EVALUATION OF RADIATION PROTECTION PRACTICES IN DENTAL RADIOGRAPHY AT KOMFO ANOKYE TEACHING HOSPITAL (KATH)

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DOI: https://dx.doi.org/10.4314/gdj.v22i2.6

ABSTRACT

BACKGROUND: The application of X-ray imaging in dentistry has undergone significant advancements since its inception in the 19th century. Dental radiographs are crucial for accurate diagnosis, effective treatment planning, ongoing monitoring, and comprehensive follow-up. Nonetheless, exposure to radiation during radiography procedures has dangers, requiring precautions for both patients and personnel. This study SEEKS to evaluate the compliance of dentists and radiographers with radiation protection protocols in dental radiography at Komfo Anokye Teaching Hospital (KATH).

MATERIALS AND METHODS: This descriptive cross-sectional study was conducted at KATH, with a total of 65 participants. The convenience sampling method was used. Data collection was facilitated through a questionnaire that assessed variables such as background information, knowledge, compliance, and factors affecting adherence to radiation protection protocol. Data analysis was performed using Statistical Package for Social Sciences (SPSS) version 27.0. Ethical approval was obtained with the number CHRPE/AP/176/24.

RESULTS: Most participants (67.7%) demonstrated a good understanding of radiation protection and the associated risks of radiation exposure. However, the majority (61.5%) of participants were not fully adhering to radiation protection protocols. The main obstacles to adherence were a lack of resources and the absence of standardized radiation protection guidelines.

CONCLUSION: The low level of adherence necessitates immediate strategic planning and the implementation of policies to enhance radiation safety at KATH.

KEYWORDS: Ionizing radiation, dental radiography, radiation protection, radiation exposure, adherence.

INTRODUCTION

Wilhelm Conrad Röntgen discovered X-rays on November 18, 1895[1], and Otto Walkhoff, assisted by Fritz Giesel, took the first dental radiograph on December 28, 1895[2]. As the test subject, Walkhoff experienced hair loss from radiation exposure[2]. Early reports of skin burns in patients and operators highlighted the urgent need for radiation protection, leading to the development of exposure-limiting protocols[3]. Any type of radiation exposure that can exert enough force on an electron to separate it from its atom and form an ion is referred to as ionising radiation[4]. It includes emissions from radioisotopes and X-rays. Despite its numerous positive applications in industry, research, medicine, and agriculture, ionizing radiation also poses a risk to human health if misused or not properly controlled[5].

Radiation Protection in Dentistry

Since the introduction of intraoral radiography, dental radiology has remained a vital tool for accurate diagnosis. Intraoral periapical and bitewing radiographs are commonly used, along with extraoral techniques such as cephalometric and panoramic imaging4. In recent years, digital imaging has increasingly replaced traditional film, offering lower radiation doses, quicker results, and improved patient communication[5]. Cone-beam CT (CBCT) is now widely preferred due to its affordability and lower radiation exposure compared to conventional CT[6]. Guidelines from bodies such as the American Dental Association (ADA)[7] and European authorities[8] help inform radiographic decisions. Operator safety protocols include radiation protection programs, the use of personal dosimeters, and the application of barrier shielding[9,10]. Standards from the International Commission on Radiological Protection (ICRP), the International Commission on Radiation Units and Measurements (ICRU)[3], and the International Atomic Energy Agency (IAEA)[11] support consistent global safety practices.

Current Situation in Ghana

Ghana's use of radioisotopes began in 1952, and the Radiation Protection Board (RPB) was formed under PNDC Law 308 in 1993[8]. Oversight transitioned from the Ghana Atomic Energy Commission (GAEC) to the Nuclear Regulatory Authority of Ghana (NRAG) under Act 895[12]. Schandorf et al. emphasized the importance of a strong safety culture and noted Ghana's potential to lead in radiation safety with IAEA support[13].

Knowledge of Radiation Protection and Dangers of Exposure to Radiation

In North Queensland, dentists demonstrated technical knowledge gaps despite high adherence to safety protocols (80.3%) and cautious radiographic use (95.2%)[14]. A study from the Medical University of Warsaw found that students and professionals had low awareness of radiation, although training improved outcomes[15]. Similarly, Moroccan research highlighted the need for an improved understanding of the "As Low As Reasonably Achievable" (ALARA) principle[16].

