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Radiation protection in dental radiology: Compliance, continuing education and equipment audit in imaging clinics

Emmanuel O. Esien-umo[1*], Valentine C. Ikamaise[2], Blessing S. Ibe[1], Akwa E. Erim[1], Christopher A. Ishiekwen[3], Kingsley C. Omeke[1], Ndubuisi O. Chiaghanam[1]

[1]*Department of Radiography and Radiological Science, University of Calabar, Nigeria.*
[2]*Department of Radiography and Radiation Science, University of Uyo, Nigeria.*
[3]*Department of Radiography and Radiation Science, Benue state University, Nigeria.*

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ABSTRACT

Background: Continuing education and the availability of protective equipment are two key factors that significantly influence compliance with radiation protection measures in imaging. Their absence could lead to practices that expose patients, staff, and the public to unnecessary risks. This study assessed compliance with respect to the continuing education of dental professionals and the availability of equipment in selected dental imaging clinics.

Materials and methods: A cross-sectional study. Questionnaires were shared to 55 dental professionals working in eight dental imaging clinics, to assess their level of compliance, specifically regarding continuing education and equipment availability (self-audit), and physical audit of the protective equipment in these clinics by the authors.

Results: About 25.5% of the respondents demonstrated a good level of compliance and equipment availability in their centres, while 50.9% received further training. The multi-level aggregate analysis showed that two clinics had high equipment score, good compliance score and compliance level. Spearman's rank order correlation between compliance and equipment availability was statistically significant (p=0.001), while Cohen's Kappa agreement between self and physical audit ranged from 38%-100% (K: 0.091-1.00).

Conclusion: This study showed that though continuing training is essential for compliance, equipment availability significantly influenced compliance with radiation protection measures.

Introduction

Doses from dental imaging though low, could from multiple imaging procedures, potentially increase the risk of adverse health effects such as thyroid, salivary gland, head and neck tumors, underscoring the need for protection against ionizing radiation in dental imaging.[1-6] The International Commission for Radiation Protection (ICRP) recommends keeping radiation doses as low as reasonably achievable (ALARA principle), as there is no known safe dose of radiation. Compliance with this principle forms the basis for radiological protection against ionizing radiation.[7,8]

In radiation protection, continuous training of dental professionals and the availability of protective equipment play a significant role in compliance.[8,9]

* **Corresponding contributor.**
Author's Address: *Department of Radiography and Radiological Science, University of Calabar, Nigeria.*
E-mail address: emmyesien@unical.edu.ng
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The assessment of the continuing education of dental professionals and audit of equipment in dental clinics evaluates the human and material factors that influence compliance with radiation protection measures in dental imaging. The outdated practice of still using lead aprons and thyroid collars to protect patients[10] further underscores the need for continuing education. Studies have reported on the impact of continuing training of dental professionals in dental imaging, but continuing education alone does not translate into good compliance in the absence of protective equipment.[11-13] Also, the availability of protective equipment significantly improves the dental clinic's ability to maintain a safe working environment. However, studies on the impact of protective equipment on compliance in dental imaging are lacking in Nigeria as previous studies focused on the knowledge of radiation protection protocols by dental students and dental professionals.[10,14,15] This present study will assess compliance with respect to the continuing education of dental professionals and the availability of equipment in selected dental imaging centres in Calabar and Uyo cities of Cross River and Akwa Ibom States respectively, Nigeria.

