JHWCR JOURNAL OF HEALTH, WELLNESS AND COMMUNITY RESEARCH 3007-0570

Original Article Volume 4, Issue 1

Awareness and Practices Regarding Radiation Safety Among Dental Students

Alssa Uqaily[1], Yash Kumar[2], Nandani Narain Das[1], Khushi Bai[3], Aamir Zada[4]

[1] BDS Student, Liaquat University of Medical and Health Science, Jamshoro, Pakistan
[2] House Officer, Liaquat University Hospital, Hyderabad, Pakistan
[3] BDS Student, Fatima Jinnah Medical and Dental College, Karachi, Pakistan
[4] Research Supervisor, Pakistan Research Institute of Dental Education, Islamabad, Pakistan
* Correspondence: Alssa Uqaily, alssauqaily110@gmail.com

ABSTRACT

Background: *Dental radiography is integral to contemporary clinical decision-making, yet ionizing radiation entails preventable occupational and patient exposure risks; adherence to radiation protection principles such as ALARA is therefore essential during undergraduate clinical training.* ***Objective:*** *To assess dental students' awareness, attitudes, and clinical practices regarding radiation safety and to examine associations of training exposure and academic level with key protective behaviors.* ***Methods:*** *A cross-sectional observational survey was conducted over two months among 203 undergraduate dental students selected by convenience sampling. A structured, literature-informed online questionnaire captured demographics, training exposure, knowledge/awareness, attitudes, and self-reported radiation safety practices. Descriptive statistics summarized responses, and chi-square tests assessed associations between selected variables, reporting effect sizes using Cramér's V. Analyses were performed in SPSS v25 with two-sided significance set at p<0.05.* ***Results:*** *Most students were familiar with radiation health risks (82.8%). Reported adherence to ALARA was 47.3%, while lead apron use was 30.5% and access to protective equipment was 27.1%. Formal training was significantly associated with ALARA adherence (χ^2=9.016, df=2, p=0.011; Cramér's V=0.21), and year of study was significantly associated with lead apron use (χ^2=13.602, df=4, p=0.009; Cramér's V=0.26). Most students endorsed strengthening curriculum coverage of radiation safety (90.1% agree/strongly agree).* ***Conclusion:*** *Despite high awareness, radiation safety practices were suboptimal; structured training and academic progression were associated with better compliance, supporting longitudinal, competency-based instruction and improved access to protective resources.*

Keywords: *Radiation safety; ALARA; Dental students; Dental radiography; Lead apron; Radiation protection; Dental education*

INTRODUCTION

Radiographic imaging is an indispensable component of modern dental practice, underpinning diagnosis, treatment planning, and follow-up across virtually all dental specialties. The widespread adoption of digital radiography and the increasing availability of advanced imaging modalities such as cone-beam computed tomography (CBCT) have substantially improved diagnostic accuracy and clinical decision-making (1). Despite these benefits, dental radiography involves exposure to ionizing radiation, which carries potential biological risks. Although individual dental doses are comparatively low, repeated or unnecessary exposures may result in cumulative stochastic effects, including an increased lifetime risk of malignancy (2). Consequently, international radiological protection bodies emphasize strict adherence to the ALARA (As Low As Reasonably Achievable) principle to minimize exposure to patients and operators without compromising diagnostic yield (1,2).

Dental students represent a particularly relevant population in this context. During undergraduate clinical training, students are frequently responsible for prescribing and acquiring radiographs, often at an early stage of skill acquisition. Their understanding of

Received: 10 December 2025
Revised: 08 January 2026
Accepted: 10 January 2026
Published: 15 January 2026

Citation: Click to Cite

radiation hazards, attitudes toward protection, and habitual clinical practices formed during training are likely to persist into professional practice (1). Studies conducted in diverse educational settings consistently report that dental undergraduates possess moderate to high theoretical awareness of radiation risks; however, this knowledge does not always translate into consistent application of protective measures such as lead apron use, beam collimation, justification of exposure, and avoidance of unnecessary retakes (1,2). This discrepancy between knowledge and practice raises concerns regarding both occupational exposure among students and patient safety during training clinics.