Degree of Compliance with Radiation Protection Protocol

Studies generally show moderate to high compliance. Using a five-point Likert scale, Panchbhai and Sonar found substantial adherence in dental radiology departments, consistent with Arnout et al.'s results[17]. However, Jacobs et al. highlighted ongoing gaps in meeting safety standards[18]. Aravind et al. observed that

while 83.3% of clinics had designated radiographic spaces, practical implementation of safety measures was lacking[19]. Yurt et al. noted that only 62% of dentists inquired about pregnancy prior to imaging[20]. In Ghana's Greater Accra region, lead aprons were the only universally available protection[21]. A 2021 study found that 90% of Ghanaian radiographers had dosimeters, but only 25% used them regularly; younger professionals were more likely to have received safety training[22].

Factors Influencing Adherence to Radiation Protection Protocol

Compliance is shaped by factors such as knowledge, workplace conditions, professional experience, and regulatory oversight[23]. Despite good attitudes toward radiation safety, Lewis et al. noted low compliance due to limited resources and insufficient institutional support[24]. The 2012 IAEA conference in Bonn emphasized the importance of evidence-based guidelines and clinical audits[25]. Although radiographers demonstrated positive attitudes, compliance remained suboptimal due to varying perceptions, resource constraints, and weak managerial support[26]. These findings underscore the need for ongoing education, regular inspections, and increased institutional support[27]. With growing patient concerns over radiation, this study aims to assess adherence to radiation protection protocols among dentists and radiographers at Komfo Anokye Teaching Hospital (KATH).

MATERIALS AND METHODS

Study Design and Site

This was a quantitative, descriptive, cross-sectional study conducted at Komfo Anokye Teaching Hospital (KATH). The study population consisted of all dentists in KATH and radiographers who operate orthopantomogram, lateral, and posterior-anterior cephalometric radiographic equipment in KATH. There were 70 dentists and four radiographers who fell within the category stated above per records from the oral health directorate and radiology directorate. They included:

- Dentists and radiographers are directly involved in dental radiological procedures.
- Dentists and radiographers employed or affiliated with Komfo Anokye Teaching Hospital.
- Dentists and radiographers who were willing to participate in the study and provide consent for data collection.

Dentists and radiographers were excluded if they declined consent, had not participated in dental radiographic procedures within the past six months, or were on prolonged leave (e.g., study, maternity, or medical leave) during the data collection period.

Sample Size Calculation

A sample was selected from the combined population of dentists and radiographers, comprising 74 individuals. Using Cochran's formula for sample size in a small finite population, a sample size of 62 was determined based on a standard deviation of 0.5, a 95% confidence level, and a 5% precision level. Allowing a non-response rate of 5%, the sample size becomes 105% * 62 = 65. A total of 65 questionnaires were administered.

A self-administered questionnaire was developed using closed-ended questions in line with studies conducted by Almohaimede et al.[16] and Panchbhai & Sonar.[18] The questionnaires were administered to eligible dentists and radiographers at the Komfo Anokye Teaching Hospital using a convenience sampling technique.

All gathered data were imported into Statistical Package for Social Sciences (SPSS) version 27.0 for analysis. The data were analyzed in terms of their knowledge, compliance, and the factors that influence their adherence to radiation protection.

Knowledge: The nine items in the knowledge section were scored on a two-point scale (1 = yes and 0 = no for questions requiring a positive answer and 0 = yes and 1 = no for questions requiring a negative answer). Entries were graded as having good knowledge or poor knowledge, using a mean score of 5.83 as the cut-off point.

Compliance: The six items on compliance were scored on a five-point Likert scale ranging from 1 to 5 (1 = always, 2 = very often, 3 = sometimes, 4 = rarely, and 5 = never for questions requiring a negative answer and 1 = never, 2 = rarely, 3 = sometimes, 4 = very often, and 5 = always for questions requiring a positive answer).

The final score for each scale was calculated by adding up the points obtained for the corresponding questions. Entries were graded as either good compliance or poor compliance, using a mean score of 16.97 as the cut-off point.

Factors: A proportional analysis was conducted on the entries in the section on factors influencing adherence.

Ethical Approval and Consideration

All participants provided informed consent, and the confidentiality of the study was maintained at all times. Participants received an explanation of the study's goals, risks, and participation requirements before completing the structured questionnaires. All information gathered from this survey remained fully anonymous. Ethical approval was obtained from the Committee on Human Research, Publication, and Ethics (CHRPE) at Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana, under reference number CHRPE/AP/176/24.

