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What Do We Need From ICRP In Medicine?

Digital and interventional radiology:
Patient dose Registries and Diagnostic Reference levels

By

Jamila Salem AlSuwaidi, BSc, MSc, PhD

Medical Physicist,

Chair, DHA Radiation Protection Committee

Medical Education Department, Dubai Health Authority, Dubai, UAE.

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Digital and interventional radiology: Patient dose Registries and Diagnostic Reference levels

J. S. AlSuwaidi[1], N. K. AlMazrouei[2], S. Pottybindu[3], M. Siraj[4], D. Mathew[4], A. A. Al Blooshi[4], V. P. Kuriakose[3]

[1]*Dubai Health Authority (DHA), Medical Education Department, Dubai Hospital,* [2] *DHA, Medical Physics Section, Radiation Protection Unit,* [3] *DHA, Latifa Hospital, Radiology Department,* [4] *DHA, Primary Health Care, Radiology Department*

Abstract– Digital Radiology introduced benefits to the medical imaging practices and enhanced the quality of services provided to patients. This paper discusses the major differences between Digital Radiology and Conventional Radiology with emphasis on methodologies followed to estimate patient radiation doses. It presents the current details on the trends in diagnostic patient dose registries and dose guidance levels applied in the digital diagnostic and interventional radiology practices. The practical impact of the new recommendations of the International Commission on Radiological Protection (ICRP) is highlighted to specify the current challenging points in the practice of radiation protection in medicine. Considering the latest ICRP recommendations and the advances in digital radiology, the importance of patient dose recording and the establishment of Diagnostic Reference Levels (DRLs) for digital radiology are indicated. Dubai Health Authority (DHA) experience in establishing local DRLs are presented along with dose guidance values published internationally. The DHA participated in national and regional projects under the umbrella of the International Atomic Energy Agency (IAEA). The necessity for local radiation protection educational programs and patient dosimetry monitoring and recording were emerged from our patient radiation dosimetry projects. These are considered as essential requirements to prompt radiation safety culture within the various healthcare communities.

Keywords: Radiation Dose, Digital Radiology, Dosimetry, Dose Registry, Dose Reference Levels, DRL

- Differences: Digital and Conventional Radiology
- Radiation Doses: Patient Dose Registry and DRL
- Dubai Health Authority (DHA) Experience

Digital and interventional radiology:
Patient dose Registries and Diagnostic Reference levels (DRL)

Review:

- ICRP Publication 60, 1991, Diagnostic Reference Levels (DRLs), which are a form of **investigation levels** to optimize image quality and the radiation dose delivered to patients.
- DRL concept was further expanded in ICRP Publication 73, 1996
- BSS 115, 1996 Guidance Levels
- ICRP, 2001 (Review and Additional advice) on applications of DRL in digital and interventional Radiology.
- ICRP Publication 105, 2007, Summary of the Recommendations.
- ICRP Publication 121, on RP in Paediatric Diagnostic and Interventional Radiology, 2013
- WHO Global Initiative on Radiation Safety in Health Care Settings, 2001Malaga Conference – International Consultation Meeting 2013

Digital and interventional radiology:
Patient dose Registries and Diagnostic Reference levels (DRL)

Diagnostic reference level

Used in medical imaging with ioning radiation to indicate whether, in routine conditions, the patient dose or administered activity (amount of radioactive material) from a specified procedure is unusually high or low for that procedure.

ICRP, Report 103, 2007

ICRP Publication – 121, 2013

(f) The development and regular updating of local, regional, or national diagnostic reference levels (DRLs) to assist in the optimisation process is encouraged. Also, **regular audits of referral criteria**, imaging quality, and imaging technique should be implemented as part of the radiological protection culture.

(38) ICRP does not specify quantities, numerical values, or details of implementation for DRLs. This is the task of the regional, national, and local authorised bodies, each of which should meet the needs in their respective areas.

Digital and interventional radiology: Patient dose Registries and Diagnostic Reference levels (DRL)

- Quantities used for DRLs should be understood by radiologists and radiographers
- DRLs should always be used in parallel with image quality evaluation (enough information for diagnosis shall be obtained)
- Quantities used for DRLs should be easily measured. DRLs can be based on several quantities (e.g. entrance surface dose and entrance surface air kerma, DAP etc.) and parameters (such as fluoro time and number of images).

Digital and interventional radiology:
Patient dose Registries and Diagnostic Reference levels (DRL)

Å Diagnostic Reference Levels are not dose limits.

Å DRLs could be assimilated to investigation levels.

Å DRL are not applicable to individual patients. Comparison with DRL shall be only made using mean values of a sample of patients. DRLs should be a reasonable indication of doses for average sized patients.

Å The main objective of DRLs is their use in a dynamic and continuous process of optimization. DRL assessments should be carried out on a regular basis, at least every three - five years or as required by national legislation.

Dosimetry in:
Digital and Conventional Radiology

- Methodologies followed to estimate patient radiation doses:

  - Doses can be **measured directly** by placing thermoluminiscent dosimeters (TLD) or diodes on the patients during the procedures

  - **Measure the kerma in air for all radiation beams and multiply it by the technique factors**

  - A properly calibrated **air-kerma-area-product (KAP)** meter (previously called DAP meter) attach to each x-ray machine .