Educational structure and institutional support appear to play a critical role in shaping radiation-safe behavior. Programs that rely predominantly on didactic, lecture-based instruction may succeed in conveying theoretical concepts but often fall short in reinforcing practical compliance during clinical work (3). In contrast, evidence from health-professional education suggests that repeated, structured training combined with supervised clinical exposure improves adherence to safety protocols and promotes long-term behavioral change (4). Within dentistry, formal radiation safety instruction and progressive clinical responsibility have been associated with improved observance of ALARA-based practices and greater use of protective equipment (1). Nevertheless, access to safety resources and consistent institutional emphasis remain variable, even within the same national context.

Recent literature from multiple regions continues to highlight persistent gaps in radiation protection practices among dental students and early-career practitioners. Cross-sectional surveys report suboptimal compliance with personal protective measures and inconsistent patient communication regarding radiation exposure, despite favorable attitudes toward safety and strong recognition of its importance (5–7). These findings suggest that awareness alone is insufficient and that deficiencies may lie in curricular design, reinforcement mechanisms, and institutional safety culture. Importantly, data from low- and middle-income countries remain limited, and local evidence is necessary to inform context-appropriate educational reforms and policy implementation.

In Pakistan, published data evaluating dental students' radiation safety knowledge and practices are scarce, despite the rapid expansion of dental education and increasing use of diagnostic imaging in undergraduate clinics. Understanding the current level of awareness, training exposure, and clinical behavior among dental students is essential to identify gaps, guide curriculum enhancement, and support the development of safer radiographic practices. Therefore, the present study was designed to assess awareness, attitudes, and practices related to radiation safety among undergraduate dental students and to examine whether academic level and formal training are associated with adherence to key protective principles. The primary objective was to evaluate compliance with radiation safety practices, particularly the ALARA principle and use of protective equipment, among dental students during clinical training.

MATERIAL AND METHODS

This cross-sectional observational study was conducted over a two-month period to evaluate awareness, attitudes, and practices related to radiation safety among undergraduate dental students. The design was selected to allow estimation of the prevalence of key radiation safety behaviors and to examine associations between educational exposure, academic progression, and compliance with protective practices at a single point in time, in line with established reporting standards for observational research (8). The study was carried out across multiple dental teaching institutions in Pakistan, encompassing both preclinical and clinical training

environments, with data collection undertaken entirely through an online platform during the study period.

The study population comprised undergraduate Bachelor of Dental Surgery (BDS) students enrolled in recognized dental colleges. Students from all academic years were eligible to participate, provided they were currently registered in the dental program and consented to take part in the survey. Students who were not enrolled at the time of data collection or who submitted incomplete questionnaires were excluded from the final analysis. Participants were selected using convenience sampling, a pragmatic approach appropriate for exploratory educational research, with efforts made to include students from different academic levels to enhance representativeness. Invitations to participate were disseminated electronically through institutional communication channels and student networks. Prior to accessing the questionnaire, participants were presented with an electronic information sheet explaining the study purpose, voluntary nature of participation, and confidentiality assurances, after which informed consent was obtained digitally.

Data were collected using a structured, self-administered questionnaire developed following a comprehensive review of the existing literature on radiation safety in dentistry and undergraduate health professions education. The instrument was designed to capture information across three domains: demographic and academic characteristics, knowledge and awareness of radiation hazards and protection principles, and self-reported clinical practices and attitudes related to radiation safety. The questionnaire consisted of closed-ended multiple-choice items and Likert-scale questions, enabling standardized data capture and quantitative analysis. Prior to full deployment, the questionnaire was pilot tested on a small group of dental students to ensure clarity, relevance, and internal consistency, and minor wording adjustments were made accordingly. Data collection was conducted over the defined study period, with responses automatically recorded and stored in a secure online database.

Key variables were operationally defined a priori. Awareness of radiation risks was assessed through items evaluating familiarity with immediate and cumulative biological effects of ionizing radiation. Radiation safety practices were measured using self-reported behaviors, including adherence to the ALARA principle, use of lead aprons during radiographic procedures, frequency of radiograph acquisition, and communication with patients regarding radiation exposure.

Formal radiation safety training was defined as participation in structured educational activities beyond brief mentions within routine lectures. Academic year and type of institution were treated as categorical independent variables. To minimize information bias, questions were phrased in neutral, nonjudgmental language, and anonymity was maintained to reduce social desirability bias. Potential confounding by academic level and training exposure was addressed analytically through stratified and multivariable comparisons where appropriate.

