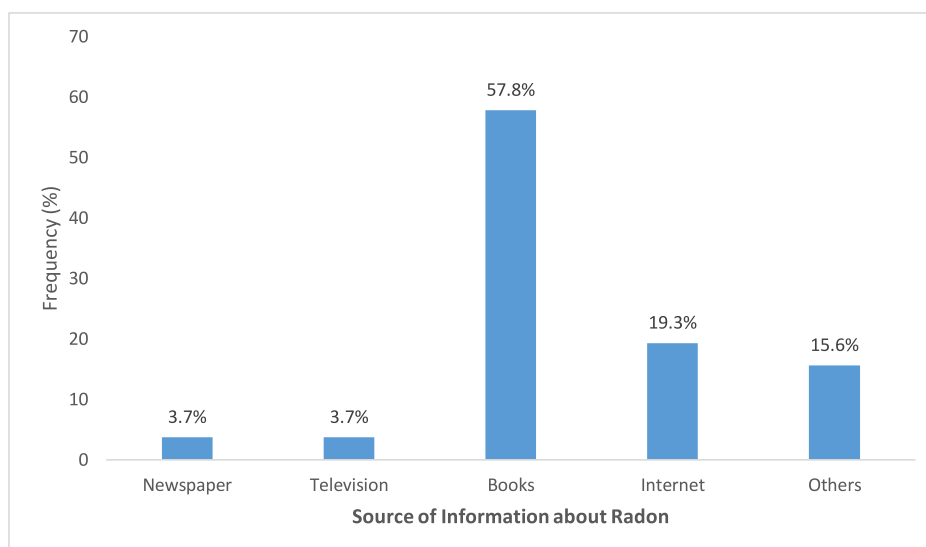


Fig. 2. Respondents source of information about radon.

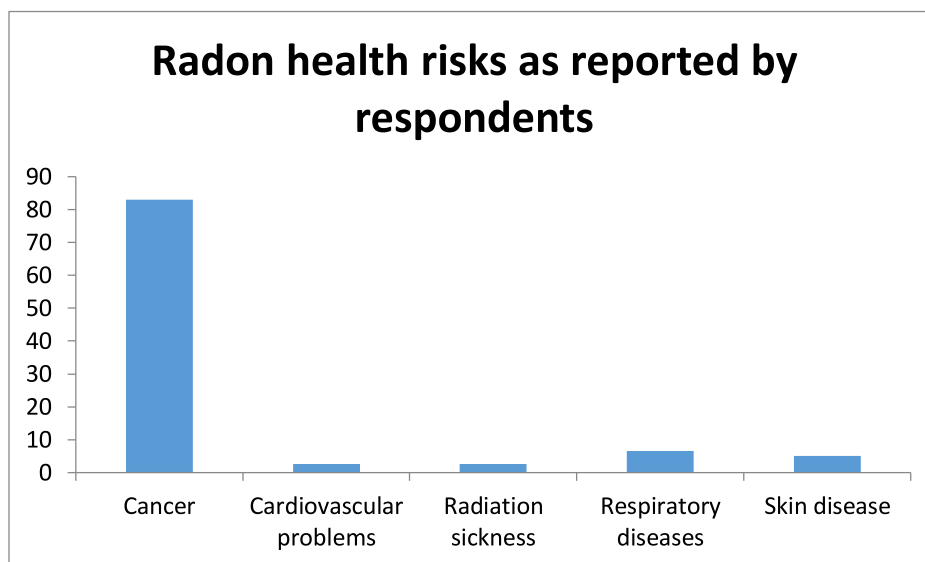


Fig. 3. Health risks of Radon as reported by respondents.