RESULTS

Demographic Characteristics

A total of 65 respondents participated in the study, with a slightly higher representation of males (55.4%) than females (44.6%). The majority of respondents (93.8%) were dentists, while 6.2% were radiographers. Regarding job positions, house officers constituted the largest group (38.5%), followed by medical officers (23.1%) and specialists (13.8%). A small proportion of respondents were senior medical officers (9.2%), principal medical officers (6.2%), and consultants (3.1%).

In terms of professional experience, 40.0% had been practicing for less than a year, while 26.2% had between 1 and 5 years of experience. Those with 6-10 years of experience comprised 20.0% of the sample, whereas 6.2% had 11-15 years of experience, and 7.7% had more than 15 years of experience.

Knowledge of Radiation Protection and Dangers of Exposure to Radiation

Most participants (67.7%) demonstrated a good understanding of radiation protection and the risks associated with radiation exposure. This indicates that a significant portion of the study population is well-informed about the necessary safety protocols and the potential dangers of radiation, suggesting effective education and training within this group. A substantial minority (32.3%) of participants have poor knowledge in this area. This

highlights a significant gap in understanding that could lead to non-compliance with safety protocols and increased risk of radiation exposure. Figure 1 illustrates the details of participants' responses regarding their knowledge of radiation protection and the associated dangers of radiation exposure.

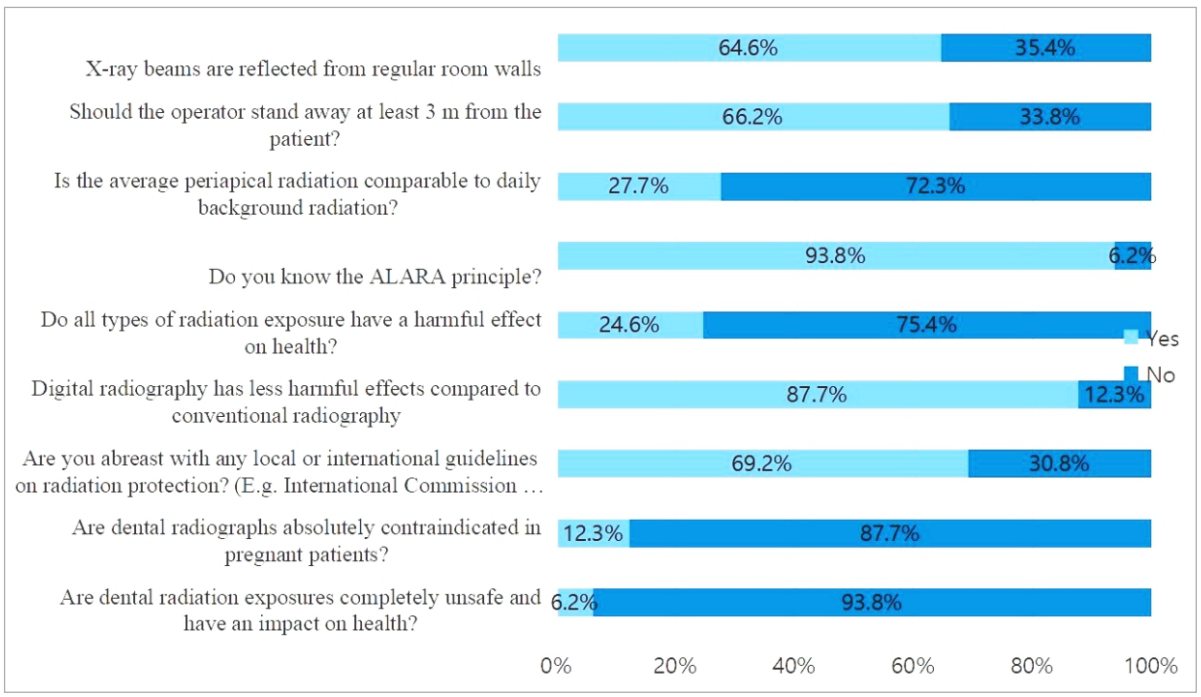

Figure 1: Knowledge of radiation protection and dangers of exposure to radiation

Degree of Compliance with Radiation Protection Protocol

The responses on compliance rates of participants in adhering to radiation safety protocols were graded using the Likert scale. This shows that a significant majority of participants are not fully adhering to the protocols, with more than half (61.5%) demonstrating poor compliance. Figure 2 also shows the details of participants' responses regarding the degree of compliance with the radiation protection protocol.