The sample size was determined pragmatically based on feasibility and anticipated response rates within the study timeframe, with a final sample of 203 participants considered sufficient to provide stable prevalence estimates and allow exploratory association testing between key variables. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS), version 25.

Descriptive statistics, including frequencies and percentages, were used to summarize participant characteristics and survey responses. Associations between categorical variables were examined using chi-square tests of independence, with exact tests applied where cell

counts were small. Effect sizes were estimated using appropriate measures to support interpretation of statistically significant findings. Missing data were minimal due to mandatory response settings within the online questionnaire and were handled through complete-case analysis. All statistical tests were two-sided, with a significance level set at $p < 0.05$.

Ethical approval for the study was obtained from the relevant institutional ethics committee prior to data collection. The study adhered to the principles of the Declaration of Helsinki, ensuring respect for participant autonomy, confidentiality, and data protection. No personally identifiable information was collected, and access to the dataset was restricted to the research team. To ensure reproducibility and data integrity, standardized data extraction procedures were followed, raw data were archived securely, and analysis steps were documented in detail to allow replication by independent researchers.

RESULTS

A total of 203 undergraduate dental students participated in the study. As shown in Table 1, most respondents were aged 21–25 years (170/203, 83.7%), with smaller proportions under 20 years (23/203, 11.3%) and above 25 years (10/203, 4.9%). Females constituted nearly two-thirds of the sample (132/203, 65.0%), while males accounted for 35.0% (71/203). The largest academic subgroup was third-year students (81/203, 39.9%), followed by fourth-year (50/203, 24.6%) and fifth-year students (45/203, 22.2%); second-year (19/203, 9.4%) and first-year (8/203, 3.9%) respondents formed smaller proportions. Most participants were enrolled in government institutions (153/203, 75.4%), compared with private (38/203, 18.7%) and semi-government colleges (12/203, 5.9%). Geographically, the sample was predominantly from Sindh (191/203, 94.1%), with fewer participants from Punjab (6/203, 3.0%), Khyber Pakhtunkhwa (3/203, 1.5%), Balochistan (2/203, 1.0%), and Gilgit Baltistan (1/203, 0.5%).

Regarding radiation safety education (Table 2), nearly half of students reported that radiation safety was only briefly mentioned in their curriculum (92/203, 45.3%), while 36.5% (74/203) indicated they had a few sessions, and only 18.2% (37/203) received multiple sessions across the course.

The dominant mode of training was lecture-based instruction (132/203, 65.0%). In contrast, relatively few students reported receiving training through workshops or seminars (17/203, 8.4%) or online courses (4/203, 2.0%), and almost one-quarter stated they had received no formal radiation safety training (50/203, 24.6%).

Reported clinical practices and safety behaviors are summarized in Table 3. Only 27.1% of participants (55/203) reported access to protective equipment such as lead aprons or thyroid collars, whereas 55.7% (113/203) reported no access and 15.3% (31/203) were unsure. Patient communication about radiation exposure was inconsistent: 25.1% (51/203) reported always informing patients, 17.2% (35/203) did so often, and 29.6% (60/203) informed patients sometimes, while 28.1% (57/203) reported never informing patients.

In terms of radiographic activity, 18.7% (38/203) took radiographs regularly, 30.5% (62/203) took them occasionally, and 30.0% (61/203) only when required, whereas 20.7% (42/203) had never taken dental radiographs. Use of lead aprons was reported by 30.5% (62/203), while the majority did not use them (141/203, 69.5%). Adherence to the ALARA principle was reported by 47.3% (96/203), compared with 52.7% (107/203) who did not follow ALARA. Perceived institutional prioritization of radiation protection was reported by 46.3% (94/203), whereas 53.7% (109/203) felt that radiation safety was not sufficiently prioritized.

Knowledge and awareness findings (Table 4) indicated that most students were familiar with immediate and cumulative health risks associated with radiation exposure (168/203, 82.8%), while 17.2% (35/203) reported lack of familiarity.

When asked to identify the main source of radiation exposure in dental practice, 70.9% (144/203) selected the X-ray machine, while 13.8% (28/203) cited panoramic radiography, 3.4% (7/203) identified CT/CBCT, and 11.8% (24/203) reported uncertainty. With respect to unnecessary radiographs, 51.2% (104/203) stated they never took unnecessary X-rays, 27.6% (56/203) reported doing so rarely, 17.7% (36/203) sometimes, and 3.4% (7/203) often.