**Table 3**  
Respondents knowledge of radon.

Variable	Frequency (n = 113)	Percentage
<b>Characteristics of radon</b>		
Knows that radon is a gas	105	92.9
Knows that radon can't be seen with naked eyes	101	89.4
<b>Where radon can be found</b>		
Open air	78	69
Ground	48	42.5
Water	37	32.7
Don't know	19	16.8
<b>Sources of radon in the home</b>		
Uranium in the soil	49	43.4
Industrial pollution	43	38
Home appliances	41	36.3
Building materials	28	24.8
Water for domestic use	19	16.8
Don't know	20	17.7
<b>Nature of radon</b>		
No odour	51	45.1
Slight odour	13	1.5
Strong odour	3	2.7
Don't know	46	40.7
Knows that radon concentration highest in basement	53	46.9
<b>Radon Measurement</b>		
Knows that radon can be detected	78	69
Knows that radon measurement varies with the time of year	35	31
<b>Association of radon risk with smoking</b>		
Increases	56	49.6
Stays the same	5	4.4
Don't know	52	46
High radon exposure can cause Lung cancer	84	74.3

cancer is the major radon health risk. Other participants mentioned cardiovascular problems (2.6%), radiation sickness (2.6%), respiratory diseases (6.5%) and skin disease (5.1%). (Fig. 3).

Results of participant knowledge on radon are revealed in Table 3. About 93% of the respondents who have the awareness stated that radon is a gas. Forty-three percent of respondents correctly identified the source of radon to be a natural resource from the soil. Forty-five percent knew that radon had no odour. Seventy-four percent reported that radon causes lung cancer; 49% were aware that radon exposure risk is more among those who smoke. 31% were aware that home measures of radon are

dependent on the season of the year, 9% knew radon could be detected while 47% knew radon measurements are most times increased in the house basements.

The composite knowledge score of respondents about radon is presented in Fig. 4. It showed that, 60.9% of the participants depicts a radon knowledge that is evaluated to be poor, 28.6% had a moderate knowledge while 10.5% of the respondent had a good knowledge of radon.

Results of perceived susceptibility to radon exposure are presented in Table 4. Only about 20% of the respondents perceived themselves at risk of radon exposure; 12% agreed with the quote "I have been exposed to radon in my house", 63% of respondents agreed with the statement, "Increased radon home level causes cancer".

Table 5 revealed participant perceived barriers to radon testing response. About 70% stated that they have no knowledge how to perform radon home testing and 74% stated that they do not know where to procure radon testing kit, whereas 5% of the participants could not ascertain if radon test were reliable and 39% stated that experienced radon contractor might not be found.

The result of the bivariate analysis testing the association of different independent variables with respondents' knowledge of radon is presented in Table 6. There was a significant relationship between knowledge of radon and the respondents' educational background ( $p < 0.001$ ); academic qualification ( $p = 0.03$ ) and designation of respondents ( $p = 0.04$ ).

Respondents risk perception of radon was also found to vary by religion ( $p = 0.03$ ) and Profession of respondents ( $p = 0.003$ ) as seen in Table 7.

## 4. Discussion

### 4.1. Knowledge of residents of OAU about radon

The study revealed lecturers' radon knowledge deficit in Obafemi Awolowo University (OAU). Radon knowledge and its health effect in the study setting area is very low. The result from this study is lower than that of a study conducted in Boston University, where 55% of respondents were aware of radon prior to the survey [12]. However, radon's knowledge was higher than in the study done by Home Owner Protection Agency among Canadian citizens, where just 8% of the surveyed home owners were aware [13].

This might be due to the fact that the present study was undertaken in a university setting, unlike the general Canadian population study. In a study