  - **Manufacturer-dependent Dose values** (Exposure Index – EI)

  - Use **mathematical models to estimate internal dose**. Mathematical models based on **Monte Carlo simulations (PCXMC).**

Dosimetry in:
Digital and Conventional Radiology

❖ Use of DICOM information for patient dosimetry:

- Mammography units
  - Variations of AGD: ± 20%
- Angiography units
  - Variations: ± 40%

(Padovani IAEA presentation 2012)

Example on Calculating the Effective Dose using DICOM Header Information

- **<u>For general X-ray done at DHA hospitals:</u>**
- PID- 88292... (Adult) DAP= 1.792 dGy cm2 (as given in the DICOM header) = 0.1792 Gy cm2 * 0.058 mSv/Gycm2 = **0.0104 mSv** (UK references quoted a figure of 0.033 mSv)

- PID – 88602… (Child) DAP = 1.016 dGy cm2 (as given in the DICOM header) = 0.1016 Gy cm2 * 0.058 mSv/Gycm2 = **0.006 mSv**

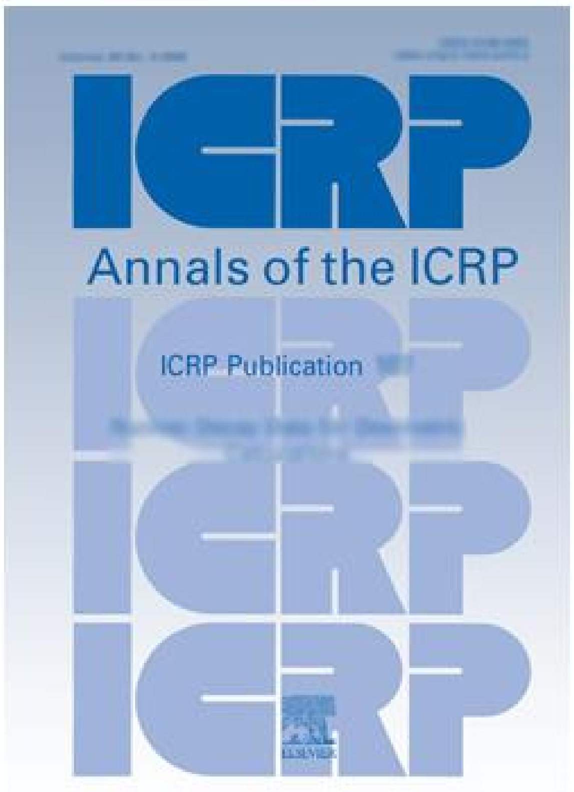
- **<u>For CT done at DHA hospitals:</u>**
- PID- 88580… CTDI(vol)=19.mGy & DLP = 379.64 mGy cm (From CT Dose Report) * 0.0021 mSv/mGycm = **0.7972 mSv** (UK references quoted a figure of 1.6 mSv).

Patient Dosimetry

Managing Patient Dose in Digital Radiology

ICRP Publication 93

Ann. ICRP 34 (1), 2004



Abstract - Digital techniques have the potential to improve the practice of radiology but they also risk the overuse of radiation. The main advantages of digital imaging, i.e. wide dynamic range, post processing, multiple viewing options, and electronic transfer and archiving possibilities, are clear but overexposures can occur without an adverse impact on image quality. In conventional radiography, excessive exposure produces a black film. In digital systems, good images are obtained for a large range of doses. It is very easy to obtain (and delete) images with digital fluoroscopy systems, and there may be a tendency to obtain more images than necessary.

In digital radiology, higher patient dose usually means improved image quality, so a tendency to use higher patient doses than necessary could occur. Different medical imaging tasks require different levels of image quality, and doses that have no additional benefit for the clinical purpose should be avoided.

Image quality can be compromised by inappropriate levels of data compression and/or post processing techniques. All these new challenges should be part of the optimisation process and should be included in clinical and technical protocols.

Local diagnostic reference levels should be re-evaluated for digital imaging, and patient dose parameters should be displayed at the operator console. Frequent patient dose audits should occur when digital techniques are introduced. Training in the management of image quality and patient dose in digital radiology is necessary. Digital radiology will involve new regulations and invoke new challenges for practitioners. As digital images are easier to obtain and transmit, the justification criteria should be reinforced.

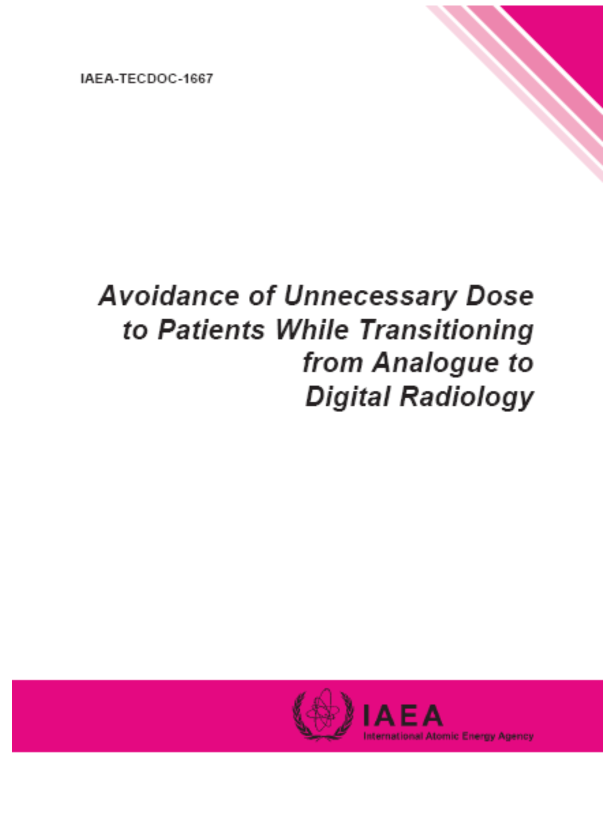
Commissioning of digital systems should involve clinical specialists, medical physicists, and radiographers to ensure that imaging capability and radiation dose management are integrated. Quality control requires new procedures and protocols (visualisation, transmission, and archiving of the images).