Materials and methods

This study was a cross-sectional survey. A purposive convenience sampling method was used to obtain data from 55 respondents in four public and four private dental clinics in Calabar and Uyo cities. The clinics were selected based on high patient throughput (50 patients/week), access to respondents and the dental clinics. Pre-tested questionnaires were shared to dental professionals (Dentists, Dental assistants, and Radiographers) involved in carrying out dental imaging procedures (self-audit), while four authors (Radiographers trained on the checklist) audited the equipment in the dental clinics (physical audit). Questionnaires comprised two sections. Section A focused on the demographics while section B assessed compliance, equipment availability and continuing education. A three-point Likert scale was used to assess the respondents' level of compliance, self-and physical audit of equipment while a binary scale was used to assess continuing education. For compliance, checklist included adherence to ALARA principle, respondents standing behind a protective barrier, use of rectangular collimator, respondents standing at a distance of at least two metres, use of digital receptors, use of receptor holders, avoiding the use of lead aprons/thyroid collars and the use of a monitoring device. Adherence with 6-8 variables on the checklist was graded as good compliance (scored 3 points), 4-5 variables was graded as fair compliance (scored 2 points) and 0-3 variables was graded as poor compliance (scored 1point) on the Likert scale. For the self- and physical audit of equipment, checklist included availability of digital receptors, receptor holders, rectangular collimators, radiation signs/symbols, designated area for dental imaging, protective barrier, monitoring devices and quality control of dental X-ray units. A score of 6-8 was depicted as high availability (3 points), 4-5 as moderate availability (2 points), and 0-3 as low availability (1point). For continuing education, respondents who had received further training on radiation protection in the last three years were classified as trained and the others were classified as not trained. Multi-level aggregate analysis was used for the non-independence of data obtained from 55 respondents nested within 8 clinics. Spearman's rank-order correlation coefficient was used to assess the association between clinic-level variables and clinic compliance, while Cohen's Kappa was used to assess the agreement between the respondents' self-audit and authors' physical audits of protective equipment. Jamovi statistical software (version 2.6.4) was used to carry out all the analyses.

Results

Of the 62 questionnaires shared, only 55 respondents completed and returned, giving a response rate of 88.7%. Figure 1 showed that most of the respondents were within the 30-39 years age bracket (N=22, 40%), with more men (N=33, 60%) than women (N=22, 40%) involved in the study. Majority were dentists (N=40, 61.8%), while 1-10 years of work experience was the most common among the respondents (N=23, 41.8%). Periapical procedures (N=34, 61.8%) were the most prevalent imaging procedures carried out in these dental clinics.