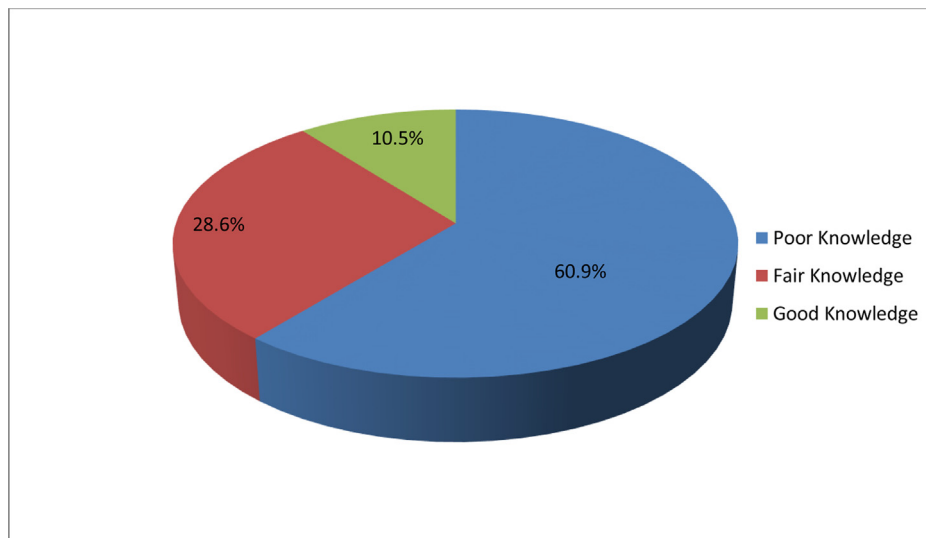


Fig. 4. Summary of knowledge level of Respondents about Radon.

**Table 4**  
Respondents perception about radon risk.

Item	Frequency(n = 113)	Percent (%)
Perceives self at risk of radon exposure		
Yes	22	19.5
None	83	73.5
Not sure	8	7.1
Considers self to have been exposed to radon at home		
Yes		
No	14	12.4
Not sure	26	23.0
	73	64.6
Believes that high levels of radon can cause cancer		
Yes		
No	71	62.8
Don't know	25	22.1
	17	15.0

**Table 5**  
Perceived barriers to radon testing.

Variable	Percent (%) "Agreed"
If I had a radon problem, it would be costly to fix	41.6
I do not know how to test my home for radon	69.9
I do not know where to buy a radon testing kit	74.4
The results of radon tests are not reliable	4.5
I don't want to get my home tested for radon because of fear of unknown	4.5
I don't have time to test my home for radon	18.6
If I did test my home for radon and the test revealed unacceptable levels of radon, I would not know how to find an experienced radon contractor to fix the problem	38.9

done by Pramod et al., 2009 [14] in India, poor awareness and knowledge of indoor air pollution (radon as an example) exist among citizens. Furthermore, the results obtained in this study are similar to what was obtained in a study conducted by Afolabi et al., 2015 [2], where knowledge of radon and its health risk was found to be low among the sampled populace. Some other studies reported that the knowledge levels were much higher 72% and 96% in the UK and the US respectively [15,16].

When respondents were asked about their source of radon information, approximately 4% of the participants had received this information

through the radio/TV. This is opposite to American studies where 85% of the general population got informed through the news [16]. Media have an important role in the transfer of health-related information to the public [17]. Although, scientific programs in the media have increased in recent years in Nigeria; unfortunately issues like radon are still neglected. Community education via comprehensive multi-media information programmes aimed at increasing awareness of radon and its health risk should be promoted in order to decrease radon's deleterious effects. It has been proven that mass education through media on hazard is a precursor to a high level of hazard prevention behaviour compare to a setting where such a potential risk is not regarded or is undermined. [6].

There are few educational campaigns in Nigeria, addressing population awareness to radon's risks. The government also does not see radon as an environmental priority concern yet which may be largely attributable to low documented/published data on radon levels in residences.

#### 4.2. Perceived susceptibility/perceived risk to radon exposure

The seriousness and long-term health effects of radon exposure is often underestimated due to inaccurate perceptions of the risk. Even though radon levels in homes can be easily tested for and homes remediated to reduce the associated risks, available literature however indicates low levels of radon testing and home remediation. In a study conducted in Iran [5], when individuals were asked to rank seven environmental risk factors, concern about radon was ranked sixth out of the seven environmental risk factors.

This finding is in keeping with our study where only a fifth (19.5%) of respondents perceived radon as a risk and at variance with what was obtained in a study conducted by Hazar et al. 2014, [5] where more than two-third of the sampled populace had a high perceived risk. In a study conducted by Duckworth and colleagues on a sample of the general population in the US, perceived risk was about 55% [7].

