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Knowledge And Practices Among Dentists Towards Radiation Protection

Muteb Husain Mohsin Alsarani[1], Hamad Hussain Ali Alharbi[2], Mosa Hussien Jordi Tohari[3], Abdullah mohana alyabes[4], Bandar jayez kalof alanezi[5], Eman Mohammad Khalid Marghalani[6], Rayan Abdullah Yousef Aljawi[7], Eyad Mohammad Khalid Marghalani[8], alanoud Sughayyir Lafi ALANAZI[9], Magdi Mohammad Ali Musal Almazroi[10], Ali Hasan Alamry[11], Naifah Khudhaier Alenezi[12]

Abstract

Background: *It is a known fact that ionizing radiation has various biological harmful effects. Dentists routinely depend on radiographs in their clinical practice for diagnosis, treatment and follow-up of lesions. So, the dentists should be aware of different radiation protection techniques to minimize the radiation and it's after effects.* ***The study aims:*** *To analyze the current status of knowledge and practices among dentists towards radiation protection.* ***Methods:*** *A cross-sectional study based on a questionnaire related to knowledge and practice regarding radiation protection of patients and dental staff from January to March 2022. The study sample included 325 dentists practicing in Makkah, KSA. The target population consisted of all dentists working in public, semi-public and private workplaces. Results: 96.6% of dentists were aware of radiation protection. However, nearly 35% were aware of ALARA (as low as reasonably achievable) principle and 73.9% thought that dental X-rays are harmful. 63.6%of subjects used digital image receptor. Only 16.7% of them used a film holder and more than 60% didn't follow the position and distance rule. The median knowledge score was 7 [5, 9], and there was a statistically significant difference ac- cording to dentist qualification (P ¼ 0.007), dental radiation protection 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[1] 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 protection measures and tools as well as dose*

[1]Dental assistant technician,Ministry of Health, Al-Nabhaniya General Hospital, Saudi Arabia.
[2]Radiological Technology,king Abdulaziz Hospital, Saudi Arabia.
[3]Assistant pharmacist,Ahad Almsarah General Hospital, Saudi Arabia.
[4]X-RAY Technician, Al Quwayiyah General Hospital, Saudi Arabia.
[5]Radiology specialist, Rawidat Al Ardah Hospital, Saudi Arabia.
[6]Resident Dentist,East Jeddah General Hospital , Saudi Arabia.
[7]Resident dentistAlwash'ha primary health care center, Saudi Arabia.
[8]Resident Dentist,Kelakh Primary health care center , Saudi Arabia.
[9]Dental assistant, Sulaymaniyah Center, Saudi Arabia.
[10]Radiography Technician Department, Khulais General Hospital Makkah Health Cluster, 11Ministry of Health, Saudi Arabia
[12]dentist, Altala'a PHC, Saudi Arabia.
[13]x-ray ,Al-Quwayiyah General Hospital, Saudi Arabia.

reduction techniques could increase their safe practices in dental radiology.

Introduction

Radiation is the transmission of energy through space and matter. It may occur in particulate or in electromagnetic radiation. Electromagnetic radiation is the movement of energy through space as a combination of electric and magnetic fields. It is generated when the velocity of an electrically charged particle is altered. ϒ-rays, X-rays, U.V. rays, visible light, infrared radiation, microwaves and radio waves are all examples of electromagnetic radiation. The types of radiation in the electromagnetic spectrum may be ionizing or nonionizing, depending on their energy [(1-5)]. The fact that ionizing radiation has various biological harmful effects, by the production of free radicals thus affecting the cell directly or indirectly, leading to DNA damage, including single or double-strand breaks, and or DNA cross-links. X-radiations are detrimental to cells of the human body and are adequately powerful and lead to cancer, leukemia and even genetic damage [(1, 2)].