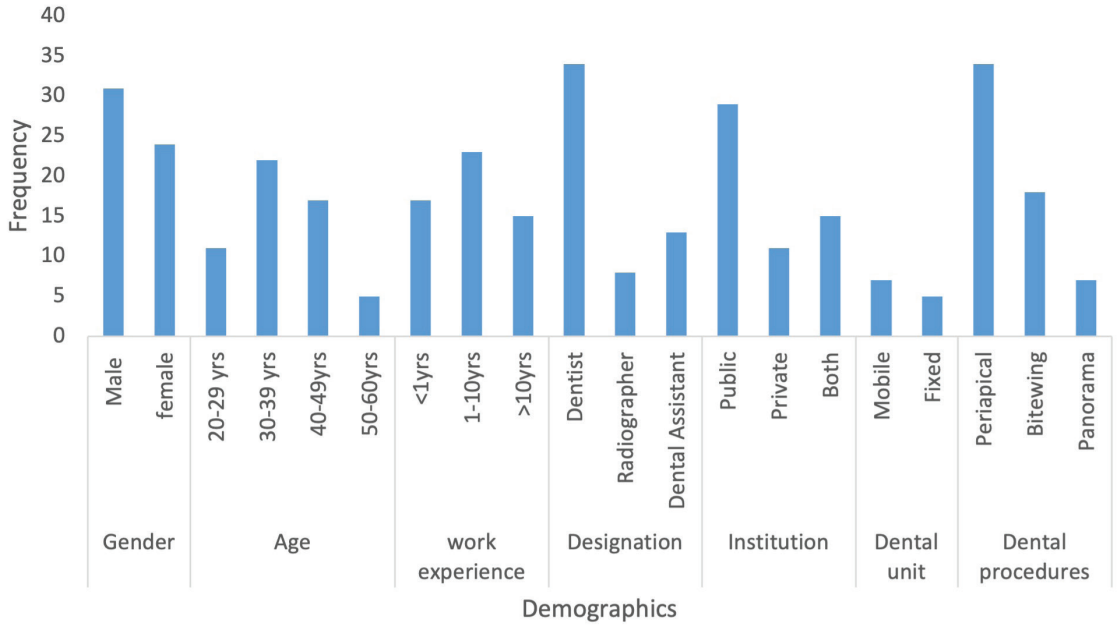

Figure 1. *Respondent's demographics*

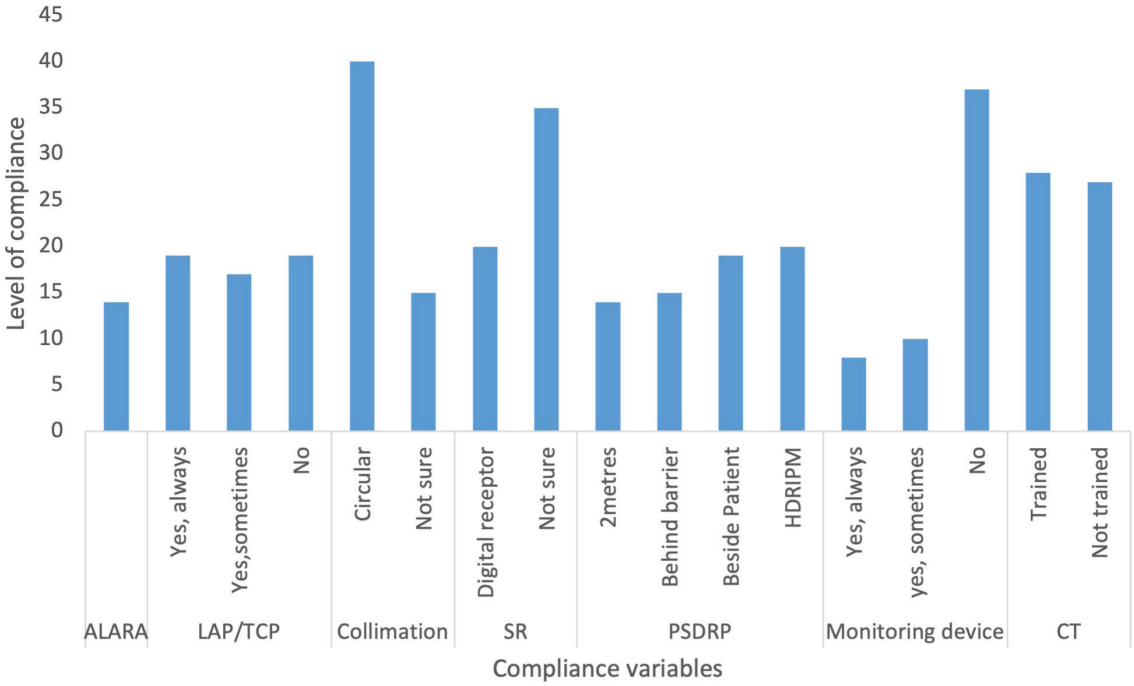

Figure 2. *Level of compliance with radiation protective measures. LAP/TCP: lead apron/thyroid collar protection, SR: speed of receptor, HDRIPM: holding of dental receptor in patient's mouth, PSDRP: position of staff during dental radiographic procedure, CE: continuing education.*

Figure 2 depicts the respondents' level of compliance with radiation protection measures. Only 14 of the 55 respondents adhered with ALARA principle giving a compliance rate of 25.5%. Majority of the respondents (N=36, 65%) used lead apron/thyroid collar for patients, while a quarter of the respondents (N=14, 25.5%), complied with the recommended two metres distance from the X-ray source. About 36.4% (N=20) of the respondents used digital receptors for dental imaging examinations, and 50.9% (N=28) received continuing education in the last three years. About 15.5% (N=8) always wore their monitoring device compared with the 18.2% (N=10) that wore theirs occasionally.

