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# Dentists' Awareness And Their Practices Towards Radiation Precaution In Saudi Arabia 2024

**Mohammad Shaikh Bamzahim[1], Mahdi Ali Bahakeem[1], Eyad Abdullah Moazin[2], Yara Musa Roblah[3], Sultan Hasan Alharbi[4], Ghazal Taher Iraqi[5], Tahani Ahmed Alqashqari[6], Arwa Faisal karakutly[7], Faidallah Majdi Toras[6], Rawan Ali Mohammad Allabban[8], Nisreen Mater Khader Allehyani[9], Ahlam Hamid Alengawi[10], Leena Ismael shukri[10]**

[1]*Consultant in Restorative Dentistry, Alnoor Hospital, dental center Makkah, Saudi Arabia.*
[2]*Dental Consultant, MOH- MAKKAH, Saudi Arabia.*
[3]*General dentist, King Abdulaziz Hospital Ministry of Health Makkah Almukaramah, Saudi Arabia.*
[4]*General Dentist, Buraydah Central Hospital ALQASSIM -Buraydah, Saudi Arabia.*
[5]*Prosthodontics, King Abdulaziz Hospital Ministry of Health Makkah Almukaramah, Saudi Arabia.*
[6]*Endodontics, King Abdulaziz Hospital Ministry of Health Makkah Almukaramah, Saudi Arabia.*
[7]*Orthodontist, King Abdulaziz Hospital Ministry of Health Makkah Almukaramah, Saudi Arabia.*
[8]*Dentistry, Health school -Makkah, Saudi Arabia.*
[9]*Dental assistant, Aljumum Healthcare Cluster, MAKKAH, MOH, KSA, Saudi Arabia.*
[10]*Dental assistant, Al Adel PHC, Saudi Arabia.*

**Abstract:**

**Background:** The science of medicine and dentistry has relied heavily on X-rays since their inception. There are several uses for X-rays, ranging from therapeutic to diagnostic. The most common use could be in dentistry, where it can be used for everything from the straightforward identification of tiny fractures and early cavities to supporting more intricate operations like precise implant planning.
**The study aims:** To analyze the current status of knowledge and practices among the dentists towards radiation precaution.
**Methods:** This is a cross-sectional study based on a questionnaire related to knowledge and practice regarding radiation precaution of patients and dental staff from January to March 2024. The study sample included 325 dentists practicing in KSA. All dentists employed in public, semi-public, and private settings made up the target population.
**Results:** Radiation precaution was known to 96.6% of dentists. However, 73.9% believed that dental X-rays are hazardous, and roughly 35% were aware of the ALARA (as low as reasonably attainable) approach. Digital image receptors were used by 63.6% of the individuals. More over 60% of them disregarded the position and distance regulation, and only 16.7% of them used a film holder. Seven was the median knowledge score [5, 9], and there was a statistically significant difference according to dentist qualification (P ¼ 0.007), dental radiation precaution continuous training (P < 0.0001), age (P ¼ 0.007) and years of experience (P ¼ 0.039). The median practice score was 5 [4, 6] and there was a statically significance association according to workplace setting (P ¼ 0.001). There was a significant positive relationship between knowledge score and practice score (r ¼ 0.24, P<0.0001). Dentist qualification (OR 0.51, 95%CI: 0.27–0.94, P ¼ 0.03) and continuous training (OR 2.40, 95%CI: 1.47–3.93, P<0.0001) were significant predictors of knowledge, while workplace setting (OR 0.54, 95%CI: 0.32–0.93, P ¼ 0.027) and knowledge score (OR 1.24, 95%CI: 1.12–1.38, P<0.0001) were predictors of practices.
**Conclusion:** Improving dentists' knowledge of radiation precaution measures and tools as well as dose reduction techniques could increase their safe practices in dental radiology.

**Keywords:** Dentists' awareness and radiation precaution

## Introduction

The movement of energy across matter and space is called radiation. It can happen in electromagnetic radiation or particle matter [1]. The flow of energy across space as a mixture of electric and magnetic fields is known as electromagnetic radiation [2]. It is produced when an electrically charged particle's velocity is changed. Electromagnetic radiation includes Y-rays, X-rays, U.V. rays, visible light, infrared radiation, microwaves, and radio waves. Depending on their energy, the radiation types in the electromagnetic spectrum can either be ionizing or nonionizing [3-5].

