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Radon Risk Awareness, Knowledge and Perception of Cancer Risk among Undergraduate Students from Ekiti State University, Ado-Ekiti, Nigeria

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ABSTRACT

This study assessed radon awareness, technical knowledge, radiological risk perception, awareness of its association with cancer, and preventive practices among 206 undergraduate students. Radon (^{222}Rn) is a naturally occurring radioactive noble gas generated predominantly through the ^{238}U decay series and constitutes an important source of environmental radiation exposure through the inhalation of its short-lived alpha-emitting progeny. Data were collected using a printed structured questionnaire and analysed using descriptive statistics and chi-square tests. The results showed that 65.5% of respondents had heard of radon, while 77.0% recognized its association with cancer. However, only 28.6% correctly identified its major sources and exposure pathways, revealing a substantial gap in technical knowledge of radon physics and environmental radioactivity. Although 78.2% perceived radon as a significant health risk, only 15.0% reported engaging in radon testing or related preventive practices. The major barrier was limited access to appropriate radon detection equipment. More than 60% of respondents expressed willingness to undertake radon testing and mitigation if affordable equipment and adequate resources were available. Chi-square analysis indicated significant patterns in radon awareness but demonstrated inadequate translation of awareness into preventive behaviour. The findings suggest that general awareness of radon and its carcinogenic potential does not necessarily imply adequate understanding of radioactive decay, exposure pathways, radiation dose, or protection principles. The study recommends incorporating radon science, environmental radioactivity, and radiation protection into relevant university curricula, supported by subsidized radon detectors, institutional screening programmes, and targeted radiation-health campaigns to improve radon-risk literacy and promote effective exposure reduction.

INTRODUCTION

Radon is a naturally occurring radioactive noble gas which is formed by the natural decay of uranium from rocks and soil. It can accumulate in indoor environments (Shan *et al.,* 2022). Radon exposure in the home increases the risk of lung cancer (Obed *et al*., 2018; WHO 2009). It is colorless, odourless, and tasteless, which makes it undetectable without specialized instruments. Radon migrates through soil pores and structural openings and can accumulate in enclosed indoor environments such as houses, hostels, and classrooms (Pacella *et al.,* 2023). According to the World Health Organization, radon exposure is one of the leading sources of natural ionizing radiation to humans worldwide (WHO, 2009). Recent research has linked radon and its progeny to increased death from heart attack and stroke (Dong *et al*., 2022).

Scientific evidence shows that prolonged radon exposure increases the risk of lung cancer, particularly among smokers and individuals living in poorly ventilated buildings (Obed *et al.,* 2018; Loffredo *et al*., 2021). The United Nations Scientific Committee on the Effects of Atomic Radiation reports that radon contributes the largest fraction of natural background radiation dose received by the public (UNSCEAR, 2020). Because exposure occurs indoors and without sensory warning, radon is often described as a silent environmental hazard (Małgorzata *et al.,* 2023).

University students represent a population group that spends substantial time indoors in lecture halls and residential buildings. However, environmental radiation topics are rarely emphasized outside specialized science disciplines, leading to limited awareness among the general student population. Studies in multiple countries show that radon awareness among young adults is often moderate while technical knowledge and preventive practices remain low (WHO, 2009; EPA, 2023; İlyas, 2025).

Effective radon risk control depends on awareness, correct knowledge, risk perception, and access to testing and mitigation tools. Without awareness and knowledge, individuals rarely adopt preventive actions such as home radon testing (Cronin, 2020; USEPA, 2023). This study therefore evaluates radon awareness, knowledge, perception of cancer risk, and preventive behaviour among undergraduate students of Ekiti State University, Ado-Ekiti, Nigeria.

Radon exposure remains under-recognised in many developing regions due to limited public awareness campaigns and insufficient access to testing services (Esan *et al.,* 2020; Darko *et al.,* 2015). The United States Environmental Protection Agency notes that millions of buildings worldwide contain elevated radon levels, yet many occupants have never conducted a radon test (Jibiri and Okeyode, 2012; EPA, 2023). Because radon cannot be detected by smell or sight, populations may be unknowingly exposed for years.

Undergraduate students form a large indoor population subgroup, yet there is limited documented evidence regarding their radon awareness, perception, and preventive behaviour in Nigeria. Without such baseline data, universities and public health agencies cannot design targeted educational interventions. This gap motivates the present study.

This study contributes to environmental health knowledge by providing baseline awareness and behaviour data for a high-occupancy indoor population. Prior international assessments show that awareness surveys are essential for designing effective radon risk communication programs (WHO, 2009; UNSCEAR, 2020).

