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Local Diagnostic Reference Levels for Intraoral and Panoramic X-ray Examinations in Government Dental Centers in Abu Dhabi

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Abstract:- **Background:** With an enormous rise in the number of clinics and health facilities in the United Arab Emirates providing treatments or cosmetic gum surgery procedures to patients, there is an urgent need to create Diagnostic Reference Levels (DRLs) in dentistry. As a result, this study aims to determine the local DRLs for pediatric and adult patients undergoing intraoral and panoramic dental examinations at government dental centers in the Abu Dhabi region.

Methods: This study measured the incident air kerma ($K_{a,\ i)}$ using radiographic exposure parameters for intraoral dental radiography. It also collected dose area product (DAP) values for actual patients from the panoramic unit system to establish diagnostic reference levels (DRLs) for both.

Results: Recommended DRL values for intraoral radiography of the adult maxillary incisor, adult mandibular molar, adult bitewing X-ray, pediatric maxillary incisor, and pediatric mandibular molar are 0.714, 0.837, 1.042, 0.343, and 0.365 mGy, respectively. Also, the DRLs for dental panoramic radiography for pediatric and adult patients are 39.19 and 68.59 (mGy cm^2), respectively.

Conclusion: After this initial study, we will create a standardized benchmark and propose an update on national diagnostic reference levels (DRLs) for intraoral and panoramic radiography in dentistry for other areas of the UAE.

Keywords*:* DRL, Dental Radiology, Intraoral, OPG, Adult dental DRLs, pediatric dental DRLs, dose area product, incident air kerma.

1. Introduction

Radiography is considered an essential tool in dentistry; however, recent reports and studies have raised concerns about its use due to the dramatic increase in the number of people visiting dental clinics for treatment or cosmetic gum surgery procedures, as well as the publication of numerous reports and studies suggesting possible overuse and overdose of radiation in some healthcare settings. All of that has raised concerns among patients and practitioners about the widespread use of radiation and its risks [1]. For that, the International Commission on Radiation Protection (ICRP) recommends using DRLs to enhance radiation protection during medical exposures to avoid unnecessary high doses patients receive [2].

The term "optimization" refers to ensuring that the dose delivered to the patient is the lowest necessary for getting the appropriate diagnostic imaging output. A DRL is a patient dose level defined in ICRP 135 as a level of patient exposure for a typical examination of a group of standard-sized individuals using a wide range of types of equipment [2].

Specific X-ray examinations have radiation dose values (DRLs) that should not be routinely exceeded for average-sized individuals if appropriate radiography practice is followed. If doses consistently exceed these recommendations, corrective measures should be pursued. DRLs were initially used in the UK four decades ago [2] and have recently been shown to be an effective dose-reduction technique, with radiation levels reducing by 16% (from 2000 to 2005 surveys) and 50% in the UK since their use in the 1980s [3]. In addition, diagnostic reference levels (DRLs) are a dose optimization tool in medical imaging. The International Commission on Radiological Protection (ICRP), the American College of Radiology, the American Association of Physicists in Medicine, the Health Protection Agency, and the International Atomic Energy Agency are just a few prestigious professional and international organizations that support these levels. As a result, diagnostic reference levels (DRLs) for all radiological procedures, including dental radiography, must be established. In large hospitals. Some countries assess DRL utilization during the licensing procedure, when establishments must report their average doses, and during routine inspections. Regulators and inspectors, the vast majority of whom have a background in medical physics, cover this topic in their training [4]. In UAE, "Medical Licensees are also required to conduct a review if typical Doses or activities for a given radiological procedure exceed or fall substantially below relevant Diagnostic Reference Levels" [FANR 007]

Many countries have established National Diagnostic Reference Levels (NDRLs) for dental radiography for many routine examinations, with differing for adults and children. Dental X-ray equipment, with fixed exposure parameters and collimation, is frequently far less complicated than standard diagnostic medical X-ray equipment, resulting in minimal change in patient exposure for the same test. Establishing Diagnostic Reference Levels (DRLs) involves ascertaining the radiation dose levels administered during specific medical procedures across several institutions within a single nation. Once the data has been collected, this country's examination-specific Diagnostic Reference Levels

DRLs are subsequently computed, often using the 75th percentile of the dose distribution. As a result, the techniques and equipment used in each country are unique. Prioritizing image quality and assessing clinical image quality when establishing DRLs is crucial recommend using objective and subjective image quality evaluations to ensure that DRLs optimize both dose and image quality [5].