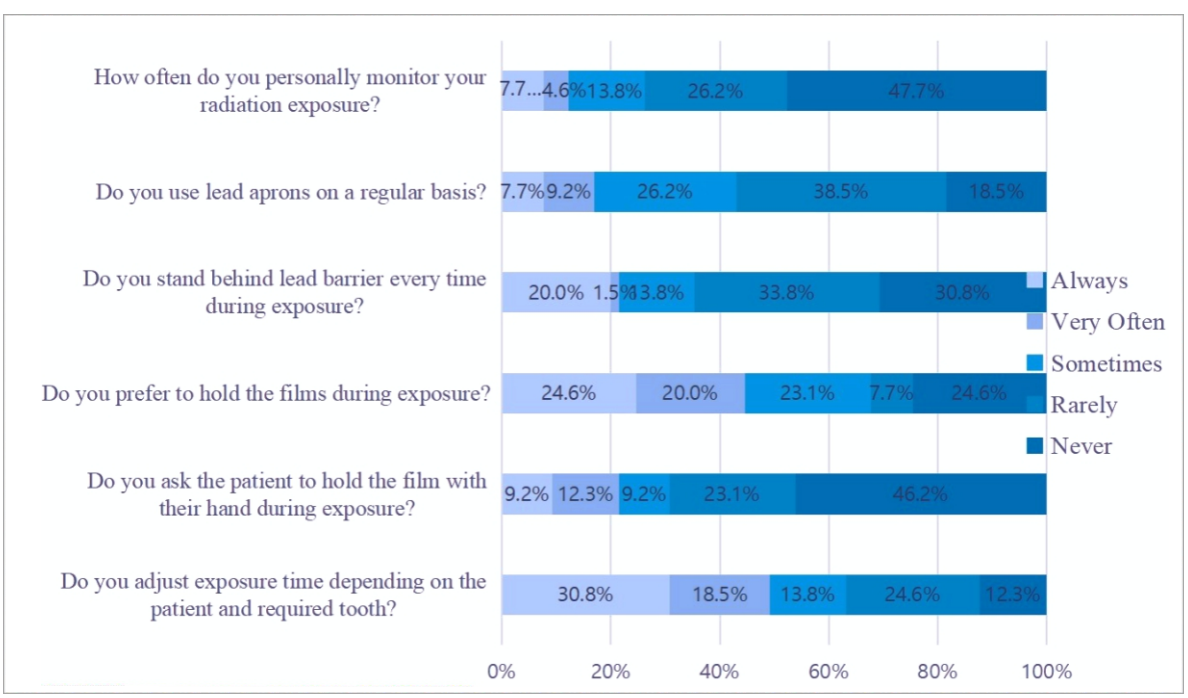

Figure 2: Compliance with radiation protection protocol

Additionally, all radiographers demonstrated good compliance, whereas more dentists showed poor compliance. This data highlights the need for improved training and reinforcement of radiation safety measures among dentists and radiographers (Figure 3).

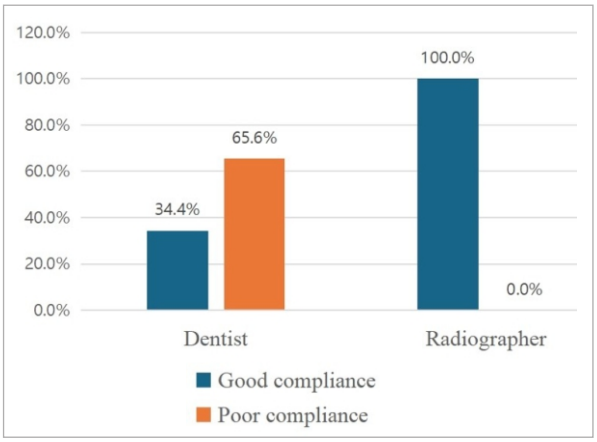

Figure 3: Degree of compliance in dentists versus radiographers

Factors Influencing Adherence to Radiation Protection Protocol

The most common barriers to adherence were the lack of needed resources (44.4%) and the lack of standardized protocols (32.3%). Fear of developing cancer (41.7%) is the most significant motivator for adherence, followed by recommendations from education and literature (29.6%). All participants were aware of the potential risks associated with non-adherence to radiation protection protocols.