Ionizing radiation has a number of detrimental biological effects, including the creation of free radicals, which can either directly or indirectly impact the cell or cause DNA damage, including single or double strand breaks and/or DNA cross-links. Because they are strong enough, X-rays harm human cells and can cause cancer, leukemia, and even genetic damage [1, 2]. In dentistry and medicine, radiology has emerged as a key diagnostic application area. In dentistry, radiographs are essential for diagnostic purposes. The rapidly growing spectrum of imaging modalities, such as orthocubic super-high resolution CT (Ortho-CT) for researching various dental diseases, Cone Beam Computed Tomography (CBCT), and Computed Tomography (CT), has greatly expanded this field [3-6].

In clinical dentistry, radiographs are the most frequently ordered test during the initial examination and are an essential component of the diagnostic process [7]. Given the large lifetime prevalence and frequency of dental X-rays, any elevated health risk connected with these examinations would be of significant public health concern, even if radiation doses from these examinations are generally low [8]. No radiation exposure may be regarded as risk-free in light of this. The dangers associated with cumulative doses should not be undervalued, even if the chance of developing a primary cancer as a result of exposure during routine dental radiography is thought to be minimal [9, 10].

In contrast to other medical examinations, dental X-rays are typically done on youngsters and younger individuals, whose teeth and dentition are still developing and for whom the hazards are greatest [11]. Dental radiography has the potential to be hazardous even while it can produce beneficial results. Four It has been linked in a number of studies to a higher risk of thyroid cancer [12, 13]. In a comprehensive study, Hwang et al., (2018) [14] demonstrated that exposure to low doses of dental X-rays is associated with an elevated risk of head and neck cancer. They also stress that cumulative exposure to low-dose radiation from dental X-rays cannot be disregarded or ruled out. According to the International Atomic Energy Agency (IAEA), patient exposure should be justified and limited to what is required to accomplish the intended goal or diagnosis [11]. Therefore, in order to prevent any needless radiation exposure, the dentist's daily activity must adhere to the ALARA (as low as reasonably possible) approach [15].

Therefore, all staff in a dental practice (not just the equipment operator) must be aware of the risks associated with the use of X-ray equipment, the precautions required to keep their dose ALARA and the importance of complying with these arrangements [16]. Every day in their practice, dentists use X-rays. Their behavior and understanding regarding the X-ray examination can affect how much radiation they and their patients are exposed to. Dentists must follow the guidelines and standards of radiation safety and precaution in order to reduce and mitigate the hazards related to the use of ionizing radiation in dentistry. Nevertheless, a number of research on dentists have revealed that their radiation precaution knowledge and practices are lacking [9, 17-19].

In Kingdom of Saudi Arabia (KSA), a study conducted by AlDossari et al., (2018) [20] at King Khalid University Hospital and King Fahad Medical Hospital, Riyadh, 157 physicians participated. It was discovered that 58.6% of participants did not know enough about the radiation dose for a large number of frequent radiological tests. Interestingly, radiologists and other physicians did not differ in their level of expertise. An additional study conducted by Saeed et al., (2018) [21] including over 450 physicians in 20 Saudi Arabian cities revealed that roughly 30% of the participants had undergone radiation precaution education. Furthermore, each of these findings amply illustrated how ignorant and uninformed doctors are. Consequently, this results in radiation abuse and may put the patient's health at danger for cancer.

Another study in KSA, conducted by Salama et al., (2016) [22] a number of health care facilities showed a lack of essential radiation precaution equipment such as lead glasses and shields. Therefore, this study aimed to analyze the status of knowledge and practices towards radiation precaution among dental practitioners.