Radiology has become a major field in diagnostic application in both medicine and dentistry. Radiographs play a critical diagnostic role in dentistry. This field has grown enormously with the rapidly expanding range of imaging modalities like Cone Beam Computed Tomography (CBCT) Computed Tomography (CT), orthoscopic super-high resolution CT (Ortho-CT) for studying different dental pathologies [(1, 5)]. Radiographs are an integral part of the diagnostic process in clinical dentistry and the most commonly ordered test in the preliminary examination [(6)]. Although radiation doses from dental X-rays are relatively low, any increased health risk associated with dental X-rays would be of considerable public health concern, given the high lifetime prevalence and frequency of these examinations [(7)].

In view of this, no radiation exposure can be considered risk-free. Even if the risk of occurrence of a primary cancer resulting from exposure during conventional dental radiography is considered negligible, the risks related to cumulative doses should not be underestimated [(8, 9)]. Unlike the rest of medicine, the dental X-ray examinations tends to be performed more on children and younger people, whose teeth and dentition are still developing and for whom the risks are highest [(10)]. Despite its useful outcomes, dental radiography has the potential to be harmful [(9)]. In several studies, it has been associated with an increased risk of thyroid cancer [(11, 12)]. Hwang et al., (2018) [(13)] showed in a systematic review the evidence of increased risk of head and neck cancer due to exposure to low doses of dental X-ray and emphasize that accumulative exposure to low-dose radiation from dental X-rays cannot be ruled out and cannot be ignored.

The International Atomic Energy Agency (IAEA) recommended that patient exposure must be justified and kept to the minimum necessary to achieve the desired diagnostic or objective [(10)]. The ALARA (as low as reasonably achievable) principle must therefore be followed in the dentist's daily work to avoid any unnecessary exposure to radiation [(14)]. 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 [(15)].

Dentists use X-rays in their practice on a daily basis. Their knowledge and behavior in relation to the X-ray examination can influence the radiation exposure of patients and themselves. In order to limit and combat the risks associated with the use of ionizing radiation in dentistry; dentists must adhere to the principles and rules of radiation protection and safety. However, numerous studies conducted among dental practitioners have shown that their knowledge and behavior regarding radiation protection are not satisfactory [(8, 16-18)].

In Saudi Arabia, a study was conducted in King Khalid University Hospital and King Fahad Medical Hospital in Riyadh which included 157 physicians. It was revealed that 58.6% of participants lacked knowledge about radiation dose for many common radiological examinations. Interestingly, there was no variation in the knowledge among radiologists and other physicians [(19)]. Another study conducted in 20 cities in Saudi Arabia with more than 450 physicians showed that about 30% of the participants have received education about radiation protection. Moreover, all these results clearly demonstrated the lack of knowledge and awareness physicians have. As a result, this leads to radiation abuse and might subject the patient's health to a potential risk of cancer [(20)]. In Saudi Arabia, a number of health care facilities showed a lack of essential radiation protection equipment such as lead glasses and shields [(21)].

Despite the growing interest in radiation protection for patients and healthcare professionals [(22)], there's a lack of data collected specifically on dental practitioners in terms of radiation protection. This gap in the literature emphasizes the need for further research in this area to better understand the current practices, level of knowledge, and adherence to radiation protection guidelines among dentists. Therefore, this study aimed to analyze the status of knowledge and practices towards radiation protection among dental practitioners.

Methods

A cross-sectional study based on a questionnaire related to knowledge and practice regarding radiation protection of patients and dental staff from January to March 2022. The study sample were dentists working in public/semi-public and private work- places setting included dentists practicing in Makkah, KSA. Ethical approval was received from the Ethical Committee of the University. 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)]. The final targeted practitioners sample size was 325 dentists [(28)].

Data collection tool: The questionnaire in the form of multiple choices questions was developed after a review of the literature relevant to knowledge and practices regarding radiation protection in dentistry [(19, 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 4 dentists, 1 epidemiologist, 2 professors specialized in medical physics, 1 radiation protection 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)].The 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.