Table 1. Demographic and Academic Characteristics of Participants (n = 203)

Variable	Category	n	%
Age (years)	<20	23	11.3
	21–25	170	83.7
	>25	10	4.9
Gender	Male	71	35.0
	Female	132	65.0
Year of Study	1st	8	3.9
	2nd	19	9.4
	3rd	81	39.9
	4th	50	24.6
	5th	45	22.2
Type of Institute	Government	153	75.4
	Private	38	18.7
	Semi-government	12	5.9
Province	Sindh	191	94.1
	Punjab	6	3.0
	KPK	3	1.5
	Balochistan	2	1.0
	Gilgit Baltistan	1	0.5

Table 2. Radiation Safety Education and Training Exposure (n = 203)

Variable	Category	n	%
Extent of radiation safety coverage	Multiple sessions	37	18.2
	Few sessions	74	36.5
	Brief mention only	92	45.3
Mode of training received	Lectures	132	65.0
	Workshops/Seminars	17	8.4
	Online courses	4	2.0
	None	50	24.6

Table 3. Radiation Safety Practices and Clinical Behaviors (n = 203)

Variable	Category	n	%
Access to protective equipment	Yes	55	27.1
	No	113	55.7
	Not sure	31	15.3
Use of lead apron	Yes	62	30.5
	No	141	69.5
Adherence to ALARA principle	Yes	96	47.3
	No	107	52.7
Informing patients about radiation	Always	51	25.1
	Often	35	17.2
	Sometimes	60	29.6
	Never	57	28.1
Frequency of taking radiographs	Regularly	38	18.7
	Occasionally	62	30.5
	Only when required	61	30.0
	Never	42	20.7
Perceived prioritization of radiation safety	Yes	94	46.3
	No	109	53.7

Table 4. Knowledge and Awareness of Radiation Safety (n = 203)

Variable	Category	n	%
Familiarity with radiation health risks	Yes	168	82.8
	No	35	17.2
Main perceived source of exposure	X-ray machine	144	70.9
	Panoramic radiography	28	13.8
	CT/CBCT	7	3.4
	Do not know	24	11.8
Taking unnecessary radiographs	Never	104	51.2
	Rarely	56	27.6
	Sometimes	36	17.7
	Often	7	3.4

Attitudinal responses (Table 5) were largely favorable toward strengthening radiation safety education. A majority either strongly agreed (103/203, 50.7%) or agreed (80/203, 39.4%) that radiation safety should be included more extensively in the curriculum, while 6.9% (14/203) were neutral and 3.0% (6/203) disagreed or strongly disagreed.

Radiation safety training was rated as very important by 85.2% (173/203) and somewhat important by 11.3% (23/203); only 3.5% (7/203) perceived it as not important. Most respondents believed that existing safety protocols are effective in minimizing exposure

(195/203, 96.1%), and 80.8% (164/203) agreed that awareness campaigns such as posters, seminars, and videos would improve compliance, while 15.3% (31/203) responded "maybe" and 3.9% (8/203) disagreed.

Table 5. Attitudes Toward Radiation Safety (n = 203)

Statement	Response	n	%
Radiation safety should be more emphasized in curriculum	Strongly agree	103	50.7
	Agree	80	39.4
	Neutral	14	6.9
	Disagree/Strongly disagree	6	3.0
Importance of radiation safety training	Very important	173	85.2
	Somewhat important	23	11.3
	Not important	7	3.5
Safety protocols effectively reduce exposure	Yes	195	96.1
	No	8	3.9
Awareness campaigns improve compliance	Yes	164	80.8
	Maybe	31	15.3
	No	8	3.9

Table 6. Association Between Academic/Training Variables and Radiation Safety Practices

Comparison	χ^2 (df)	p-value	Effect Size (Cramér's V)
Year of study × Familiarity with radiation risks	2.801 (4)	0.592	0.12
Type of institute × Access to protective equipment	8.667 (6)	0.193	0.15
Formal training × ALARA adherence	9.016 (2)	0.011	0.21
Year of study × Lead apron use	13.602 (4)	0.009	0.26
Type of institute × Perceived prioritization of safety	3.650 (2)	0.161	0.13

Inferential testing (Table 6) identified two statistically significant associations. First, formal training was associated with adherence to the ALARA principle (χ^2=9.016, df=2, p=0.011), with a small-to-moderate effect size (Cramér's V=0.21). Second, year of study was associated with lead apron use (χ^2=13.602, df=4, p=0.009), also demonstrating a small-to-moderate effect (Cramér's V=0.26).