## Methods and materials

A cross-sectional study was conducted based on a questionnaire related to knowledge and practice regarding radiation precaution of patients and dental staff from January to March 2024. Ethical approval was received from the Ethics Committee. The purpose of the study was explained, informed and written consent was obtained from all participants.
The study required a sample size of 295 as calculated online with 95% confidence level and 5% error margin. As we recorded around 10% non- response in this population in previous studies, we expect a drop-out rate of 10% [23-27]. All dentists employed in public, semi-public, and private settings made up the target population [28]. The final targeted practitioners sample size was 325 dentists practicing in KSA.
The questionnaire in the form of multiple choices questions was developed after a review of the literature relevant to knowledge and practices regarding radiation precaution in dentistry [17, 29, and 30] and international guidelines and national regulations.
The content validity of the questionnaire was approved by a panel of experts that comprised of four dentists, one epidemiologist; two professors specialized in medical physics, one radiation precaution officer. The content validity was tested using item content validity index (I-CVI) and scale content validity index (S-CVI) for both relevance and clarity aspects of the questionnaire. If the item-CVI was less than 0.70, the item was excluded from the scale. If the item CVI was in the range of 0.70–0.79, it was revised [31]. I-CVI was found to range from 0.86 to 1 for both relevance and clarity. The scale CVIs (S-CVI) for relevance and clarity, based on the results of the universal agreement (UA) within the experts (S-CVI/UA) and the average CVI (S-CVI/Ave) approaches were in the ranges of 0.82–0.92 and 0.97–0.99, respectively.
Based on the recommendations of the expert panel and the results of the data analysis, certain revisions and modifications were made then the questionnaire was pretested for feasibility, readability, ambiguity and all necessary changes were made. The internal consistency reliability of 13 items on knowledge and 11 items on practice were measured using Kuder-Richardson-20 (KR-20) coefficient. The KR-20 formula is one of the most powerful tools for assessing the reliability of measurements for specific test items that are scored dichotomously [32]. KR-20 values over 0.6 indicated that items had integrity and the test was homogenous [33]. The results of the pilot study showed that the KR-20 for knowledge and practice were 0.70 and 0.68, respectively.
Direct communication with the researcher, as well as phone calls, emails, and short message services (SMS), were used to invite and encourage participants to participate in the study. Following phone conversations with practice managers, the questionnaire was utilized to gather data in the form of paper copies or electronic files that were delivered to inaccessible locations via email and social media sites (Facebook, Whats App). Microsoft forms were used in the creation of the computerized self-administered survey. The lead investigator distributes and gathers the majority of the data in easily accessible locations.
The questionnaire had three parts: the first part included general information regarding demographic and training data (gender, age range, and years of professional experience, workplace setting, dentist qualification and radiation precaution continuous training). The second part had 13 questions that evaluate the knowledge of dentists about radiation precaution. The third part had 11 questions related to their practices towards radiation precaution.
Knowledge-based questions elicited responses in a variety of formats, including “yes”, “no” or “no idea” and closed-ended questions with categories (yes or no) or multiple choice questions with one or more correct answers. The choice of “no idea” was offered to the participant in order to avoid random marking of the answers. Thus, the participants who did not answer the question correctly (choosing either “no idea” or the other wrong answer or non-response) have no points out of that question. On the other hand, each correct answer was worth one point, so that the total number of the correct answers directly corresponded to the overall knowledge score for each participant. For the 11 practice questions, each safe practice was given 1 point and an unsafe practice was given 0 point.
The collected data was analyzed using SPSS 28.0 software. Demographic characteristics and descriptive data were expressed by frequencies and percentages. Pearson Chi-square test was used for data comparison. In cases where the distribution of answers was very unequal, some items were turned into dichotomous items, for example, the answer options "public", "semi-public" and "private" were collapsed into two categories by merging ‘public’ and ‘semi-public’. The normality of the data was checked by Shapiro–Wilk statistics. Non-parametric statistical tests (Kruskal–Wallis and Mann Whitney U test) were used. The relationship between knowledge and practices on dental radiation

precaution was obtained using Spearman correlation test. A binary logistic regression analysis of the socio-demographic and professional characteristics with appropriate knowledge score and safe practice score was used to find predictors of radiation precaution knowledge and practices. Statistical results were considered significant at P < 0.05.

**Results**

Out of a total of 325 questionnaires distributed, 320 responses were received, resulting in a response rate of 98.46%. In the study population, 64.1% were female and 35.9% were male. 34.4% of participants were under 29 years old, 36.3% were aged between 30 and 39 years, 18.4% were aged between 40 and 49, while the rest of the studied population was aged 50 years or older. The experience in dental practice was less than 10 years for 63.8% of the participants. 64.4% of dentists were general dental practitioners (GDP) and 35.6% were specialists. Among all participants 67.5% worked at private practice, 32.5% at dental public health service. 100% of the dentists received courses about radiation precaution during their studies, and 49.1% of them had received continuous training in dental radiation precaution.

**Table (1)** shows the results of radiation protection knowledge among dentists. About 96.6% of subjects were aware of radiation protection. Furthermore, there was no statistical difference regarding responses of dentists who received continuous training in dental radiation protection in comparison to those who did not. However, almost 35% were aware of the ALARA principle and only 29.2% were aware of international radiation protection guidelines. A statistically significant difference was found in the responses of dentists according to continuous training in dental radiation protection (P<0.0001).