Dosimetry in:
Digital and Conventional Radiology

Å IAEA 1667, 2011:

It is not know yet whether the widespread introduction of DR techniques will also result in increase in the use of x-ray examinations and hence will increase doses to patients and to population.

Hence, studies on **frequency of radiological procedures** are essential.


IAEA-TECDOC-1667

Avoidance of Unnecessary Dose to Patients While Transitioning from Analogue to Digital Radiology

IAEA
International Atomic Energy Agency

Dubai Health Authority (DHA) Experience

Å The DHA participated in national and regional projects under the umbrella of the International Atomic Energy Agency (IAEA).

Dubai Health Authority (DHA) Experience

1- General Radiology (Paediatric)/LH 2012

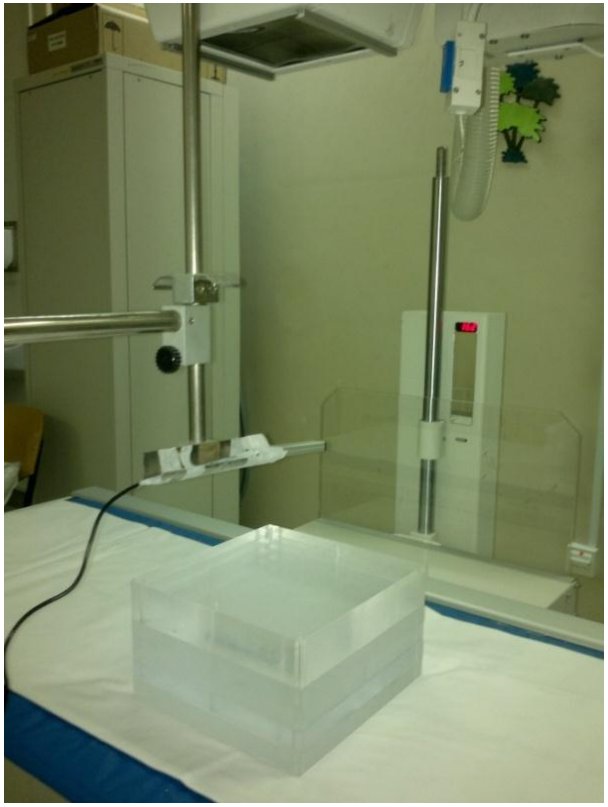
Patient Data Collection / Phantom Studies

Dubai Health Authority (DHA) Experience
General Radiology (Paediatric)/LH 2012

- The phantoms were designed for GR and Fluoro radiology practices and the patient data collection took place.

- The phantoms were as:

Abdomen/Lumbar Phantom (ANSI)



<u>Phantom Material:</u>

Sheets of Perspex (PMMA)

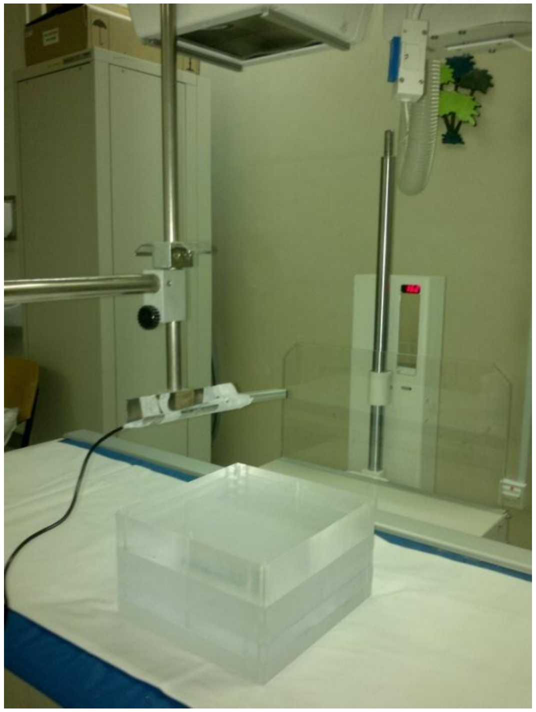
<u>Phantom Thickness:</u>

4 sheets of PMMA each as 25 cm x 25 cm x 2.54 cm, total thickness 10.16 cm for Neonatal Paediatric Group

4 sheets of PMMA each as 25 cm x 25 cm x 2.54 cm & 1 PMMA 25 cm x 25 cm x 5.08, total thickness 15.24 cm for the 1m-10y Paediatric age group