Participants were invited and encouraged to participate in the study through direct contact with the researcher or via phone call, emails and short message service (SMS). The questionnaire was used to collect data either by hard copy or electronic file sent via email and social media platforms (What Sapp, Facebook) to inaccessible areas after phone contact with practice managers. The electronic self-administered questionnaire was designed via Microsoft forms. The predominate form of data collection being distributed and collected by the principal investigator in accessible areas.

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 protection continuous training). The second part had 13 questions that evaluate the knowledge of dentists about radiation protection. The third part had 11 questions related to their practices towards radiation protection.

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 version 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 protection 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 protection knowledge and practices. Statistical results were considered significant at $P < 0.05$.

Results

Descriptive data

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 protection during their studies, and 49.1% of them had received continuous training in dental radiation protection.

In terms of the radiographic equipment available in their practice, 87.2% of participants had intra-oral radiography equipment, 28.1% of them had extra-oral radiography equipment and 11.9% had mobile or hand-held device.

Radiation protection knowledge and practices among dentists

Results of radiation protection knowledge among dentists are summarized in **Table (1)**. 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 (P ¼ 0.061). 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, **Table 1**).

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.

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%).

The results showed also that film holders were not in common use with 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 periodical 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.

In univariate analysis, the knowledge score was observed to decrease with age and years of professional experience (**Table 2**). 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). 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 3**).

Table (1): Knowledge of participants towards dental radiation protection [n(%)].

Knowledge items	**Responses**	**RPC training**		**P-value**	**Dentist qualification**	**Specialist**	**P-value**
		Yes	**No**		**G.D.P**		
Awareness of radiation protection	Yes	154 (98.7)	152 (94.4)	0.06	196 (95.1)	113 (99.1)	0.105
	No	2	9		10	1 (0.9)	

Knowledge items	Responses	RPC training		P-value	Dentist qualification	Specialist	P-value
		Yes	No		G.D.P		
		(1.3)	(5.6)		(4.9)		
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)	
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)	
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)	

Knowledge items	**Responses**	**RPC training**		**P-value**	**Dentist qualification**	**Specialist**	**P-value**
		Yes	**No**		**G.D.P**		
	Reproductive organs	42 (26.9)	40 (24.8)		55 (26.7)	28 (24.6)	
	Bonemarrow 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 Trainning. radiation protection continuous training; NRPC. National Radiation Protection Center; MHSP. Ministry of Health and Social Protection; [a] median [Q_1,Q_3].

Table (2): Social demographic and professional characteristics of participants with dental radiation protection knowledge

Items	OR	Univariate analysis 95%CI	. value	OR	Multivariate analysis 95%CI	P-value
Gender						
Male	1.15	0.72–1.84	54			
Female	1					
Age (years)			046			0.85
≤29	3.25	1.35–7.81	008	1.78	0.31–10.37	0.52
30–39	2.31	0.96–5.56	06	1.29	0.26–6.20	0.74
40–49	1.85	0.71–4.87	21	1.28	0.33–4.97	0.71
≥50	1			1		
Years of experience (years)			12			0.86
<5	2.31	1.07–4.97	03	1.31	0.27–6.36	0.74
5–10	2.37	1.09–5.14	029	1.63	0.39–6.76	0.49
11–20	1.71	0.76–3.93	2	1.37	0.394.78	0.62
>20	1			1		
Dentist Qualification						
GDP	0.54	0.33–0.86	011	0.51	0.27–0.94	0.03
Specialist	1			1		
RPC training						
Yes	2.53	1.59–4.03	).000 1	2.40	1.47–3.93	<0.0 001
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

Table (43): Social demographic and professional characteristics of participants with dental radiation protection practices

Items	OR	Univariate analysis 95%CI	P-value	Multivariate analysis OR	95% CI	P-value
Gender						
Male	1.27	0.79–	0.32			

Items	OR	Univariate analysis 95%CI	P-value	Multivariate analysis OR	95% CI	P-value
		2.06				
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					
RPC training						
Yes	1.10	0.69–1.76	0.68			
No	1					
Knowledge score	1.22	1.10–1.35	<0.0001	1.24	1.12–1.38	<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

The results of this study showed that out of 320 dentists, only 34.3% knew about the ALARA principle, and only 29.2% were aware about the international radiation protection recommendations. This result is low and alarming and point out the necessity to more emphasized the education of dental students and dental practitioners alike on those important principles. These findings were similar to some studies that showed either a low adherence among dentists to the ALARA principle [17] or to the international radiation protection recommendations [18]. Whereas, other reports showed a higher level of awareness, regarding these recommendations and principle, among dentists [34, 35].