2. Materials and Methods

DRLs assessments were performed on 34 intraoral and eight panoramic units installed in various government dental centers in Abu Dhabi, UAE. These dental organizations were chosen based on their workload and clinical experience. Before initiating the measurements in dental facilities, we distributed a questionnaire to the various centers, gathering information on the typical imaging exposure parameters, radiation safety status, and detector type (film or digital).

It is essential to have a clear, accurate, and easy-to-use method for determining a patient's radiation dose. In oral radiology, imaging can be done with different X-ray machines. Each of these methods works differently and makes images differently. As a result, different dosimetric methods must be used to measure the amount of radiation given to a patient. Table 1 shows how the used dose quantities in practice varies depending on the imaging method. [6].

Table 1: Specific quantities for patient estimation in dental radiology [6].

Dose quantity	Modality	Symbol	Common abbreviation	Unit
Incident air kerma	Intraoral radiography	K_i	IAK	mGy
Entrance surface air kerma	Intraoral radiography		ESAK, ESD	mGy
Air kerma–area product	Panoramic radiography, cephalometric radiography, CBCT	P_{KA}	KAP, DAP	mGy·cm2

Air kerma– length product *	CT, panoramic radiography	P_{KL}	DLP	mGy·mm
CT air kerma index	CT, CBCT	C	CTDI	mGy
*: Also termed 'dose width product' for dental panoramic radiography. Note: CBCT — cone beam computed tomography; CT — computed tomography				

A. Samples for data collection:

This study will determine the DRLs of the most frequent internal and exterior dental examinations conducted in healthcare and dental centers in Abu Dhabi, as indicated in table 2.

This study compared local dental DRLs in Abu Dhabi dental centers for intraoral procedures, particularly posterior (molar) procedures, to those from the UAE (2015) and compared the other internal dental x-ray procedures to international DRLs (from the UK and Europe).

Table 2: Common dental exams in dental centers and healthcare clinics in Abu Dhabi

Dental Imaging	Procedure (View)	Patient Category
Intra Oral Dental	Periapical X-rays (Anterior)	Adult and Pediatric
	Periapical X-rays (Posterior)	Adult and Pediatric
	Bitewing X-rays	Adult
Extra Oral Dental	Panoramic (full jaw)	Adult and Pediatric

B. Dosimeter measurements:

The air kerma values for all dental units were taken using a calibrated (Unfors RaySafe dosimeter and a RaySafe X2 Solo dosimeter. The data was collected by distributing a questionnaire to dental workers assigned to intraoral dental units [7]. The questionnaire queried protocol exposure parameters, including tube kVp, mA, patient entrance dose, exposure time, and patient characteristics, such as pediatric and adult patients, and was the most often done. The study used this questionnaire to measure the air kerma ($K_{a,\,i}$) in mGy by applying the protocol exposure parameters for adults and pediatrics according to the study's protocol. After measuring ($K_{a,\,i}$), the suggests stile values from the median of the dose distribution suggest local DRLs in intraoral procedures in all dental centers to propose the DRLs. Figure 1 shows the method used in intraoral radiography to estimate patient doses. The dosimeter was situated at the exit cone of the X-ray tube, and the primary beam covered the whole sensitive area of the dosimeter. When no patients were present, we used standard exposure settings to take measurements after positioning the dosimeter. The dosimeter's lead backing prevents surface backscattering, resulting in precise ($K_{a,\,i}$) results.

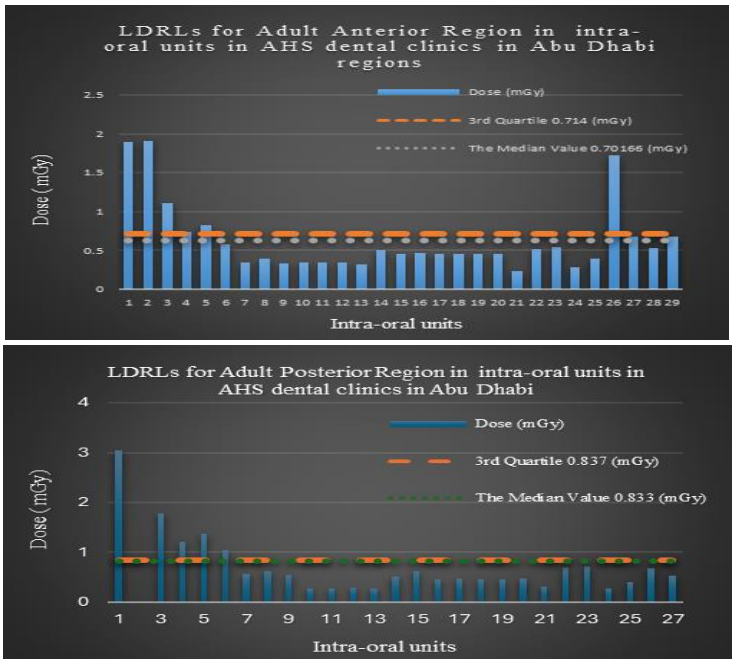
Figure 1: Pictorial representation of incident air kerma ($K_{a,\,i}$) measurement and parameters sitting in intraoral units.