No statistically significant association was observed between year of study and familiarity with radiation risks (χ^2=2.801, df=4, p=0.592; Cramér's V=0.12). Similarly, type of institute was not significantly associated with access to protective equipment (χ^2=8.667, df=6, p=0.193; Cramér's V=0.15) or with perceived prioritization of radiation protection (χ^2=3.650, df=2, p=0.161; Cramér's V=0.13).

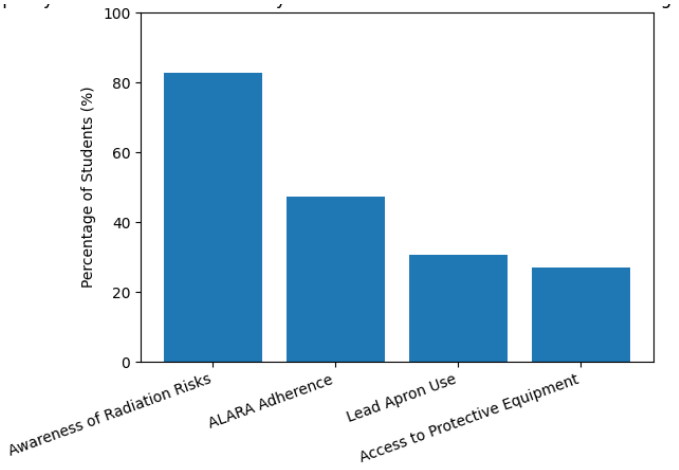

Figure 1 Disparity Between Radiation Safety Awareness and Protective Practices Among Dental Students

The figure demonstrates a pronounced gradient between cognitive awareness and applied radiation safety behaviors among undergraduate dental students. While a substantial majority reported familiarity with immediate and cumulative radiation health risks (82.8%), fewer than half adhered to the ALARA principle during clinical practice (47.3%), and less than one-third consistently used lead aprons (30.5%) or reported access to protective equipment (27.1%). The absolute drop of 35.5 percentage points between awareness and ALARA adherence, and of more than 50 percentage points between awareness and both lead apron use and equipment access, highlights a marked implementation gap. Clinically, this pattern underscores that high theoretical awareness does not translate into proportional protective behavior, suggesting that structural and training-related factors, rather than knowledge alone, are key determinants of radiation safety compliance in undergraduate dental settings.

DISCUSSION

The present study provides a comprehensive evaluation of radiation safety awareness, attitudes, and clinical practices among undergraduate dental students and reveals a clear and clinically important disconnect between knowledge and behavior. Although a large majority of participants demonstrated familiarity with the health risks associated with ionizing radiation, fewer than half reported adherence to the ALARA principle, and only a minority consistently used lead aprons during radiographic procedures. This divergence suggests that cognitive awareness alone is insufficient to ensure safe radiographic practice, reinforcing the concept that radiation protection is fundamentally a behavioral and systems-based issue rather than purely a knowledge-based one (9). The observed level of awareness in this cohort is consistent with findings from previous studies conducted among dental students and practitioners in diverse regions, which have similarly reported high recognition of radiation hazards but suboptimal compliance with protective measures (10,11). For example, surveys among dental trainees have shown that while most students can correctly identify sources and risks of radiation exposure, routine application of protective protocols remains inconsistent, particularly in busy clinical training environments (12). These parallels indicate that the awareness–practice gap identified in the present study reflects a broader, persistent challenge in dental education rather than an isolated institutional shortcoming.

Importantly, the study demonstrated a statistically significant association between formal radiation safety training and adherence to the ALARA principle, with a small-to-moderate effect size. This finding aligns with earlier evidence suggesting that structured and repeated

educational exposure plays a decisive role in translating theoretical principles into clinical behavior (13). Training that extends beyond brief curricular mentions and incorporates applied instruction appears to enhance students' ability to internalize dose-minimization concepts and apply them consistently. This supports the argument that radiation safety education should be longitudinal and competency-oriented rather than confined to isolated lectures early in the curriculum (14). A second significant association was observed between academic year and use of lead aprons, with senior students demonstrating higher compliance. This trend likely reflects increased clinical exposure, closer supervision, and greater professional responsibility in later years of training. Similar gradients across academic progression have been reported in other studies, where advanced students exhibited better adherence to safety protocols despite comparable baseline knowledge across years (11,15). These findings suggest that experiential learning and clinical accountability may be critical drivers of safe practice, underscoring the value of early integration of supervised radiographic procedures and reinforcement of protective behaviors throughout training.