Dubai Health Authority (DHA) Experience
General Radiology (Paediatric)/LH 2012

- **X ray equipment:**
  - X ray unit and model: GR Siemens, Bucky Diagnost
  - Imaging using digital image receptor: Fujifilm
  - Image receptor model: FCR Capsula XL



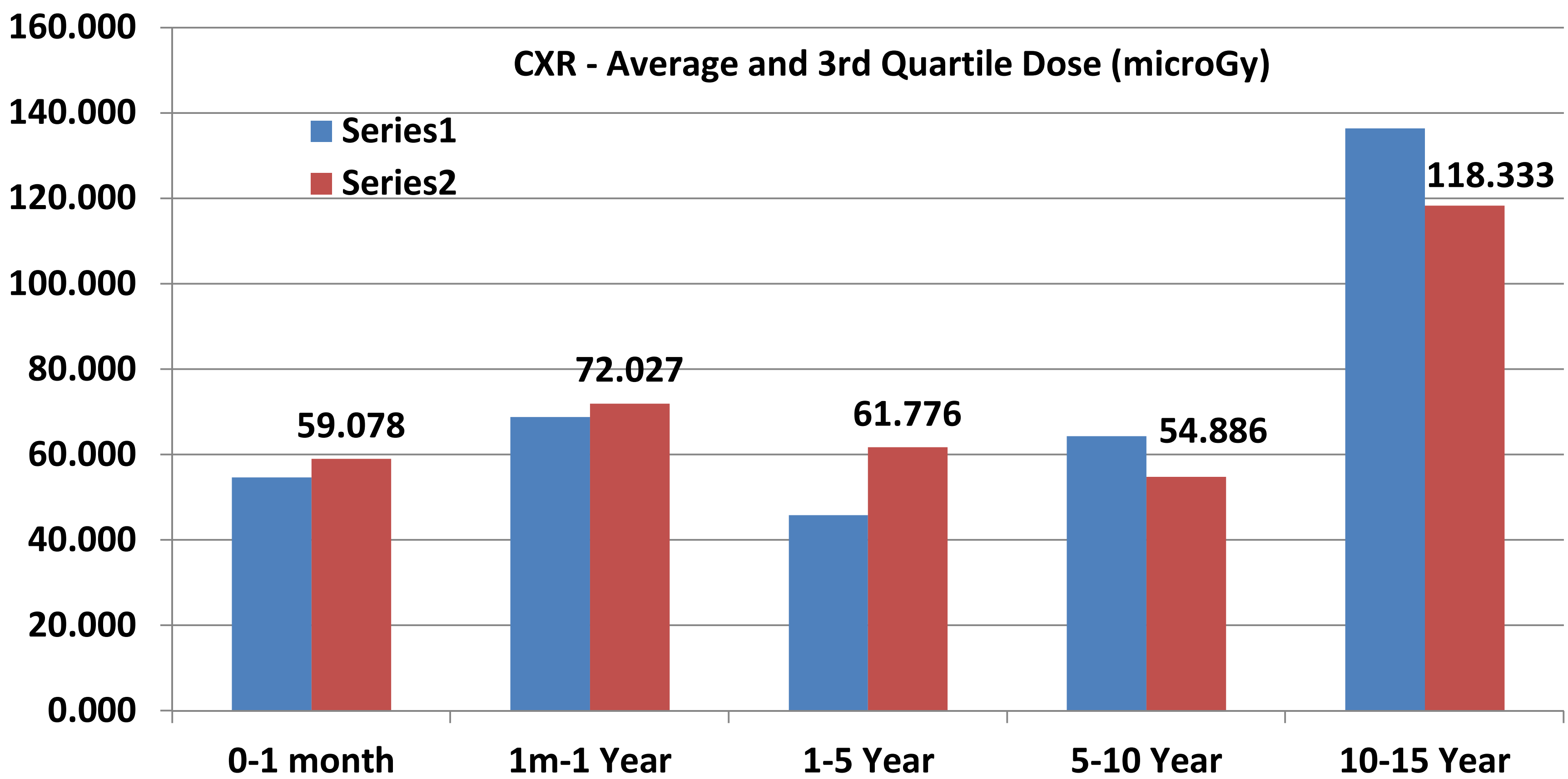
Unfors Xi Dosemeter
(Serial No.: 128771)

Dubai Health Authority (DHA) Experience
General Radiology (Paediatric)/LH 2012

Average Incident Air Kerma (microGy)
3rd Quartile Incident Air Kerma (microGy)

Age	0-1 month	1m-1 Year	1-5 Year	5-10 Year	0-1 month	1m-1 Year	1-5 Year	5-10 Year	10-15 Year
Exam	CXR-AXR	AXR	AXR	AXR	CXR	CXR	CXR	CXR	CXR
average	56.402	65.303	94.876	284.949	54.689	68.869	45.840	64.300	136.439
min	42.724	49.235	50.626	79.872	39.646	57.313	19.221	35.589	44.691
max	76.276	96.092	238.536	1107.508	73.143	92.838	86.497	294.454	373.741
3rd quartile	61.135	70.214	114.299	324.882	59.078	72.027	61.776	54.886	118.333
no of Patients	17	21	22	20	20	24	25	21	5