MATERIALS AND METHODS

Research Design

This study adopted a descriptive cross-sectional survey design. The design was considered appropriate because the study aimed to assess awareness, knowledge, perception, and preventive behavior at a single point in time without manipulating any variables. Cross-sectional survey designs are widely used in environmental health awareness research to generate baseline population data and evaluate risk communication gaps (WHO, 2009).

The design allows for the collection of quantitative data from a defined population and facilitates statistical analysis of categorical variables using inferential techniques such as chi-square testing (UNSCEAR, 2020). Since the objective was not to establish causality but to describe patterns and test proportion-based hypotheses, the descriptive survey approach was suitable.

Study Area

The study was conducted among undergraduate students from Ekiti States, Ado-Ekiti, Nigeria. These institutions accommodate large numbers of students residing in hostels and off-campus housing, where indoor environmental exposures such as radon may accumulate. Indoor radon levels are influenced by geological formations and building structures, making university residential settings relevant environments for exposure assessment (EPA, 2023).

Population of the Study

The target population comprised all registered undergraduate students in Ekiti State University Ado-Ekiti, Nigeria during the first semester of 2024/2025 session. Undergraduate students were selected because they represent a significant indoor population group and are accessible for structured questionnaire surveys.

Ethical Approval and Declaration

Ethical approval for the study was obtained from the University Research Ethics Committee of Ekiti State University, Ado-Ekiti, Nigeria, before commencement of data collection. Permission to conduct the study was also obtained from the University's registrar. Participation in the study was voluntary. Before completing the questionnaire, each participant was informed about the purpose and procedures of the study, the expected nature of their participation, and their right to decline participation or withdraw at any time without penalty. Informed consent was obtained from all participants prior to questionnaire administration.

Confidentiality and anonymity were maintained throughout the study. The information obtained was used strictly for research purposes, and access to the collected data was restricted to the research team.

Sample Size and Sampling Technique

A total of 206 respondents participated in the study. The sample size was considered adequate for categorical data analysis using chi-square statistical testing, which requires sufficient expected frequencies in each category. A multistage sampling approach was used for the selection of faculty and departments (stratified sampling). Selection of respondents within strata employed the simple random sampling. This approach ensured representation across gender, residence type, and academic level.

Instrument for Data Collection
Data were collected using a structured questionnaire developed based on international radon awareness frameworks (WHO, 2009; EPA, 2023).

RESULTS AND DISCUSSION
Demographic Characteristics
Table 1 shows the demographic characteristics of the respondents. Gender distribution showed 91 males (44.2%), 97 females (47.1%), and 18 respondents (8.7%) who preferred not to disclose their gender. The near-balanced gender distribution enhances representativeness and reduces gender bias in awareness assessment. Age distribution revealed that 181 respondents (87.9%) were within the 18–25 age bracket, while 23 respondents (11.2%) were below 18 years, and only 2 respondents (1.0%) were above 25 years. This indicates that the sample is predominantly young adults, a population group highly relevant for environmental health literacy studies.
Regarding educational status, all 206 respondents (100%) were undergraduates enrolled in tertiary education. This confirms homogeneity in academic exposure level.

Table 1: Respondent Profile (N = 206)

Variable	Category	Frequency	Percentage
Sex	Male	91	44.2
Female	Female	97	47.1
	Prefer not	18	8.7
Age	<18	23	11.2
	18–25	181	87.9
	≥26	2	1.0
Residence	Apartment/Flat	169	82.0
	Detached	16	7.8
	Semi-detached	12	5.8
	Traditional	9	4.4
Stay Duration	1–5 years	153	74.3

Residential patterns showed that 169 respondents (82.0%) lived in apartments/flats, 16 (7.8%) in detached houses, 12 (5.8%) in semi-detached houses, and 9 (4.4%) in traditional buildings. The dominance of apartment residence is significant because radon accumulation tends to occur in enclosed indoor environments, particularly ground-contact buildings.
Length of residence revealed that 153 respondents (74.3%) had lived in their current residence for 1–5 years, 30 (14.6%) for less than one year, 13 (6.3%) for 6–10 years, and 10 (4.9%) for more than 10 years. Prolonged indoor residence duration increases cumulative exposure risk, making this demographic characteristic relevant for interpretation of perception and behavior.
Overall, the respondents represent a young, indoor-oriented population with extended residence duration appropriate for radon risk evaluation.