In extraoral radiography, setting up a DRL means getting the

karma area product (PKA), or DAP, and directly collecting data from the system on doses given to real patients. This study used a method to determine actual dose values for patients receiving radiation doses from OPG procedures. A questionnaire was distributed to dental staff, which included the clinic's name, machine manufacturer, the most common protocols, the patient's age, patient classification (adult or pediatric), and protocol exposure parameters (tube kVp, mA, exposure time, DAP, or Kerma Area Product (KAP) ($mGy.cm^2$). Each group recorded the dose area product (DAP) for a standard exposure for adults and pediatrics. Following the guidelines of ICRP 135,[2] the present study has collected the DAP median values from a panoramic machines system (median from a minimum of 20 readings); from these obtained media readings, the DRLs were found at the 75th percentile using Microsoft spreadsheets. Before beginning DRL evaluation work, all selected X-ray units must have passed Quality Assurance (QA) examinations. Parameters such as exposure accuracy are determined during quality assurance tests. Time, operating potential, tube current linearity (mA/mAs), and radiation output consistency are all factors to consider. The amount of leakage from the X-ray tube housing is determined. Only modules that have passed quality assurance tests will be subjected to DRL assessments [7].

3. Results

Table 3 shows the average, third quartile, maximum, and minimum incident air kerma ($K_{a,\ i}$) in mGy for common intraoral exams in healthcare clinics in Abu Dhabi. The Abu Dhabi region's dental clinics gathered these findings from 34 intraoral units. The suggested DRLs for the 'adult maxillary incisor,' 'adult mandibular molar,' 'adult bitewing X-ray," pediatric maxillary incisor,' and pediatric mandibular molar are 0.714, 0.837, 1.042, 0.343, and 0.365 mGy, respectively, by the comprehensive investigation. In this investigation, bitewing X-rays of adults exhibited the highest DRL value, while maxillary incisors of pediatricians displayed the lowest. Figure 2 represents the graphical representation of the determined DRL and the measured ($K_{a,\ i}$) values derived from 34 intraoral units. Table 4 shows the median, third quartile, maximum, and minimum dose area product (DAP) for panoramic examinations standard in dental centers and healthcare clinics in Abu Dhabi. Dental clinics in the Abu Dhabi region collected these results from eight central panoramic units. The suggested DRLs for the adult panoramic (full jaw) x-ray and pediatric panoramic (full jaw) x-ray are 68.59 and 39.19 ($mGy.cm^2$), respectively, by the comprehensive investigation. An approximately 3-fold difference was observed between the minimum (32.97 $mG.cm^2$) and maximum (97 $mGy.cm^2$) panoramic DAP values for adults, while there was only a 2-fold difference between the minimum (30.24 $mGy.cm^2$) and the maximum (68 $mGycm^2$). This difference can be mainly attributed to exposure parameters, beam area, latent, and tube filters' age.