The most radiosensitive organs in dental radiology were the thyroid gland according to 66.6% of respondents, the salivary glands according to 40.3%, the reproductive organs according to 25.9%, bone marrow and brain according to 15.3%. 73.9% of dentists thought that dental X-rays are harmful whereas 15.7% did not think it is harmful which is concerning. 88.7% reported that any radiation exposure brings a possibility of occurrence of the harmful effects as cancer. (Table 1)

In terms of dentists' radiation protection practices, the study revealed that 63.6% of the participants used digital image receptor, only11% of dentists reported to operate between 60 and 70 kVp, whereas 69.5% of them had no idea. There was statistical significance difference according to workplace setting (P < 0.0001). Regarding the collimator use, 11.3% of the dentists used a rectangular collimator and 54.7% used a round collimator. Long cone was the most used cone type among dentists (47.5%). (Table 1)

The median knowledge score in this study was 7 [5, 9] on a scale of 0–15. There was a statistically significant difference between responses according to dentist qualification (P ¼ 0.007), protection continuous training (P < 0.0001), age (P ¼ 0.007) and years of experience (P ¼ 0.039). (Table 1)

**Table (1): Knowledge of participants towards dental radiation protection n (%)**

| Knowledge items | Responses | RPC training | | P-value | Dentist qualification | | P-value |
|---|---|---|---|---|---|---|---|
| | | Yes | No | | G.D.P | Specialist | |
| Awareness of radiation protection | Yes | 154 (98.7) | 152 (94.4) | 0.06 | 196 (95.1) | 113 (99.1) | 0.105 |
| | No | 2 (1.3) | 9 (5.6) | | 10 (4.9) | 1 (0.9) | |
| Awareness of ALARA principle | Yes | 76 (49.4) | 33 (20.5) | <0.0001 | 62 (30.2) | 47 (41.6) | 0.061 |
| | No | 78 (50.6) | 128 (79.5) | | 143 (69.8) | 66 (58.4) | |
| Moroccan radiation regulatory agency is | NRPC | 36 (23.2) | 37 (23.3) | 0.213 | 43 (21) | 31 (27.7) | 0.62 |
| | MHSP | 8 (5.2) | 10 (6.3) | | 14 (6.8) | 5 (4.5) | |
| | AMSs NUR | 22 (14.2) | 11 (6.9) | | 21 (10.2) | 12 (10.7) | |
| | No idea | 89 (57.4) | 101 (63.5) | | 127 (62) | 64 (57.1) | |
| Awareness of international RP recommendations in dentistry | Yes | 64 (41.6) | 28 (17.4) | <0.0001 | 63 (30.7) | 30 (26.5) | 0.056 |
| | No | 68 (44.2) | 97 (60.2) | | 97 (47.3) | 69 (61.1) | |
| | No idea | 22 (14.3) | 36 (22.3) | | 45 (22) | 14 (12.4) | |

| Knowledge items | Responses | RPC training | | P-value | Dentist qualification | | P-value |
|---|---|---|---|---|---|---|---|
| | | Yes | No | | G.D.P | Specialist | |
| Awareness of need to instructions for safety, use and maintenance of X-ray devices | Yes | 83 (53.2) | 61 (37.9) | 0.008 | 91 (44.2) | 55 (48.2) | 0.716 |
| | No | 73 (46.8) | 100 (62.1) | | 115 (55.8) | 59 (51.8) | |
| Awareness of need to quality control plan for the X-ray devices | Yes | 42 (26.9) | 22 (13.7) | 0.005 | 44 (21.4) | 21 (18.4) | 0.719 |
| | No | 114 (73.1) | 139 (86.3) | | 162 (78.7) | 93 (81.6) | |
| Annual radiation dose limit for a dentist in mSv | 1 mSv | 6 (3.9) | 4 (2.5) | 0.037 | 6 (2.9) | 4 (3.6) | 0.70 |
| | 6 mSv | 20 (13) | 17 (10.6) | | 25 (12.2) | 13 (11.6) | |
| | 20 mSv | 34 (22.1) | 18 (11.3) | | 29 (14.1) | 23 (20.5) | |
| | No limit | 0 (0) | 1 (0.6) | | 1 (0.5) | 0 (0) | |
| | No idea | 94 (61) | 120 (75) | | 144 (70.3) | 72 (64.3) | |
| Dental X-rays are harmful | Yes | 126 (81.3) | 108 (67.5) | 0.019 | 149 (72.7) | 86 (76.1) | 0.168 |
| | No | 17 (11) | 32 (20) | | 30 (14.6) | 20 (17.7) | |
| | No idea | 12 (7.7) | 20 (12.5) | | 26 (12.7) | 7 (6.2) | |
| The most radiosensitive organs or tissues is or are | Thyroid gland | 112 (72.3) | 100 (62.1) | 0.44 | 132 (64.1) | 81 (71.7) | 0.04 |
| | Salivary glands | 60 (38.5) | 68 (42.2) | | 73 (35.4) | 56 (49.1) | |
| | Reproductive organs | 42 (26.9) | 40 (24.8) | | 55 (26.7) | 28 (24.6) | |
| | Bone marrow and brain | 25 (16) | 23 (14.3) | | 30 (14.6) | 19 (16.7) | |
| | No idea | 29 (18.6) | 34 (21.1) | | 48 (23.3) | 17 (14.9) | |
| For the same external exposure the radiation dose in children is | > to adult | 56 (35.9) | 56 (34.8) | 0.805 | 66 (32) | 48 (42.1) | 0.198 |
| | ¼ to adult | 94 (60.3) | 96 (59.6) | | 129(62.6) | 62 (54.4) | |
| | No idea | 6 (3.8) | 9 (5.6) | | 11 (5.3) | 4 (3.5) | |
| For the same external exposure the radiation risk of cancer induction in children is | ¼ to adult | 106 (67.9) | 110 (68.3) | 0.47 | 143 (69.4) | 75 (65.8) | 0.12 |
| | 2 to 3 × >adult | 47 (30.1) | 44 (27.3) | 54 (26.2) | | 38 (33.3) | |
| | No idea | 3 (1.9) | 7 (4.3) | | 9 (4.4) | 1 (0.9) | |
| Any radiation exposure brings a possibility of occurrence of the harmful effects as cancer | Yes | 140 (90.3) | 140 (87) | 0.72 | 178 (86.8) | 105 (92.1) | 0.539 |
| | No | 5 (3.2) | 8 (5) | | 9 (4.4) | 4 (3.5) | |
| | No idea | 10 (6.5) | 13 (8) | | 18 (8.8) | 5 (4.4) | |
| risk of occurrence of a primary cancer resulting from low-dose exposure | Yes | 127 (81.4) | 102 (63.7) | 0.002 | 145 (70.7) | 86 (76.1) | 0.069 |
| | No | 14 (9) | 29 (18.1) | | 25 (12.2) | 18 (15.9) | |
| | No idea | 15 (9.6) | 29 (18.1) | | 35 (17.1) | 9 (8) | |
| Score 7 [5, 9][a] | | 8 [6, 9] | 6 [5, 8] | <0.0001 | 6 [5, 8] | 8 [6, 9] | 0.007 |