Dubai Health Authority (DHA) Experience
General Radiology (Paediatric) LH 2012

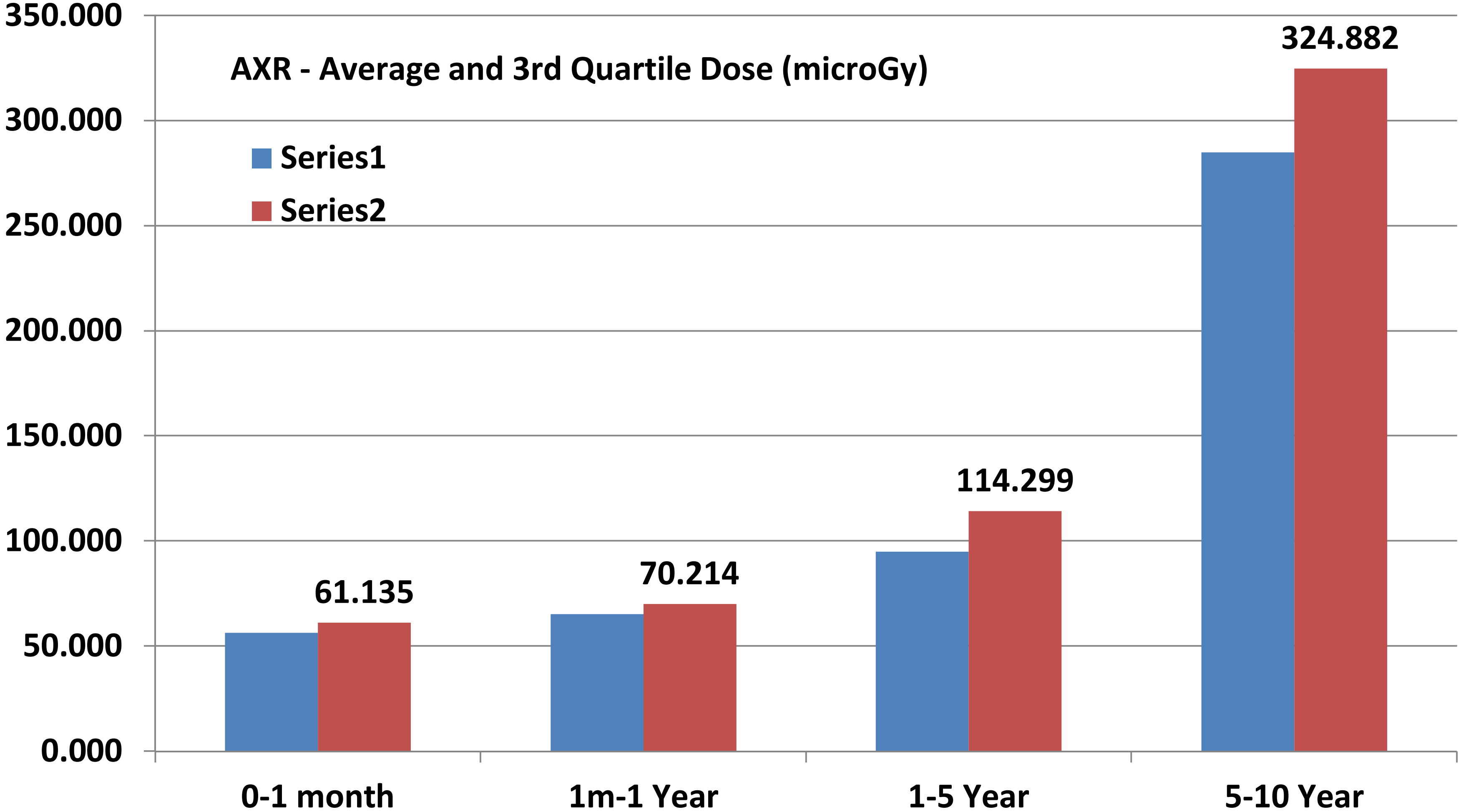


Paediatric Chest General X-ray Dose Data:

Series1: Average Incident Air Kerma (microGy)

Series2 : 3rd Quartile Incident Air Kerma (microGy)

Dubai Health Authority (DHA) Experience
General Radiology (Paediatric) / LH 2012



Paediatric Abdomen General X-ray Dose Data:

Series1: Average Incident Air Kerma (microGy)

Series2 : 3rd Quartile Incident Air Kerma (microGy)

ICRP Publication 121 / EC Data

Table 3.1. Examples of diagnostic reference levels in paediatrics for standard 5-year-old patients, expressed in entrance surface dose per image for single views (European Commission, 1996).

Radiograph	5-year-old patients Entrance surface dose per single view (mGy)*
Chest: postero-anterior	0.1
Chest: anteroposterior (for uncooperative patients)	0.1
Chest: lateral	0.2
Skull: postero-anterior/anteroposterior	1.5
Skull: lateral	1.0
Pelvis: antero-posterior	0.9
Abdomen: anteroposterior/postero-anterior with vertical/horizontal beam	1.0

* Upper diagnostic reference level expressed as entrance surface dose to the patient. The entrance surface dose for standard-sized patients is the absorbed dose in air (see explanation in Para. 7 on the use of air kerma vs absorbed dose to air) (mGy) at the point of intersection of the beam axis with the surface of a paediatric patient, backscatter radiation included.