Table 1 displays the multi-level aggregate analysis of the respondents' responses in the eight imaging clinics. It showed that high continuing education score did not always result in a good compliance score and compliance level, rather clinics with high equipment score also had a good compliance score and compliance level. Clinics with high gender and work experience scores did not also affect the compliance

level. Dental clinic 2, had the highest number of respondents (12) and work experience score (8.88), while dental clinic 1 had the highest equipment and compliance scores. Five of the eight clinics showed poor compliance level, while two clinics showed good level of compliance with radiation protection measures.

Table 2 depicts the Spearman's rank order association between equipment availability and compliance was statistically significant (p=0.001), while it was not significant for continuing education, gender and work experience.

Table 3 showed that dental clinics 1 and 8 had the six of the eight items on the audit checklist and therefore scored 3-points (high equipment availability), while dental clinic 7 with four items on the checklist scored 2-points (fair equipment availability). Dental clinics 2, 3, 4, 5 and 6 had between 1-3 items on the checklist (1-point) and graded as having poor equipment availability. None of the clinics surveyed had rectangular collimator on their dental X-ray machines.

Table 4 depicts that the Cohen's Kappa analysis of agreement between the self-audit and the physical audits was perfect for warning signs/symbols and quality control procedures compared with substantial agreement shown by the other equipment. Digital receptor showed poor agreement.

Table 1. Multi-level aggregate analysis of the respondents' demographics, continuing education, equipment availability score and compliance score in the dental clinics.

Dental clinic	Number of respondents	Gender (female)	Work experience	Continuing education	Equipment score	Compliance score	Compliance level
1	6	33.3	5.17	66.7	79.17	6.33	Good
2	12	41.7	8.88	58.3	20.04	2.08	Poor
3	5	60.0	3.20	20.0	12.50	1.00	Poor
4	8	37.5	7.63	50.0	4.49	0.38	Poor
5	6	33.3	5.17	33.3	4.17	0.33	Poor
6	6	33.3	5.17	66.7	16.69	1.33	Poor
7	4	50.0	2.75	50.0	50.00	4.00	Fair
8	8	37.5	7.63	50.0	68.75	6.05	Good

Table 2. Spearman's rank order association between equipment availabilty, continuing education, gender, work experience and compliance.

Variables	Compliance	
	Spearman's rho	*p* value
Equipment availability	1.000	0.001
Continuing training	0.565	0.145
Gender	0.012	0.977
Work experience	0.012	0.977

Table 3. Physical audit of protective equipment and services in dental imaging clinics.

Dental clinic	Designed room	protective barrier	Rectangular collimator	Monitoring device	Warning signs	Digital receptor	Quality control for equipment	Digital receptor holder
1	A	A	NA	A	A	A	NA	A
2	NA	NA	NA	NA	NA	A	NA	A
3	NA	NA	NA	NA	NA	A	A	A
4	NA	NA	NA	NA	NA	A	NA	NA
5	A	NA	NA	NA	NA	A	NA	NA
6	A	NA	NA	NA	NA	A	NA	NA
7	A	A	NA	A	NA	NA	NA	A
8	A	A	NA	A	A	A	A	NA

Note: *A: availability, NA: not availability.*

Table 4. Summary of Cohen's Kappa results.

Equipment and services	Agreement (%)	Cohen's Kappa (K)	*p* value	Strength of agreement
Designated area for dental imaging	88	0.710	0.035	Substantial
Presence of protective barrier	88	0.750	0.028	Substantial
Presence of warning signs/symbols	100	1.000	0.005	Perfect
Digital receptor	38	0.091	0.537	Poor
Digital/film holders	88	0.750	0.028	Substantial
Monitoring device	88	0.750	0.028	Substantial
Quality control for dental units	100	1.000	0.005	Perfect

Discussion

Our study on the assessment of compliance with radiation protection measures in Calabar and Uyo cities revealed that many dental professionals could not identify some dental imaging equipment, such as collimators and dental receptors.