Note: G.D.P. general dental practitioner; RPC Training: Radiation Protection Continuous training; NRPC: National Radiation Protection Center; MHSP: Ministry of Health and Social

Protection; [a] median $[Q_1, Q_3]$.

**Table (2)** shows that film holders were not in common use with Moroccan dentists. Only 16.7% of dentists used a film holder. 62.1% of them allow patients to hold a dental film by finger and 34.7% of practitioners, themselves, stabilized intra-oral image receptors during exposure. The most common technique for taking intraoral per apical radiographs was the parallelism technique based on 61.1% of the answers against 49.3% for the bisector angle technique. 59.3% of the dentists kept less than 2 m distance between the primary source of radiation and themselves, and only 16.7% of them stood at an angle between 90◦ and 135◦ from the central radius of the X-ray beams. The median practice score in this study was 5 [4, 6] on a scale of 0–11 (Table 2).
The knowledge score of dental specialists were found to be significantly higher than that of general dental practitioners (P ¼ 0.007), while there was no significant difference in terms of practices score between the two groups (P ¼ 0.585). According to workplace setting, the practices of participants were statistically significant (P ¼ 0.001, Table 2).

**Table (2): Practices of participants towards dental radiation protection [n (%)]**

| Practices items | Responses | Workplace setting | |
|---|---|---|---|
| | | PDHS | PP |
| Number of intraoral radiographs taken/ prescribed per week [a] | ≤ 100 | 61 (58.7) | 175 (81.0) |
| | >100 | 8 (7.7) | 5 (2.3) |
| | No idea | 35 (33.7) | 36 (16.7) |
| Number of extra oral radiographs per week [a] | ≤ 50 | 62 (60.2) | 178 (82.4) |
| | >50 | 7 (6.8) | 6 (2.8) |
| | No idea | 34 (33) | 32 (14.8) |
| Type of intraoral image receptor [a] | Conventional film | 5 (4.9) | 25 (11.7) |
| | Self-developing film | 3 (2.9) | 61 (28.5) |
| | Digital image receptor | 77 (75.5) | 124 (57.9) |
| | No idea | 16 (15.7) | 4 (1.9) |
| kVp of intraoral equipment [a] | <60 | 4 (3.9) | 49 (22.8) |
| | 60-70 | 6 (5.8) | 29 (13.5) |
| | 71-90 | 1 (1) | 6 (2.8) |
| | >90 | 0 (0) | 1 (0.5) |
| | No idea | 92 (89.3) | 130 (60.5) |
| Type of collimator used in X-ray unit [a] | Rectangular | 4 (3.8) | 32 (14.8) |
| | Round | 41 (39.4) | 134 (62) |
| | No idea | 59 (56.7) | 50 (23.1) |
| Types of intraoral cone [a] | Long | 34 (32.7) | 118 (54.6) |
| | Short | 11 (10.6) | 44 (20.4) |
| | Pointed | 0 (0) | 3 (1.4) |
| | No idea | 59 (56.8) | 51 (23.6) |
| Holding of film during exposure [a] | Film holder | 21 (20.4) | 32 (15) |
| | Assistant finger | 3 (2.9) | 3 (1.4) |
| | Dentist finger | 13 (12.6) | 97 (45.3) |
| | Patient finger | 74 (71.8) | 123 (75.5) |
| Technique for taking intraoral per apical radiographs (IOPAR) | Parallelism technique | 57 (60.6) | 119 (61.3) |
| | Bisector technique | 44 (46.8) | 98 (50.54) |
| | No idea | 1 (1.1) | 0 (0) |
| Position taken during intra-oral exposure | Fixed position | 34 (32.7) | 60 (28.8) |