The study also showed that a significant proportion of respondents do not receive regular training in radiation protection protocols. Notably, 43.1% reported never receiving training, while 33.8% stated they rarely received it. Only 15.4% of participants indicated they sometimes received training, and 7.7% reported receiving training very often. These findings suggest a gap in ongoing radiation safety education, highlighting the need for more structured and frequent training programs to ensure compliance with radiation protection standards (Figure 4).

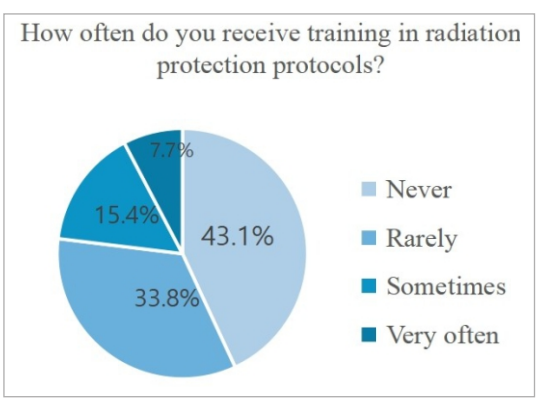

Figure 4: Adequacy of training for radiation protection

The survey results reveal varying perceptions regarding the adequacy of resources available for adhering to radiation protection protocols. A significant proportion (40.0%) of respondents felt only slightly equipped, while 30.8% reported being moderately equipped. However, 23.1% indicated that they were not equipped at all, highlighting a concerning gap in resource availability. Only a small fraction (6.2%) of respondents felt very well-equipped. These findings suggest the need for improved resource allocation and support to enhance adherence to radiation protection protocols in clinical practice (Figure 5).

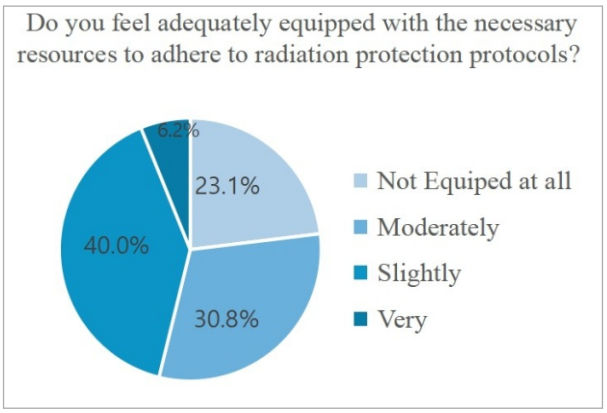

Figure 5: Adequacy of resources for radiation protection

A comparison of compliance levels between dentists and radiographers revealed a significant difference. While all radiographers demonstrated good compliance, a substantial number of dentists showed poor adherence to radiation protection protocols. Using Fisher's Exact Test, a statistically significant association was found between job category and compliance level ($p = 0.030$) (See Table 1), indicating that radiographers were significantly more compliant with radiation safety standards compared to dentists.

Table 1: Cross-tabulation of job category and compliance level with Fisher's Exact Test

	Good Compliance (O)	Poor Compliance (O)	Total
Dentist	24	37	61
Radiographer	4	0	4
Total	28	37	65
Fisher's Exact Test p-value	0.03		

DISCUSSION

Knowledge of Radiation Protection and Dangers of Exposure to Radiation

The majority of participants (67.7%) in this study, who demonstrated a high level of knowledge, reflect the effectiveness of current education programs. For this degree of awareness to be sustained and raised, these programs must be continuously reinforced. Almohaimede et al.16 concluded, based on similar results, that radiation awareness among dentists and radiographers was lacking. On average, dentists correctly answered 64% of the 13 knowledge-based questions, while radiographers achieved an accuracy rate of 62%. Only 46 dentists (48%) and 40 radiographers (45%) achieved nine or more correct answers. They had high expectations for the respondents, as the questions were straightforward and focused on general knowledge rather than specialized academic information. None of the questions required precise numerical data, and only a few were theoretical and not directly applicable to everyday practice 16. Nevertheless, a systematic review by Behzadmehr et al. 28 revealed that in over 50% of the studies (18 out of 33), participants had sufficient knowledge of radiation protection.