This study showed a low level of compliance with radiation protection measures among respondents (N=14, 25.5%), which could be attributed to the failure to adhere with the variables on the checklist for compliance. The low level of adherence with ALARA principle, from our survey was majorly due to the exposure settings of most of the dental X-ray units, which only allowed adjustable exposure time. The kilovoltage (kV) and milliamperes (mA) were fixed, restricting the flexibility to adjust to the required contrast and density. Thus, making the respondents to depend on the exposure time to compensate for varying thickness[16] which could result in motion blur, and implications, being increased radiation dose to the patient and dental professionals from repeat examination. Thyroid collars and lead aprons are now discouraged in imaging modality.[9] However, about 65.5% of the respondents still carry out this outdated practice. This practice is consistent with the study by Lawani *et al,*[10] indicating a gap in knowledge of the current standards in radiation protection, as lead aprons and thyroid collars are reported to introduce artefacts into dental images by obstructing the primary beam resulting in repeat examinations and do not protect against internal scatter radiation.[9,17] And the implication being more radiation dose to the patients and dental staff. While 36.4% of the respondents used digital receptors, the remaining 63.6% were not sure of the dental receptor, revealing a failure to identify the type of dental receptor used rather than a lack of equipment. This failure is confirmed by the physical audit report, that digital receptors were present in seven of the eight dental clinics but only 36.4% of the respondents reported their use, suggesting the need for continuing education for these respondents. Again, dental professionals are adviced to refrain from holding dental receptors during dental imaging procedures, as this could result in hand lesions.[18]

However, 36.4% of the respondents still hold dental receptors in the patient's mouth during the dental imaging procedure. This practice is consistent with studies by Samejo *et al.*,[5] and Lawani *et al.*,[10] with the implication being an increased likelihood of deterministic effects on the fingers.[5,18] The lack of dental receptor holders, fear of non-cooperation by children and claims of the holders making patients uncomfortable, were given as reasons for this practice by the respondents. Another 34.5% preferred to stand beside the patient during the dental examination, citing the need to reassure non-cooperative children and anxious patients as reasons, ignoring the scatter radiation and claiming that they are not in the path of the primary beam. The implication of this practice is increased exposure to the dental staff, because the closer the staff is to the patient, the more the radiation exposure.[7] Radiation monitoring device ensures that dose limits are not exceeded. About 67.3% of the respondents did not use monitoring devices during dental imaging procedures because the devices were not provided by their dental clinics, implying that dose limits are not maintained for the staff and facility.

Continuing education or training through workshops, conferences, and seminars has been recommended for dental professionals to stay updated on current standards in radiation protection.[19] Although 50.9% of the respondents had received further training on radiation protection, the level of compliance remained low, suggesting that continuing education may not be the reason for this level of adherence. Spearman's rank order correlation between continuing education and compliance was not significant, even with the knowledge gaps identified with respect to certain radiation protection measures, indicating that education did not affect compliance in this study. The reason continuing education did not affect compliance, as revealed in this study, may be due to the lack of protective equipment in most of the clinics. The availability of protective equipment allows for the practical application of knowledge gained from continuing education. When the equipment is absent, it becomes impossible to comply with the practice, meaning that the continuing education of the dental

professionals working in a poorly equipped clinic will not improve compliance.

This is evidenced in the correlation between equipment availability and compliance, which indicated a significant association. And further implies that dental professionals working in dental clinics with high equipment availability are more likely to demonstrate good compliance with radiation protection measures. This association is confirmed by the multi-level aggregate analysis in which clinics with the high equipment availability score also had good compliance score and compliance level. The Cohen's Kappa agreement between self-and physical audit showed that while self-audit was reliable in identifying structures and services, it was less reliable in identifying equipment like digital receptors. A perfect agreement depicted easy identification without misinterpretation, while substantial agreement indicated good identification but with minor uncertainties. Poor agreement indicated a high level of identification uncertainty due to the respondents' lack of awareness, showing a knowledge gap and the need for continuous education. The absence of rectangular collimators reported to reduce radiation dose to patient and dental staff by 60% [9] in all the dental clinics, the absence of protective barrier, warning signs/ symbols and monitoring device in many dental clinics surveyed affected compliance, suggesting that the respondents may be unnecessarily exposed to scatter radiation.[20]