| | Variable position | 70 (67.3) | 148 (71.2) |
| Distance from the X-ray tube during intraoral exposure (m)[a] | <1.5 | 27 (26) | 105 (48.8) |
| | 1.5 - 2.0 | 22 (21.2) | 35 (16.3) |
| | >2.0 -3.0 | 28 (26.9) | 53 (24.7) |
| | >3.0 | 17 (16.3) | 18 (8.4) |

| Practices items | Responses | Workplace setting | |
|---|---|---|---|
| | | PDHS | PP |
| | No idea | 10 (9.6) | 4 (1.6) |
| Angle of the X-ray tube during exposure [a] | <90 | 6 (5.8) | 35 (16.4) |
| | 90 -135 | 12 (11.7) | 41 (19.2) |
| | >135 | 3 (2.9) | 8 (3.7) |
| | No idea | 81 (78.6) | 130 (60.7) |
| Score [ab] | 5 [4, 6] | 5 [3, 6] | 5 [4, 6] |

Note: PDHS. Public dental health service; PP: Private Practice; IOPAR. Intraoral Periapical Radiography; a P <0.05; b median [Q1, Q3]

In univariate analysis, the knowledge score was observed to decrease with age and years of professional experience (**Table 3**). Indeed, dentists who were 29 years old or younger are almost four times more likely to have an appropriate level of knowledge than dentists who were aged 50 years or older (OR 3.25, 95%CI: 1.35–7.81, P ¼ 0.008). In addition, dentists with less than 5 years of experience were 2.31 times more likely to have an appropriate level of knowledge than dentists with over 20 years of experience (OR 2.31, 95%CI: 1.07–4.97, P ¼ 0.03). Dentists worked in public dental health service were 1.62 times more likely to have an appropriate level of radiation protection knowledge than those in private practice (OR 1.62, 95%CI: 1.01–2.61, P ¼ 0.047).

**Table (3): Social demographic and professional characteristics of participants with dental radiation protection knowledge**

| Items | Univariate analysis | | | | | |
|---|---|---|---|---|---|---|
| | OR | 95%CI | P-value | OR | 95%CI | P-value |
| **Gender** | | | | | | |
| Male | 1.15 | 0.72–1.84 | 0.54 | | | |
| Female | 1 | | | | | |
| **Age (years)** | | | 0.046 | | | 0.85 |
| ≤ 29 | 3.25 | 1.35–7.81 | 0.008 | 1.78 | 0.31–10.37 | 0.52 |
| 30 -39 | 2.31 | 0.96–5.56 | 0.06 | 1.29 | 0.26–6.20 | 0.74 |
| 40 -49 | 1.85 | 0.71–4.87 | 0.21 | 1.28 | 0.33–4.97 | 0.71 |
| ≥ 50 | 1 | | | 1 | | |
| **Years of experience (years)** | | | 0.12 | | | 0.86 |
| <5 | 2.31 | 1.07–4.97 | 0.03 | 1.31 | 0.27–6.36 | 0.74 |
| 5-10 | 2.37 | 1.09–5.14 | 0.029 | 1.63 | 0.39–6.76 | 0.49 |
| 11-20 | 1.71 | 0.76–3.93 | 0.2 | 1.37 | 0.394.78 | 0.62 |
| >20 | 1 | | | 1 | | |
| **Dentist Qualification** | | | | | | |
| GDP | 0.54 | 0.33–0.86 | 0.011 | 0.51 | 0.27–0.94 | 0.03 |
| Specialist | 1 | | | 1 | | |
| **Workplace setting** | | | | | | |
| PDHS | 1.62 | 1.01–2.61 | 0.047 | 0.94 | 0.50–1.79 | 0.87 |
| PP | 1 | | | 1 | | |
| **RPC training** | | | | | | |
| Yes | 2.53 | 1.59–4.03 | <0.0001 | 2.40 | 1.47–3.93 | <0.0001 |

| Items | Univariate analysis | | | | | |
|---|---|---|---|---|---|---|
| | OR | 95%CI | P-value | OR | 95%CI | P-value |
| No | 1 | | | 1 | | |

Note: OR. Odds ratio; CI: Confidence interval; PDHS: Public Dental Health Service; PP: Private Practice; GDP: General Dental Practitioner; RPC training: Radiation Protection Continuous training.