Table 3.2. Variations of entrance surface dose* (converted to mGy, to the nearest two decimal places) observed in the three European Union paediatric trials (1989/91, 1992, 1994/95): median, minimum–maximum values and corresponding ratio (minimum:maximum) of frequent x-ray examinations in paediatric patients.

Examination type	Infant			5 year old			10 year old		
	Median	Min–max	Min:max	Median	Min–max	Min:max	Median	Min–max	Min:max
Chest AP (1000 g newborn)	0.05	0.01–0.34	1:35						
Chest PA/AP	0.08	0.02–1.0	1:47	0.07	0.02–1.35	1:71	0.07	0.02–1.16	1:68
Chest AP (mobile)	0.09	0.03–0.72	1:21	0.07	0.03–0.33	1:11	0.09	0.03–0.76	1:26
Chest lateral				0.14	0.04–0.55	1:15	0.15	0.04–1.98	1:51
Skull PA/AP	0.93	0.15–4.51	1:30	1.00	0.24–4.63	1:19	1.04	0.13–5.21	1:40
Skull lateral				0.70	0.14–2.36	1:17	0.58	0.11–3.79	1:33
Pelvis AP	0.26	0.02–1.37	1:76	0.49	0.09–2.79	1:32	0.81	0.09–4.17	1:47
Full spine PA/AP	0.87	0.12–0.44	1:41						
Thoracic spine AP							0.89	0.20–4.31	1:21
Thoracic spine lateral							1.63	0.30–6.66	1:22
Lumbar spine AP							1.15	0.13–5.69	1:43
Lumbar spine lateral							2.43	0.25–23.5	1:94
Abdomen AP/PA	0.44	0.08–3.21	1:42	0.59	0.06–2.92	1:52	0.73	0.15–3.98	1:27

AP, anteroposterior; PA, postero-anterior.

* See definition for entrance surface dose in Table 3.1.

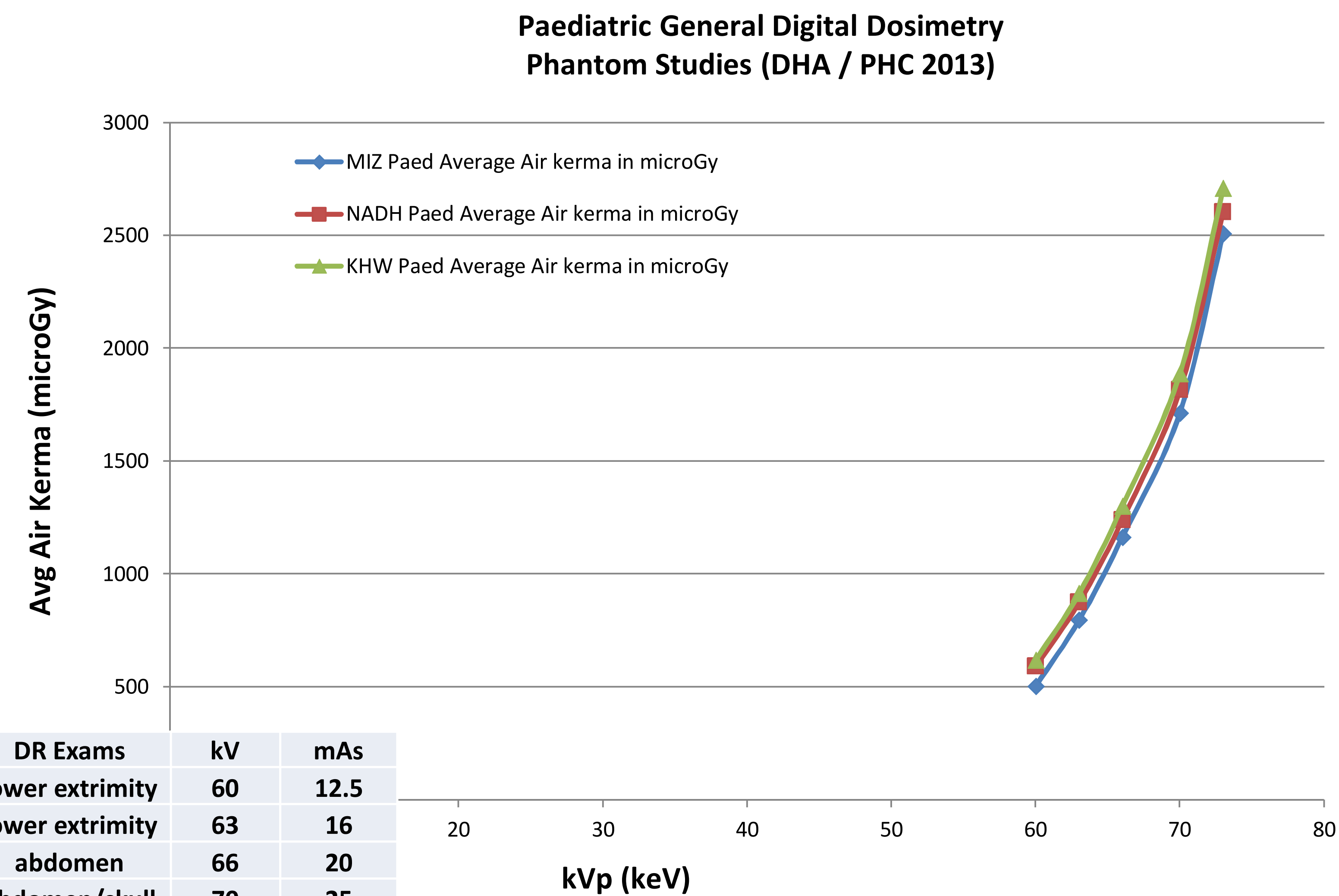
ICRP Publication 121

Dubai Health Authority (DHA) Experience

2- General Digital Radiology (Paed - PHC)