In contrast, no significant association was found between type of institution and either access to protective equipment or perceived prioritization of radiation safety. This suggests that gaps in resource availability and institutional emphasis may be widespread and not limited to a specific category of dental college. Comparable results have been reported in regional and international studies, where institutional variability did not consistently predict radiation safety compliance among students (10,16). Such findings highlight the need for standardized minimum requirements for radiation protection infrastructure and training across dental institutions, supported by regulatory oversight and accreditation standards. From a clinical perspective, the low prevalence of lead apron use and limited access to protective equipment are particularly concerning. Lead aprons and thyroid collars remain fundamental components of radiation protection, especially in training settings where repeat exposures may occur due to inexperience (17). The finding that fewer than one-third of students reported routine use of such equipment raises potential implications for cumulative occupational exposure and patient safety. Moreover, inconsistent communication with patients regarding radiation exposure observed in this study reflects an additional gap in professional practice that warrants attention, as informed consent and patient reassurance are integral to ethical radiographic practice (18).The findings of this study have important educational and policy implications. They suggest that improving radiation safety among dental students requires a multifaceted approach that combines enhanced curricular content, practical and simulation-based training, consistent supervision, and reliable access to protective resources. Emerging evidence indicates that interactive teaching strategies, including simulations and competency-based assessments, are more effective than traditional didactic methods in fostering sustained safety behaviors (19). Integrating such approaches into undergraduate dental curricula may help bridge the persistent gap between awareness and practice demonstrated in this and other studies. Several limitations should be acknowledged. The cross-sectional design precludes causal inference, and reliance on self-reported practices may introduce reporting bias. The use of convenience sampling and the predominance of participants from a single province may limit generalizability. Nevertheless, the study provides valuable baseline data from an underrepresented context and offers insights that are consistent with broader international evidence. In summary, this study demonstrates that while dental students exhibit generally high awareness and positive attitudes toward radiation safety, adherence to key protective practices remains inadequate. Formal training and academic progression were associated with improved compliance, emphasizing the importance of structured, longitudinal education and experiential learning. Addressing these gaps through curricular reform, institutional support, and reinforcement

of a safety-oriented culture is essential to protect both future dental practitioners and their patients from avoidable radiation exposure (20).

CONCLUSION

In conclusion, this study demonstrates that although undergraduate dental students possess a high level of awareness regarding the risks associated with ionizing radiation and express positive attitudes toward radiation safety, this awareness does not consistently translate into safe clinical practice. Less than half of the students adhered to the ALARA principle, and only a minority routinely used lead aprons or reported adequate access to protective equipment. Formal radiation safety training and advancement in academic year were significantly associated with improved compliance, highlighting the critical role of structured, longitudinal education and experiential learning. These findings underscore the need for comprehensive curricular reform, strengthened institutional support, and consistent availability of protective resources to foster a robust radiation safety culture that safeguards both patients and future dental practitioners.

REFERENCES

1. Abuelhia E, Alghamdi A, Tajaldeen A, Mabrouk O, Bakheet A, Alsaleem H, et al. Dental undergraduates and interns' awareness, attitudes, and perception of radiological protection. Int J Dent. 2022;2022:5812627.

2. Ageeli W, Alfaify A, Abdali E, Sharafy A, Gissy A, Ageel M, et al. Assessment of dental students' knowledge towards ionizing radiation in dentistry: a cross-sectional study. Radioprotection. 2024;59(4):270–7.

3. Al-Koky M, Daud A, Neville P. Dental students' self-reported confidence level in restorative crown and bridge procedures: a UK quantitative study. Eur J Dent Educ. 2023;27(1):187–94.

4. Amini H, Gregory ME, Abrams MA, Luna J, Roland M, Sova LN, et al. Feasibility and usability study of a pilot immersive virtual reality–based empathy training for dental providers. J Dent Educ. 2021;85(6):856–65.