The result of multivariate logistic regression analysis showed that dentist qualification (OR 0.51, 95%CI: 0.27–0.94, P ¼ 0.03) and continuous training (OR 2.40, 95% CI: 1.47–3.93, P<0.0001) were significant predictors of knowledge (Table 3), while workplace setting (OR 0.54, 95% CI: 0.32–0.93, P ¼ 0.027) and knowledge score (OR 1.24, 95% CI: 1.12–1.38, P<0.0001) were predictors of practices (Table 4).

**Table (4): Social demographic and professional characteristics of participants with dental radiation protection practices**

| Items | Univariate analysis | | | Multivariate analysis | | |
|---|---|---|---|---|---|---|
| | OR | 95% CI | value | OR | 95%CI | P-value |
| Gender | | | | | | |
| Male | 1.27 | 0.79–2.06 | 0.32 | | | |
| Female | 1 | | | | | |
| Age (years) | | | 0.49 | | | |
| ≤29 | 0.71 | 0.32–1.61 | 0.42 | | | |
| 30–39 | 1.04 | 0.47–2.29 | 0.92 | | | |
| 40–49 | 1.01 | 0.51–2.01 | 0.41 | | | |
| ≥50 | 1 | | | | | |
| Years of experience (years) | | | 0.79 | | | |
| <5 | 0.97 | 0.47–2.00 | 0.94 | | | |
| 5–10 | 0.76 | 0.36–1.60 | 0.46 | | | |
| 11–20 | 1.004 | 0.46–2.19 | 0.99 | | | |
| >20 | 1 | | | | | |
| Dentist qualification | | | | | | |
| GDP | 1.17 | 0.72–1.91 | 0.52 | | | |
| Specialist | 1 | | | | | |
| Workplace setting | | | | | | |
| PDHS | 0.61 | 0.36–1.03 | 0.06 | | –0.93 | 7 |
| PP | 1 | | | | | |
| RPC training | | | | | | |
| Yes | 1.10 | 0.69–1.76 | 0.68 | | | |
| No | 1 | | | | | |
| Knowledge score | 1.22 | 1.10–1.35 | <0.0001 | | | <0.0001 |

Note: OR. Odds ratio; CI: Confidence interval; PDHS: Public Dental Health Service; PP: Private Practice; GDP: General Dental Practitioner; RPC training: Radiation Protection Continuous training.

**Discussion:**

According to the study's findings, only 34.3% of the 320 dentists were aware of the ALARA principle, and only 29.2% were aware of the worldwide radiation protection guidelines. This low and concerning result highlights the need for greater emphasis on teaching dentistry students and professionals these crucial concepts. These results were consistent with other research that indicated dentists did not follow the worldwide radiation protection guidelines or the ALARA principle12 [19]. However, some research indicated that dentists were more aware of these guidelines and principles [34, 35]. According to the optimization principle, dentists should take all practical steps to minimize needless exposure to themselves, their employees, and their patients.

The ALARA principle states that ionizing radiation exposure should be kept to a minimum. [36]. This study showed also that 73.9% of participants thought that dental X-rays are harmful, while 15.7% did not. This concerning result is consistent with previous studies [19, 34]. Whereas some studies reported that dental X-rays are harmful, more than 80% of dentists agreed that [35, 37]. The salivary and thyroid glands are among the most radiosensitive organs in dental radiology, and it is generally acknowledged that X-rays can negatively impact biological tissue. In particular, the salivary glands often lie within the primary beams in both intraoral and panoramic radiography [38].

Regarding the most sensitive organ towards radiation 66.6% of participants selected the thyroid gland, 40.3% selected the salivary gland, while 15.3% said that bone marrow and brain are the most vulnerable tissue. Assiri et al., (2020) [39] reported roughly the same results. Whereas, Yurt et al., (2022)[18] indicated that 66.7% of their subjects' study selected the salivary gland, while 9.1% chose thyroid as the most sensitive body organs during oral radiation. Pediatric patients have a higher average risk of developing cancer compared with adults receiving the same dose. The longer life expectancy in children allows more time for any harmful effects of radiation to manifest, and developing organs and tissues are more sensitive to the effects of radiation [40].