Radon Awareness
Table 2 shows that out of 206 respondents, 135 (65.5%) reported that they had heard of radon gas, while 61 (29.6%) had not. The mean awareness score of 2.59 indicates moderate awareness within the population.

Table 2: Awareness of Radon

Response	Frequency	Percentage
Yes	135	65.5
No	61	29.6

Knowledge of Radon
Knowledge was assessed using objective technical questions and the results were presented in Table 3.
Radon description: 145 respondents (70.4%) correctly identified radon as a radioactive gas, while 28 (13.6%) selected chemical gas, 5 (2.4%) biological agent, and 28 (13.6%) did not know.
Source of radon: Only 59 respondents (28.6%) correctly identified soil and rocks as the primary source. However, 108 (52.4%) incorrectly selected industrial waste, 5 (2.4%) water only, and 34 (16.5%) did not know. This reflects substantial misconception regarding geological origin.
Entry pathways: 46 (22.3%) selected cracks in floors, 102 (49.5%) selected gaps/pipes, 6 (2.9%) building materials, 18 (8.7%) correctly selected all of the above, and 34 (16.5%) did not know. The low percentage selecting "all of the above" demonstrates fragmented understanding.
Highest concentration location: 123 (59.7%) correctly identified basements, 35 (17.0%) ground floor, 9 (4.4%) upper floor, and 39 (18.9%) did not know. Health impact: 151 respondents (73.3%) correctly identified lung cancer,

23 (11.2%) skin disease, 9 (4.4%) heart disease, and 23 (11.2%) did not know.
Smoking interaction: 185 (89.8%) correctly indicated that smoking combined with radon increases cancer risk.
Overall, knowledge index of 55% obtained, is moderate but inconsistent. The major weakness lies in misunderstanding of radon origin and entry mechanisms.

Table 3: Knowledge Accuracy

Item	Correct	%
Radioactive gas	145	70.4
Correct source	59	28.6
Correct entry pathway	18	8.7
Highest in basement	123	59.7
Causes lung cancer	151	73.3
Smoking increases risk	185	89.8

Risk Perception

Table 4 shows the levels of risk perception of the respondents. Perceived seriousness: 24 (11.7%) considered radon not serious, 21 (10.2%) slightly serious, 108 (52.4%) moderately serious, and 53 (25.7%) very serious. Combined moderate/very serious = 78.1%, indicating high perceived severity. Public health problem: 157 (76.2%) agreed radon is a national public health issue, 15 (7.3%) disagreed, 34 (16.5%) were unsure. Personal vulnerability: 39 (18.9%) not vulnerable, 40 (19.4%) slightly vulnerable, 112 (54.4%) moderately vulnerable, 15 (7.3%) highly vulnerable.
Comparative hazard: 139 (67.5%) considered radon more dangerous than other hazards, 32 (15.5%) equally dangerous, 9 (4.4%) less dangerous, and 26 (12.6%) unsure.
Thus, high perception indicators demonstrate strong recognition of seriousness and vulnerability.

Table 4: Risk Perception Indicators

Indicator	Moderate/High	%
Radon serious	161	78.2
Public health problem	157	76.2
Personally vulnerable	127	61.6
More dangerous	139	67.5

Cancer Link Awareness

Table 5 presented the results based on the cancer link to radon exposure. Awareness of cancer link: 159 (77.2%) aware, 47 (22.8%) unaware. Second leading cause of lung cancer: 168 (81.6%) correctly answered true, 9 (4.4%) false, 46 (22.3%) did not know. Children/non-smokers vulnerability: 36 (17.5%) strongly agree, 38 (18.4%) agree, 83 (40.3%) neutral, 39 (18.9%) disagree, 10 (4.9%) strongly disagree. Likelihood of causing cancer: 126 (61.2%) likely, 17 (8.3%) very likely, 16 (7.8%) unlikely, 19 (9.2%) very unlikely.
This section indicates strong general cancer awareness but uncertainty regarding non-smoker susceptibility.

Table 5: Cancer Link Awareness

Item	Correct	%
Radon linked to cancer	159	77.2
Second lung cancer cause	168	81.6
Likely causes cancer	143	69.4

Preventive Behaviour

Table 6 presented the preventive behaviours of the respondents as follows. Home testing: Only 31 (15.0%) had tested their homes, while 175 (85.0%) had not. Reasons for not testing: 113 (54.9%) lack of testing equipment, 45 (21.8%) not aware of radon, 18 (8.7%) cost, 23 (11.2%) not concerned, 7 (3.4%) other reasons. Willingness to test: 139 (67.5%) willing, 46 (22.3%) not willing, 21 (10.2%) unsure. Willingness to mitigate: 128 (62.1%) willing, 46 (22.3%) unwilling, 32 (15.5%) unsure.
Thus, preventive behaviour is low, but behavioral intention is high when barriers are removed.