In our study, individual risk perception was found to be associated with religion ( $p = 0.03$ ) and professional background of respondents ( $p < 0.001$ ). The knowledge of human thinking on the potential risk is the factor to action or inaction regarding the risk. Communication on exposure to potential threat to health has two processes which are; threat appraisal and coping appraisal [6]. Persons evaluate risk to health through communication and the coping strategies to be adopted are dependent on the motivation evolving from the evaluation of the supposed risk factor to health. If radon's health effects are perceived as immaterial (It may affect others but not me) or not significant (the threat level is low), then there will not be a driving force to listening to radon

**Table 6**  
Determinant of Knowledge of Radon among employees of OAU.

Variable	N	Level of knowledge			Statistic
		Good	Fair	Poor	
<b>Educational Background</b>					
Social Science	80	4 (5.0%)	15 (18.8%)	61 (76.2%)	$\chi^2=12.64$ p < 0.001
Science & Technology	128	15 (11.7%)	40 (31.3%)	73 (57.0%)	
Health	40	7 (17.5%)	16 (40.0%)	17 (42.5%)	
<b>Academic Qualification</b>					
Ph.D	156	21 (13.5%)	42 (26.9%)	93 (59.6%)	$\chi^2=9.47$ p = 0.03
Masters	73	5 (6.8%)	18 (24.7%)	50 (68.5%)	
Degree	10	0 (0.0%)	5 (50.0%)	5 (50.0%)	
<b>Cadre</b>					
Professor/Reader	30	8 (26.7)	9 (30.0)	13 (43.3)	$\chi^2=10.12$ p = 0.04
Senior Lecturer/Lecturer I	139	12 (8.6)	40 (28.8)	87 (62.6)	
Lecturer II and below	73	6 (8.2)	19 (26.0)	48 (65.6)	

**Table 7**  
Bivariate analysis of risk Perception of Radon exposure among Residents.

Variable	Perceived Risk			Statistic
	Yes	No	Don't know	
<b>Gender</b>				
Male	15 (17.9)	63 (75.0)	6 (7.1)	0.141
Female	7 (24.1)	20 (69.0)	2 (6.9)	
<b>Religion</b>				
Christianity	18 (18.9)	69 (72.6)	8 (8.4)	0.030
Islam	4 (23.5)	13 (76.5)	0 (0.0)	
<b>Professional Background</b>				
Social	4 (17.4)	16 (69.6)	3 (13.0)	0.003
Science and Technology	8 (11.9)	54 (80.6)	5 (7.5)	
Health	10 (71.4)	4 (28.6)	0 (0.0)	

communication (education), and the person will be adamant in sustaining any communication regarding radon information-education. Radon risk perception influences people's judgement to undertake radon testing and mitigation.

#### 4.3. Perceived barriers

Table 4.5 showed responses to investigating perceived radon testing barrier. About 70% of participants stated they are unaware of home radon testing and 74% reported they have no knowledge on where to procure the radon testing kit, and 39% stated there might not be a way to getting an expert (contractor) with experience in radon when necessary while 18.6% said they do not have time to test home for radon. Therefore, promotion of radon campaigns needs to comprise foundational principles regarding procedures in radon testing.

This study also showed a significant relationship between knowledge and Professional background, Academic qualification and designation of lecturers/residents.

Lack of information, inaccurate perceptions of risk of radon could deter individuals from making decisions on minimising radon exposures. The understanding of the population's knowledge about radon can provide insights for public health practitioners and policy makers in developing radon testing promotion campaigns.

While the governmental agencies in the US and other high income countries had set regulatory limits and standards for radon in their countries, Nigeria to date does not have a regulatory limit nor standards for radon in dwellings and the government is not focusing on the issue yet.

## 5. Conclusion

The study revealed low knowledge about radon among respondents and poor/negative perception of radon risk. There is, therefore a need to

create more awareness through media, public lectures, and mass campaigns for the members of the community which should make them take better decisions regarding the indoor potential radon exposure risk and increase the radon level home testing volition in houses and consequently reduce indoor radon risk.

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## Ethics approval

Ethical clearance was obtained from UI/UCH ethics review committee of the University of Ibadan, Ibadan (Protocol number: UI/EC/16/0352). Informed consents was also obtained from participants before commencement of the study.

## CRedit authorship contribution statement

**Deborah T. Esan:** Formal analysis, Writing - original draft. **Rachel I. Obed:** Formal analysis. **Olusegun T. Afolabi:** Formal analysis, Writing - original draft. **Mynepalli K. Sridhar:** Formal analysis. **Babakayode B. Olubodun:** Formal analysis. **Carlos Ramos:** Formal analysis.

## Declaration of competing interest

The authors declare no competing interest exist regarding this research work.

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