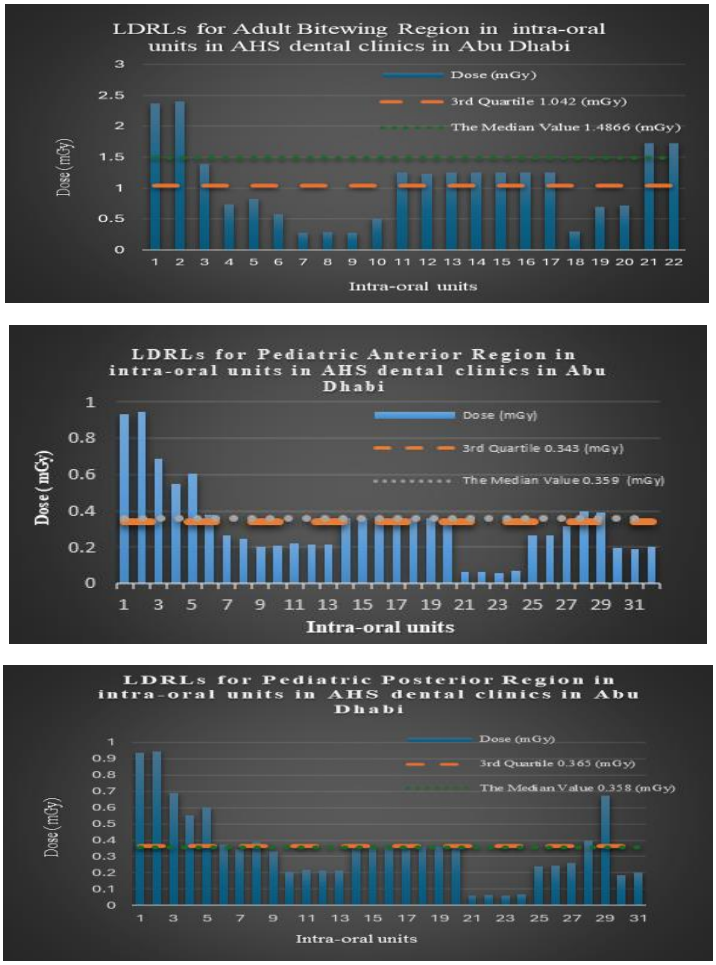


Figure 2: The graphical representation of the determined DRL and the measured $K_{a,i}$ values in dental centers and healthcare clinics in Abu Dhabi

Table 3: Average, third quartile, maximum, and minimum $K_{a,i}$ for different procedures in dental centers and healthcare clinics in Abu Dhabi.

Examinations	Average K a,I (mGy)	Third quartile K a,i (mGy)	Max Value K a,i (mGy)	Min Value K a,i (mGy)
Maxillary incisor (Adult Periapical X-rays (Anterior)	0.632	0.714	1.911	0.237
Mandibular molar,(Adult Periapical X-rays Posterior)	0.833	0.837	3.039	0.275
Adult Bitewing X-rays	1.4866	1.042	2.398	0.297
Pediatric Maxillary incisor (Periapical X-rays (Anterior)	0.359	0.343	0.945	0.0586
Pediatric mandibular molar (Periapical X-rays Posterior)	0.358	0.365	0.944	0.0586

Table 4 : Average, third quartile, maximum, and minimum for DAP in panoramic examinations in Abu Dhabi dental centers and healthcare clinics

Examinations	Average DAP value (Gy cm^2)	Third quartile DAP value (mGy.cm^2)	Max DAP value (mGy.cm^2)	Min DAP value (mGy.cm^2)
Adult Panoramic	60.34	68.59	97	32.97
Pediatric Panoramic	44.36	39.19	68	30.24

Figure 3 shows the graphical representation of the proposed DRLs for panoramic examinations. It represents the identified DRL by summing the (DAP) values from the system of eight panoramic units.

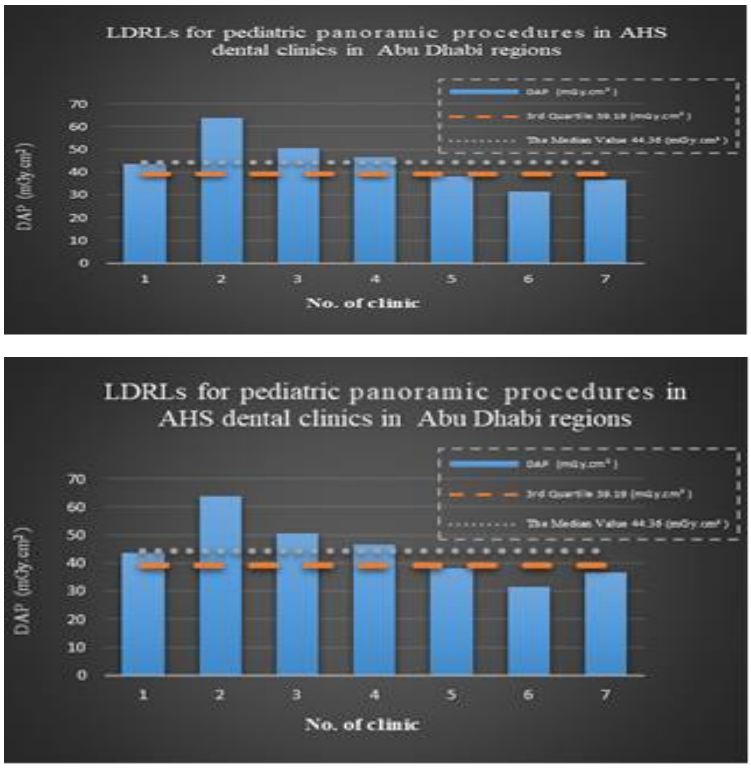


Figure 3: The graphical representation of the proposed LDRLs for panoramic examinations in Abu Dhabi dental centers and healthcare clinics.