Phantom Studies

Dubai Health Authority (DHA) Experience
General Digital Radiology (Paed - PHC)



DR Exams	kV	mAs
lower extrimity	60	12.5
lower extrimity	63	16
abdomen	66	20
abdomen/skull	70	25
pelvis/ dorsal spine	73	32

Phantom Thickness 10 & 15 cm

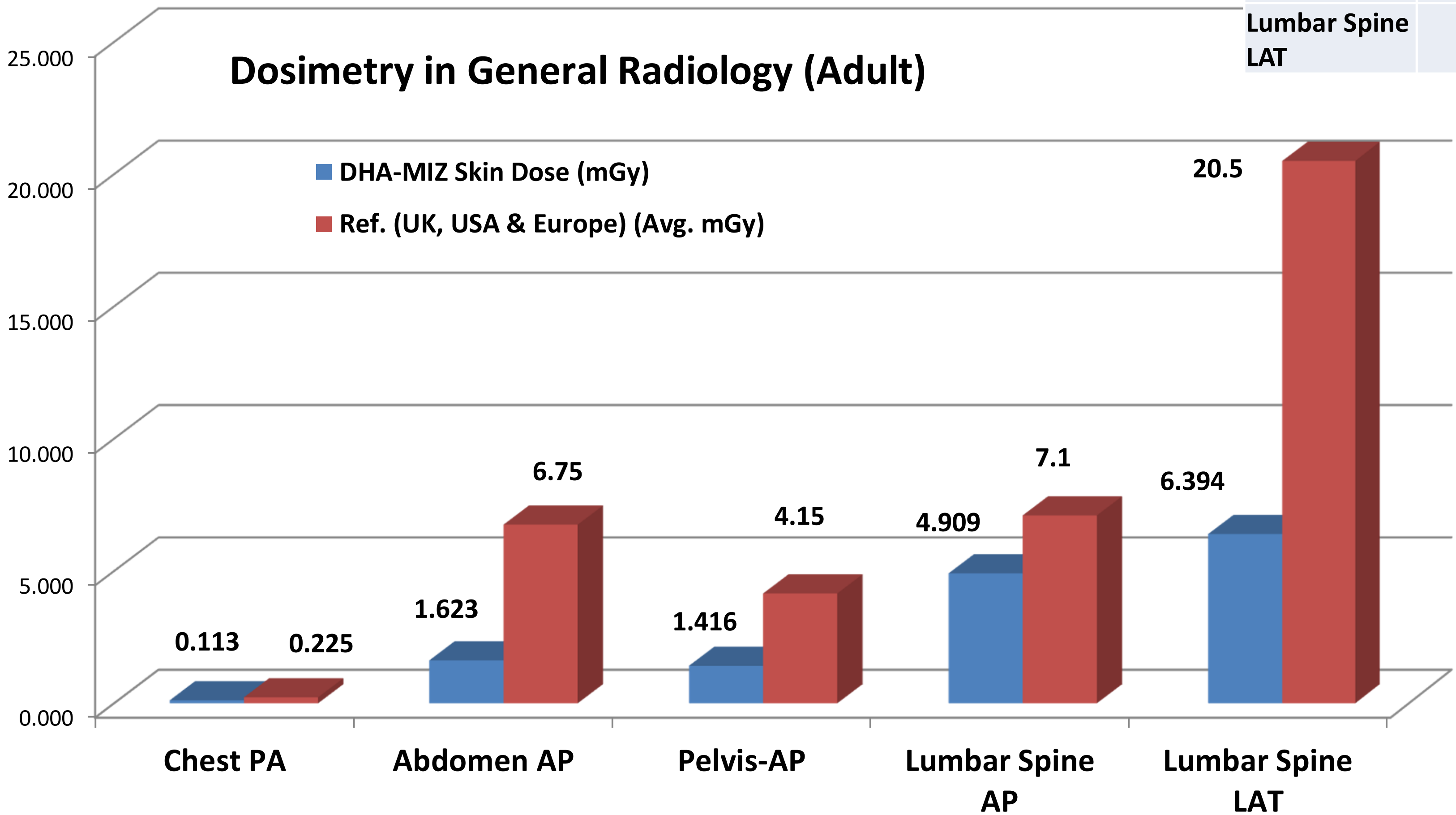
Dubai Health Authority (DHA) Experience
General Digital Radiology (Paed)

Paediatric General Digital Dosimetry Phantom Studies (DHA / PHC 2013)