Based on the principle of optimization, dentists should use every reasonable means to reduce unnecessary exposure to their patients, their staff, and themselves. Based on ALARA principle, exposure to ionizing radiation should be as low as reasonably achievable [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 [28, 34]. Whereas, some studies reported that more than 80% of the dentist agreed that dental X-ray are harmful [35, 37]. Indeed, it is unanimously accepted that X-rays may affect badly biological tissue, and the salivary and thyroid glands are among the most radiosensitive organs in dental radiology [38].

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) [17] 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 [10]. 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) [10].

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) [16] in Nigeria, which 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 in Cameroon [42] showed that 77.1% of participants were unaware of the agency in charge of radiation protection in Cameroon. In opposition, Binnal et al., (2013) [43] reported that 59.8% of Indian dentists were aware of the governing bodies of radiation protection.

Patient doses should be kept as low as reasonably achievable. In dental radiography, patient dose limitation involves consideration of the X-ray equipment, the beam size and the image receptor. Optimization of each of these acts synergistically to substantially reduce doses [15]. Digital imaging may offer lower patient dose for intraoral radiography than conventional films ranged between 25% and 55% [44]. 63.6% of the participants used digital image receptor. Indeed, this equipment is becoming popular in dental offices, which is satisfactory, even if it is still less than in developed countries [39, 45]. But yet, it is higher than in some African countries or in Brazil, where the percentage of the use of digital receptors is ranging between 4.3% and 35.22% [8, 34, 42, and 46].

Low rates of digital image use by dentists in these studies may be due to many factors as the lack of knowledge, the high cost of equipment and the difficulty in mastering the techniques of digital image acquisition and processing. Details of radiographic equipment and technique are essential to dental radiation protection practices. The tube voltage affects the image quality and the radiation doses (47). A kilo voltage 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 (10, 15, 44). 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 (5, 46). However, Asha et al., (2015) (48) showed that most dentists used kVp settings between 65 and 70 kVp, which are in accordance with the guidelines.

The results of this study revealed that participants' knowledge scores decreased with age and years of professional experience. In a further finding, the knowledge score of dental specialists was significantly higher than that of general dental practitioners. These results are in line with those reported by Yurt et al., (2022) (17)

Conclusion

The study results indicate that the knowledge and practices adopted by practicing dentists remain insufficient to maintain appropriate radiation protection barriers and to comply with the ALARA principle. However, improving dentists' knowledge of radiation protection measures and tools as well as dose reduction techniques could increase their safe practices. Results from the current study suggest that practicing dentists are implementing some safe radiation protection practices and should be enticed and encouraged to conform to the rules of protection from X-rays.

Furthermore, training has a positive influence on participants' knowledge. It is therefore strongly recommended to organize regular workshops and continuing education programs in dental radioprotection, with emphasis on recent researches and protocols. The competent authorities in this field should also ensure that basic training in radiation protection for patients and professionals is further developed in the dental and medical curriculum, as well as requiring qualified and accredited training in radiation protection for dentists possessing X-ray equipment in their offices.

Emphasis must be placed in these training programs (basic and continuing) on: the importance of radiation protection and the implementation of these principles in daily practice, ionizing radiation and factors influencing the biological effects of exposure, doses usually delivered in dental radiology, artificial intelligence and DRLs as optimization tools, radiation vigilance and quality control rules, intervention with at-risk populations such as children and pregnant women.

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