Again, the lack of quality control measures in most dental clinics could result in undetected equipment malfunctions, leading to increased and unnecessary exposure from inconsistent radiation output.[8] Our survey revealed that the lack of enforcement of safety regulations and the high cost of radiation protection equipment and services were reasons given for the low equipment availability in the surveyed dental clinics. Gender and work experience of the respondents did not also affect compliance.

The overall implication of this poor level of compliance due to the lack of radiation protective equipment and the knowledge gaps identified, is the potential increase in ionizing radiation dose to the patients and dental professionals. This study also had its share of limitations, being the small sample size from eight dental facilities. However, these facilities have the highest number of dental imaging examinations in the two states. In addition, the survey did not carry out inter-rater reliability test as multiple authors did not audit the same dental centre. The discrimination of the respondents into professional category and dental clinics into public and private centres was not also explored.

Conclusion

This study showed that though, continuing education is essential, equipment availability significantly influenced compliance with radiation protection measures. Continuing education is recommended to address the knowledge gaps identified and the routine inspection of facilities by Regulatory Authority to enforce adherence with the minimum requirements for setting up dental imaging clinics in-order to ensure a safe working environment.

Ethics Approval

Ethical approval for this study was obtained from the Ethical Research Committee of the Department of Radiography and Radiological science, Faculty of Allied Medical Sciences of the University of Calabar with Reference number UC/ECRA/25/011.

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Conflict of interest

The authors have no conflicts of interest to declared.

CRediT authorship contribution statement

Emmanuel O. Esien-umo: conceived the idea of 'Assessing the impact of continuing education and equipment availability on compliance with radiation protection measures in dental radiology in Calabar and Uyo metropolis', designed the study; generation, processing and analysis of the data, writing: final draft; **Valentine C. Ikamaise**: designed the study; generation, processing and analysis of the data, writing; final draft; **Blessing S. Ibe**: writing: first draft, designed the study, generation, processing and analysis of the data; **Akwa E. Erim**: writing: first draft and final draft; **Christopher A. Ishiekwen**: writing: first draft; **Kingsley C. Omeke**: conceived the idea of 'Assessing the impact of continuing education and equipment availability on compliance with radiation protection measures in dental radiology in Calabar and Uyo metropolis', designed the study; generation, processing and analysis of the data, writing: first draft; **Ndubuisi O. Chiaghanam**: designed the study; generation, processing and analysis of the data, writing: final draft.

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References

[1] Crane GD, Abbott PV. Radiation shielding in dentistry: an update. Aust Dent J. 2016; 61(3): 277-81. doi.10.1111/adj.12389

[2] Han MA, Kim JH. Diagnostic X-ray exposure and thyroid cancer risk: systematic review and meta-analysis. Thyroid. 2018; 28(2): 220-8. doi.org/ 10.1089/thy.2017.0159.

[3] Hwang SY, Choi ES, Kim YS, et al. Health effects from exposure to dental diagnostic X-ray. Environ Health Toxicol. 2018; 33(4): e2018017. doi.org/

10.5620/eht.e2018017.

[4] Memon A, Rogers I, Paudyal P, et al. Dental X-rays and the risk of thyroid cancer and meningioma: a systematic review and meta-analysis of current epidemiological evidence. Thyroid. 2019; 29(11): 1572-93. doi.org/10.1089/thy.2019.0105.

[5] Samejo I, Kumar B, Musharraf H, Ahmed J, Memon L, Bhatti R. Assessment of knowledge and perspective toward dental radiography among dental practitioners of Sindh Province of Pakistan. J Evolution Med Dent Sci. 2021; 10(29): 2186-92. doi.10.14260/jemds/2021/447.