4. Discussion

Due to a scarcity of literature on DRLs in dental imaging procedures in the UAE, this study is relatively new, with only one 2015 study conducted in the UAE and republished by FNAR in 2018 establishing DRLs in dental procedures (Al Kaabi et al., 2015; National DRLs Project Team in UAE, 2018). The experience of the Health Authority was one of the first in this field, as it began under the leadership of Dr. Jamila Al-Suwaidi, the first and one of the most important medical physicists in the UAE at that time, to collect data from important government hospitals and clinics in the UAE. And this was the beginning (National DRLs Project Team in UAE, 2018) [8]. Table 5 compares the intraoral procedures DRLs proposed in this study to those suggested by other countries. Although our results are lower than the DRL values recommended in different countries, they are consistent with those reported in those countries, indicating adherence to radiation safety guidelines during imaging. Our panoramic radiography results were much lower than those of India, Kosov, the UK, Sudan, Saudi Arabia, and Colombia. The difference in DAP in the current study may be attributed to the difference in patient physical parameters, exposure criteria, inherent filtration tube, dosimeter type, method usage, and year of study (oldest and most recent units).

This study, conducted in 2015 by medical physicists from Abu Dhabi, Dubai, and other emirates in the United Arab Emirates, aimed to investigate the dosages administered to juvenile and adult patients in various dental

radiology techniques. Furthermore, it was an integral component of technological initiatives implemented by the International Atomic Energy Agency (IAEA) in the United Arab Emirates (UAE) to assess and oversee the radiation doses received by patients. In the preceding examination on dental radiology dosimetry in the UAE, 85 digital units and 16 panoramic (OPG) machines were used. Furthermore, the outcomes of this review study are considered preliminary for UAE DRLs. These results indicate that the exposure levels in the UAE are less than and comparable to those reported in the scientific literature [9].

Table 5: Comparison of the intraoral LDRLs in (mGy) obtained in this study with other countries

Examinations	**Japan** [10]	**India** [11]	**Kosovo** [12]	**Cyprus** [13]	**UK** [14]	**Western Australia** [15]	**UAE (2015)** [8]	**This study**
Maxillary incisor (Adult Periapical X-rays (Anterior)	1.93	0.9	-	3.68	-	-	-	**0.714**
Mandibular molar (Adult Periapical X-rays Posterior)	1.51	1.0	-	4.75	1.2	-	0.880	**0.837**
Adult Bitewing X-rays	1.2	1.5	1.8	-	-	2		**1.042**
Paediatric mandibular molar (Periapical X-rays Posterior)	-	1.18	-	3.10	0.7	-	0.598	**0.343**
Paediatric Maxillary incisor (Periapical X-rays (Anterior)		1.16	-	2.41	-	-	-	**0.365**

Table 6: Comparison of the panoramic LDRLs in (mGy.cm^2), obtained in this study with other countries.

Examinations	India [11]	Kosovo [12]	UK (2019) [14]	Sudan 2018 [16]	Saudi Arabia 2020 [17]	Kolombia 2019 [18]	This study 2024
Adult Panoramic	-	74.1	81	103.4	99	103.9	68
Paediatric Panoramic	82	62.7	60	70.4	58.5	-	39

5. Conclusion

Dental DRLs have been proposed for intraoral and panoramic radiography in Abu Dhabi, UAE, government dental clinics. The results of the present study, which show a considerable variation in mean doses among the panoramic scanners, suggest the possibility of significant improvements. The difference in radiation doses between clinics with similar scanners indicates a considerable possibility for improving panoramic operations, opening the path for a safer and more efficient future in radiography. The recommended values are lower than those in other

countries, indicating that professionals working there are willing to follow radiation safety protocols to protect themselves and their patients. Dental DRLs have been suggested for intraoral and panoramic radiography in Abu Dhabi, UAE, and at government dental clinics.

Conflict of interest:

"The author declares that they have no conflicts of interest."

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