5. Dhokar A, Aranha V, Bodhare A, Desai V, Bhatnagar S, Bhanushali N. Assessment of knowledge and attitude pertaining to cone-beam computed tomography among dental health professionals in Maharashtra: a cross-sectional study. J Niger Acad Med. 2022;1(2):65–71.

6. Elmorabit N, Obtel M, Azougagh M, Ennibi O. Radiation protection knowledge and practices among Moroccan dentists: a cross-sectional study. Radiat Med Prot. 2024;5(2):131–8.

7. Gameraddin M, Alessa AA, Aloufi HS, Alzaidi SD, Gareeballah A, Alsaedy HI, et al. Dental radiography and safety awareness: insights from radiographers, dentists, and students in a cross-sectional study. PLoS One. 2025;20(3):e0314884.

8. Gorman LK. Improving dental residents' radiographic perceptual abilities using visual thinking strategies: a quasi-experimental pilot study [dissertation]. Saint Louis University; 2025.

9. Hasan MJ, Islam S, Sujon H, Chowdhury FI, Islam M, Ahmed M, et al. Research involvement among undergraduate medical students in Bangladesh: a multicenter cross-sectional study. BMC Med Educ. 2025;25(1):126.

10. Hasan MJ, Zaman S, Islam S, Hoque MB, Fardous J, Afrin S, et al. Research engagement and career aspirations among public health graduate students: experiences from a developing country. BMC Med Educ. 2025;25(1):512.

11. Mahabob MN, Alabdulsalam M, Alabduladhem A, Alfayz S, Alzuriq A, Almomin AM. Knowledge, attitude and practice about radiation safety among undergraduates in Eastern Province Dental College. J Pharm Bioallied Sci. 2021;13(Suppl 2):S1442–7.

12. Mishra A, Sethi KK, Srivastava S, Mishra R, Tuteja A, Dubey A. Knowledge, awareness, attitudes of radiation hazards and protection among dentists: a questionnaire survey. J Pharm Bioallied Sci. 2025;17(Suppl 1):S281–3.

13. Moazin EA, Bahakeem MA, Bamzahim MS, Sultan MS, Almusallam MA, Allehyani NMK, et al. Dentists' awareness and their practices towards radiation precaution in Saudi Arabia 2024. J Int Crisis Risk Commun Res. 2024;7(S8):752.

14. Özkan G, Ak RS, Akkaya N, Öztürk H. Awareness level of dentists and dental students about radiation doses of dental imaging methods. Int J Radiat Res. 2021;19(3):729–36.

15. Radaideh K, Matalqah L, Radaideh L. Knowledge, attitudes, and practices of occupational radiation safety among healthcare professionals: a multi-setting study in Jordan. Health Phys. 2025.

16. Rahman MHA, Uddin MS, Dey A. Investigating the mediating role of online learning motivation in the COVID-19 pandemic situation in Bangladesh. J Comput Assist Learn. 2021;37(6):1513–27.

17. Rangegowda RD, Shesha S, Erathimmaiah S, Jadiyappa S, Mugalgaon RS. Radon activity and their radiological doses in drinking water of Chitradurga district, Karnataka, India. Radiat Prot Dosimetry. 2023;199(20):2542–7.

18. Thurzo A, Urbanová W, Waczulíková I, Kurilová V, Mriňáková B, Kosnáčová H, et al. Dental care and education facing highly transmissible SARS-CoV-2 variants: prospective biosafety setting study. Int J Environ Res Public Health. 2022;19(13):7693.

19. Yousef M, Wali L, Kensara L, Alshaebi M, Shablout R, Gamil S, et al. Bridging the gap in radiation protection knowledge among medical students: a call for curriculum reform. Radiat Phys Chem. 2025;236:112844.

20. Yurt A, Ayrancıoğlu C, Kılınç G, Ergönül E. Knowledge, attitude, and behavior of Turkish dentists about radiation protection and radiation safety. Dentomaxillofac Radiol. 2022;51(1):20210120.

DECLARATIONS

Ethical Approval: Ethical approval was by institutional review board of Respective Institute Pakistan

Informed Consent: Informed Consent was taken from participants.

Authors' Contributions:

Concept: AZ; Design: AU; Data Collection: AU, YK, NND, KB; Analysis: AU; Drafting: AU, YK, NND, KB; Supervision: AZ

Conflict of Interest: The authors declare no conflict of interest.

Funding: This research received no external funding.

Data Availability: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Acknowledgments: NA

Study Registration: Not applicable.