[6] Elmorabit N, Obtel M, Azougagh M, Ennibi O Radiation protection knowledge and practices among Moroccan dentists: A cross-section study. Radiat med & Prot. 2024; 5(2): 131-8. doi.10.1016/j.radmp.2024.03.001.

[7] National Council for Radiation Protection & Measurements Radiation protection in dentistry 2003; Report No. 145 Bethesda, Md.

[8] International Atomic Energy Agency Radiation. Protection in Dental Radiology. 2022; Safety Report Series No. 108 Vienna. www.iaea.org/publications.

[9] Benavides E, Krecioch JR, Connolly RT, Allareddy T, et al. Optimizing radiation safety in dentistry. J Amer Dent Ass. 2024; 155(4): 280-93. doi.10.1016/j.adaj.2023.12.002

[10] Lawani U, Edetanlen E, Ogbebor I. A study on Awareness, knowledge and practice of exposure protection protocols by dentists in a Nigerian Teaching Hospital. J Global Oral Health 2023; 6(2): 101-6. doi.10.25259/JGOH_17_2023

[11] Sarman I, Che Hassan DH. Factors affecting radiographers' compliance with radiation protection on all areas of hospital settings worldwide-A meta-analysis. Int J Res Sc & Tech. 2016; 3(4): 433-38.

[12] Torresan TT, Rodrigues IC, Poletto MC, et al. Radioprotection in dentistry: knowledge and practices. Res Sov Dev. 2021; 10(14): e5831014 22429. doi.org/10.33448/rsd- v10i14.22429.

[13] Hussein SM, Abdelsalam N, Hashem N, Ibrahim BA. Knowledge, attitude and practice of radiation safety among dentists in Ismailia City, Egypt. J High Inst Pub Health. 2024; 54(1): 23-31. doi.10.21608/jhiph.2024.373484.

[14] Enabuelele J, Igbinedion B. An assessment of dental students' knowledge of radiation protection and practice. J Edu and Ethics in Dentistry. 2013; 3(2): 54-9. doi.10.4103/0974-7761.136044.

[15] Awosan KJ., Ibrahim MTO, Saidu SA, Ma'aji SM, et al. Knowledge of radiation hazards, radiation protection practices and clinical profile of health workers in a teaching hospital in Northern Nigeria. J Clin & Diag Res. 2016; 10(8): LC07-LC12. doi.10.7860/JCDR/2016/20398.8394.

[16] Praveen BN, Shubhasini AR, Bhanushree R, Sumsum PS, Sushma CN. Radiation in dental practice: Awareness, protection and recommendations. J Contem Dent Prac. 2013; 14(1):143-8. doi.10.5005/jp-journals-10024-1289

[17] Pauwels R. Cone beam CT for dental and maxillofacial imaging: dose matters. Radiat Prot Dosimetry. 2015; 165(1-4): 156-61. doi.org/10.1093/rpd/ncv057.

[18] Agrawal B, Dosi T, Hazari A, Maheshwari C, Rajput R, Yadav N. Evaluation of radiation awareness amongst general dental practitioners of Western Rajasthan in India. J Int Oral Health. 2015; 2(12): 51-5. https://www.ispcd.org/userfiles/rishabh/V7I12/V7I12A11.pdf.

[19] Alanazi AH, Alamoudi HI, Alqahtani SIS, Alshahrami FA, et al. Attitude and awareness of general dental practitioners towards radiation hazards and safety. J Pop Ther & Clin Pharm (JPTC) 2022; 29(4): 998-1002. doi.https://doi.org/10.53555/jptcp.v29i04.5639.

[20] Sudarshan R, RajVikram N, Rajakumar P, Ganesh R. Radiation safety practice in dentistry. Afr J Biomed Res. 2024; 27(3): 619-24. doi.https://doi.org/10.53555/AJBR.v27i3S.2072.