The 2022 IAEA safety report noted that pediatric exposures require special consideration due to the higher effective dose compared to adults for an identical set of exposure parameters, owing to smaller size.5 In the present study, only few participants knew that for the same external exposure, the radiation dose and the risk of cancer induction in children are higher than that in adult (35.6% and 29.1% respectively). Whereas, Zakirulla et al., (2020) [41] reported that 83% of participants agreed that children are at a higher risk of harm from radiation than adults. The recommended dose limit for radiation workers, including dental workers, is 20 mSv for annual effective dose (whole-body) [11]. In KSA the dose limits and classification of occupational exposed workers are defined in second legislation in accordance with international legislation.

The majority of dentists (68.2%) were unaware of the annual radiation dose limit for a dentist in mSv. This finding was in agreement with study conducted by Enabulele et al., (2013)[17] showed that 100% of the participants did not know about the international legislation on limits for healthcare workers radiation. However, in Kingdom of Saudi Arabia (KSA) Mahabob et al., (2021) [35] showed that 81% of the participants were conscious about it. As regards the awareness of radiation regulatory agency, 89.68% of participants were not aware about it. Similarly, another study conducted Azodo et al., (2015) [42] showed that 77.1% of participants were unaware of the agency in charge of radiation protection. In opposition, Binnal et al., (2013) [43] reported that 59.8% of dentists were aware of the governing bodies of radiation protection.

Details of radiographic equipment and technique are essential to dental radiation protection practices. The tube voltage affects the image quality and the radiation doses [44, 45]. A kilovoltage of around 60–70 kV for intraoral radiography is considered to be a reasonable compromise choice in terms of limiting dose and all-round diagnostic efficacy [45-47]. It is worrying to report that 69.5% of dentists didn't know the kVp of their equipment, and of those that did only 11% operated between 60 and 70 kVp. Similar data have also been reported in other reports [47, 48]. However, Asha et al., (2015) [49] showed that most dentists used kVp settings between 65 and 70 kVp, which are in accordance with the guidelines. To reduce patient's ionizing radiation, increasing the distance from the focus-to-skin (FSD) by using a long cone (30 or 40 cm) is associated with significantly lower patient doses compared to a shorter cone with an FSD of 20 cm [50].

The present study showed that 47.5% of dentists worked with a long cone radiographic machine. Same findings were seen in some studies [43, 47]. Additionally, the size of the X-ray beam exiting the cone orifice should have approximately the size of the X-ray film. Therefore, rectangular collimator was recommended instead of the round one [42]. A recent systematic review showed that using rectangular collimator reduces radiation dose to the patient of at least 40% [51]. Senior et al., (2020) [52] reported that rectangular collimator increases the quality of the image by reducing dispersion. Thus, rectangular collimation should always be used for intraoral radiography.

The present study showed that large group of practitioners used collimators; but only 11.3% of them used rectangular collimators. The percentage of dentists using rectangular collimators was described as low in many countries including Brazil (0) [9], Turkey (9.1%) [18], Pakistan (17%) [47] and Australia (5%) [53]. Senior et al., (2020) [52] reported that 75%, of private Canadian dentists (60 out of 80) were aware of the importance of rectangular collimation in reducing radiation dose, but only 12.2% used it systematically for intraoral imaging. This could be due to lack of training to use rectangular collimation or a resistance to change an established dental practice behavior [52].

## Conclusion

According to the study's findings, practicing dentists' knowledge and methods are still insufficient to uphold suitable radiation protective barriers and adhere to the ALARA principle. Nonetheless, enhancing dentists' understanding of radiation safety precautions and equipment, together with dose reduction strategies, may improve their safe practices. The current study's findings indicate that dentists in practice are following certain safe radiation protection procedures, and they ought to be persuaded to follow the guidelines for X-ray safety.

Additionally, training improves the knowledge of individuals. Therefore, it is highly advised to regularly host seminars and continuing education courses on dental radioprotection, with a focus on current studies and procedures. In addition to requiring qualified and accredited radiation protection training for dentists who have X-ray equipment in their offices, the responsible authorities in this field should make sure that the dental and medical curricula further develop the fundamental training in radiation protection for patients and professionals.

Artificial intelligence and DRLs as optimization tools, radiation vigilance and quality control regulations, ionizing radiation and factors influencing the biological effects of exposure, doses typically administered in dental radiology, the significance of radiation protection and the application of these principles in daily practice, and intervention with at-risk populations like children and pregnant women must all be emphasized in these training programs (basic and continuing).

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