A serious cause for concern is the 32.3% of participants who lacked sufficient knowledge. This is similar to the study carried out in North Queensland, where 27% of dentists incorrectly answered knowledge-based

questions on average. This pointed to a widespread knowledge deficiency among private dentists in North Queensland[15]. Although not statistically significant, those with the least experience had the highest rate of incorrect answers to knowledge questions[15]. A targeted educational intervention is necessary to bridge the knowledge gap and address the existing shortcomings. All dental professionals must have access to comprehensive and current radiation safety training.

This finding aligns with previous research by Elmorabit et al.[17], which also identified a correlation between insufficient training and poor adherence to radiation safety protocols. These results suggest that limited continuous education may lead to knowledge gaps and poor compliance, thereby increasing the risks of radiation exposure. Enhancing regular training and reinforcing radiation safety education could improve adherence to safety standards.

Degree of Compliance with Radiation Protection Protocol

Sixty-one and a half percent (61.5%) of participants, all of whom were dentists, demonstrated poor compliance with radiation safety protocols, which is alarming. This poor adherence could lead to increased risks of radiation exposure for both patients and healthcare workers. Non-compliance with safety protocols can result in harmful consequences, including increased radiation doses to patients, potential health risks for practitioners, and legal and ethical issues for the healthcare providers involved. This is in stark contrast to other studies, such as one carried out by Panchbhai and Sonar[18], in which the majority of participants (86.5%) consistently used personal protection devices and radiation safety measures, including the wearing of lead aprons, thyroid shields, and lead goggles. The majority of the participants(90.2%) in that study consistently wore radiation dosimeters while in the radiology department, indicating good adherence to radiation safety protocols in the dental radiology department. These findings correspond with those from similar studies by Aravind et al.19, Arnout et al.[20], and Sarman Hassan.[25] This study reveals notable gaps in protocol adherence at KATH. The significant difference in compliance between dentists and radiographers, confirmed by Fisher's Exact Test ($p = 0.030$), suggests that radiographers, likely due to their more focused training in radiological safety, consistently demonstrate superior adherence to safety guidelines and highlights the need for targeted continuous education and institutional support, particularly for dental professionals, to enhance overall compliance with radiation protection protocols.

Factors Influencing Adherence to Radiation Protection Protocol

The main barrier to adherence was the lack of necessary resources, including protective equipment, updated technology, and training materials. Addressing this gap is crucial for improving compliance and ensuring safety. Another key barrier was the absence of standardized protocols, which made it challenging for practitioners to implement consistent radiation safety measures. Establishing and disseminating clear guidelines would promote a uniform approach to safety. The most significant motivator for adherence was fear of developing cancer, likely due to participants' awareness of the risks associated with non-compliance. Recommendations from education and literature also played an important role, emphasizing the impact of continuous education and current research on promoting safe practices, as supported by the conceptual framework of this study. These findings differ slightly from those of Sarman and Hassan[25], who identified knowledge, work site, years of experience, and inspection as major factors, but are similar to those noted by Lewis et al.[26]

CONCLUSION

While most participants demonstrated a good understanding of radiation protection, the presence of a notable minority with inadequate knowledge highlights the urgency for targeted educational interventions. The study reveals significant deficiencies in compliance, necessitating immediate attention from stakeholders. Lessons from settings with higher adherence levels suggest that structured strategies can drive improvements. The primary barriers identified—lack of resources and standardized protocols—must be addressed to bridge the compliance gap. Key motivators for adherence include concerns about radiation-induced cancer and guidance from education and literature. While awareness of radiation risks is high, overcoming structural challenges through better resource allocation, implementation of standardized safety protocols, and continuous professional education is essential to achieving improved compliance and ensuring occupational and patient safety.

LIMITATIONS OF STUDY

In this study, dentists and radiographers submitted self-reported data. Inaccurate responses may have introduced errors due to recall bias. There was a huge difference between the number of dentists and radiographers, and this could have hindered accurate analysis of the data collected.

RECOMMENDATIONS

- Resource Allocation – Ensure dental and radiology departments have adequate protective gear, modern equipment, and comprehensive training materials.
- Standardized Protocols – Develop and update clear, accessible radiation protection guidelines based on current research and technology.
- Education & Training – Implement mandatory CPD programs, workshops, and curriculum updates to emphasize radiation safety.
- Monitoring & Feedback – Establish a system to track adherence to safety protocols and provide feedback to improve compliance.

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