Table 6: Testing and Mitigation

Behaviour	Yes	%
Tested home	31	15.0
Willing to test	139	67.5
Willing to mitigate	128	62.1

Policy and Information Needs

Table 7 indicated policy and information needs regarding radon exposure. Government awareness: 156 (75.7%) strongly agree, 30 (14.6%) agree, 7 (3.4%) neutral, 7 (3.4%) disagree, 6 (2.9%) strongly disagree. Total agreement = 90.3%. Preferred information source: 76 (36.9%) schools, 61 (29.6%) media, 36 (17.5%) social media, 26 (12.6%) health facilities, 7 (3.4%) community outreach. This confirms strong support for institutional intervention, particularly through educational channels. Policy support is overwhelming, with over 90% calling for stronger government awareness campaigns, and schools identified as the preferred information channel, validating campus-based intervention strategies.

Table 7: Policy and Information Needs Regarding Radon Exposure (N = 206)

Variable	Response Category	Frequency (n)	Percentage (%)
Government should increase radon awareness campaigns	Strongly Agree	101	49.0
	Agree	85	41.3
	Neutral	12	5.8
	Disagree	6	2.9
	Strongly Disagree	2	1.0
	Total	206	100.0
Universities should educate students about radon risks	Strongly Agree	112	54.4
	Agree	74	35.9
	Neutral	11	5.3
	Disagree	6	2.9
	Strongly Disagree	3	1.5
	Total	206	100.0
Radon testing should be mandatory in residential buildings	Strongly Agree	88	42.7
	Agree	79	38.3
	Neutral	21	10.2
	Disagree	12	5.8
	Strongly Disagree	6	2.9
	Total	206	100.0
Preferred source of radon information	Schools/Universities	76	36.9
	Television/Radio	61	29.6
	Internet/Social Media	36	17.5
	Health workers	18	8.7
	Newspapers	9	4.4
	Friends/Family	6	2.9
	Total	206	100.0

Statistical Analysis

Based on Table 8, the chi-square analysis indicates that respondents' awareness, knowledge, and perception of radon-related cancer risk show statistically significant patterns. The chi-square value for awareness ($\chi^2 = 27.06$, $\alpha = 0.05$) is greater than the critical value of 3.84, indicating a significant level of awareness of radon among the respondents. Similarly, risk perception ($\chi^2 = 32.60$, $\alpha = 0.05$) exceeds the critical value, suggesting that respondents significantly perceive radon as a potential health hazard and recognize its association with cancer risk. However, despite this awareness and perception, the result for knowledge source ($\chi^2 = 38.00$, $\alpha = 0.05$) was classified as inadequate, implying that respondents may not be obtaining sufficient or reliable information about radon and its health effects. Furthermore, testing behaviour ($\chi^2 = 50.30$, $\alpha = 0.05$) was found to be very low, indicating that although individuals may be aware of radon and perceive it as a cancer risk, this awareness has not translated into proactive actions such as radon testing. Overall, the findings suggest a gap between awareness and practical knowledge, highlighting the need for improved public education and access to credible information on radon exposure and its link to cancer.

Table 8: Chi-Square Results

Variable	χ^2	df	Critical	p-value	Decision
Awareness	27.06	1	3.84	0.05	Significant
Knowledge source	38.00	1	3.84	0.05	Inadequate
Risk perception	32.60	1	3.84	0.05	Significant
Testing behaviour	50.30	1	3.84	0.05	Very low

CONCLUSION

Based on the findings, the study concludes that undergraduate students demonstrate moderate awareness and high perceived seriousness of radon exposure; however, technical knowledge regarding radon origin and building entry mechanisms remains insufficient. While awareness of the radon-cancer linkage is strong, misconceptions persist, particularly regarding geological sources and universal susceptibility.

Preventive behaviour is significantly low, despite high willingness to engage in testing and mitigation. The results suggest that the primary barrier to action is structural rather than attitudinal. Limited access to radon testing equipment and insufficient practical guidance impede translation of awareness into preventive practice. The study therefore concludes that awareness alone is inadequate to ensure protective behaviour. Effective radon risk reduction requires a combination of technical education, infrastructure support, and policy-driven intervention. Bridging the gap between knowledge and action is essential for sustainable environmental health protection in university populations.

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