Exams	kV	mAs	% Variation between DICOM dose and Measured doses		
			MIZ	NADH	KHW
lower extrimity	60	12.5	-29.467	-15.117	-14.180
lower extrimity	63	16	-21.573	-12.536	-11.293
abdomen	66	20	-16.708	-10.086	-8.601
abdomen/skull	70	25	-12.143	-6.624	-5.518
pelvis/ dorsal spine	73	32	-7.040	-3.568	-2.417

Dubai Health Authority (DHA) Experience
General Digital Radiology (Adult)

	Ref. (UK, USA & Europe)
	mGy
Chest PA	0.15-0.3
Abdomen AP	3.5-10
Pelvis-AP	4.15
Lumbar Spine AP	4.2-10
Lumbar Spine LAT	11_30



Results of Patient Data Collection
Adult Phantom Thickness 19 cm

Dubai Health Authority (DHA) Experience

Mammography
Patient Data Collection / Phantom Studies

Step3: Average Glandular Dose, DG:*

- The measurements of the Entrance Surface Air Kerma $K_{a,e}$ were performed in two steps. First, the ACR phantom was exposed to X-ray beams using automatic mode to get the kVp, mAs, and target/filter combination used in each facility.
- Then, the phantom was removed and a similar exposure was performed in manual mode with no phantom.
- In some hospitals the manual mode was used instead of the automatic mode.
- Dedicated ionization chambers fitted to suitable Multimeters were utilized to measure the Incident Air Kerma. The value of $K_{a,e}$, the Entrance Surface Air Kerma (ESAK) was deduced.

The Average Glandular Dose DG was calculated as:

$$DG = K_{a,e} \cdot g . c . S$$

***g*: factor of galndularity of 50%**
C: corrects for the different breast composition
S: correct for different choice of X-ray spectrum

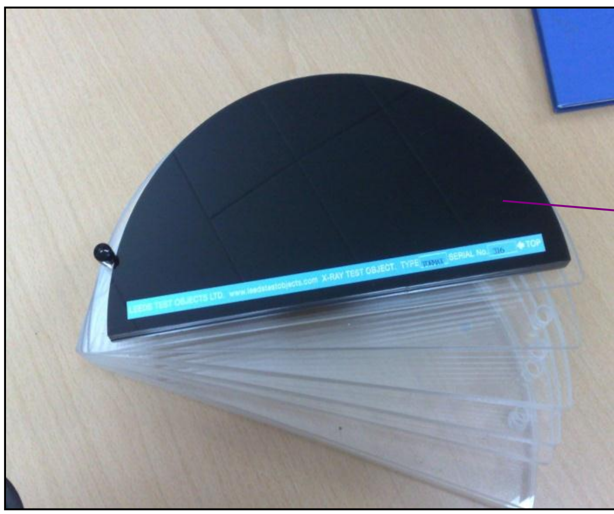
Ms.Najlaa Khalfan Almazrouei - WC2009 ï
Muncih, 2009

** Step1: QC and Step2: Contrast –Noise Ratio*

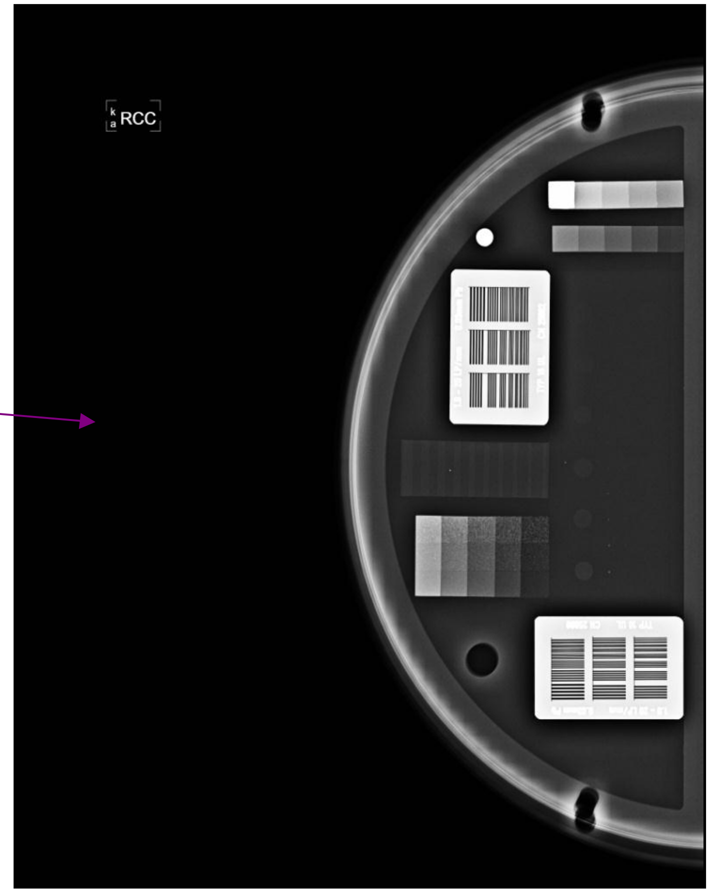
Å For the measurement of ESAK:

Ms.Najlaa Khalfan Almazrouei - WC2009 - Muncih

Image Quality



ToRMAX-316 (Leeds Test Object)



Dubai Health Authority (DHA) Experience
Mammography

Conventional Mammography

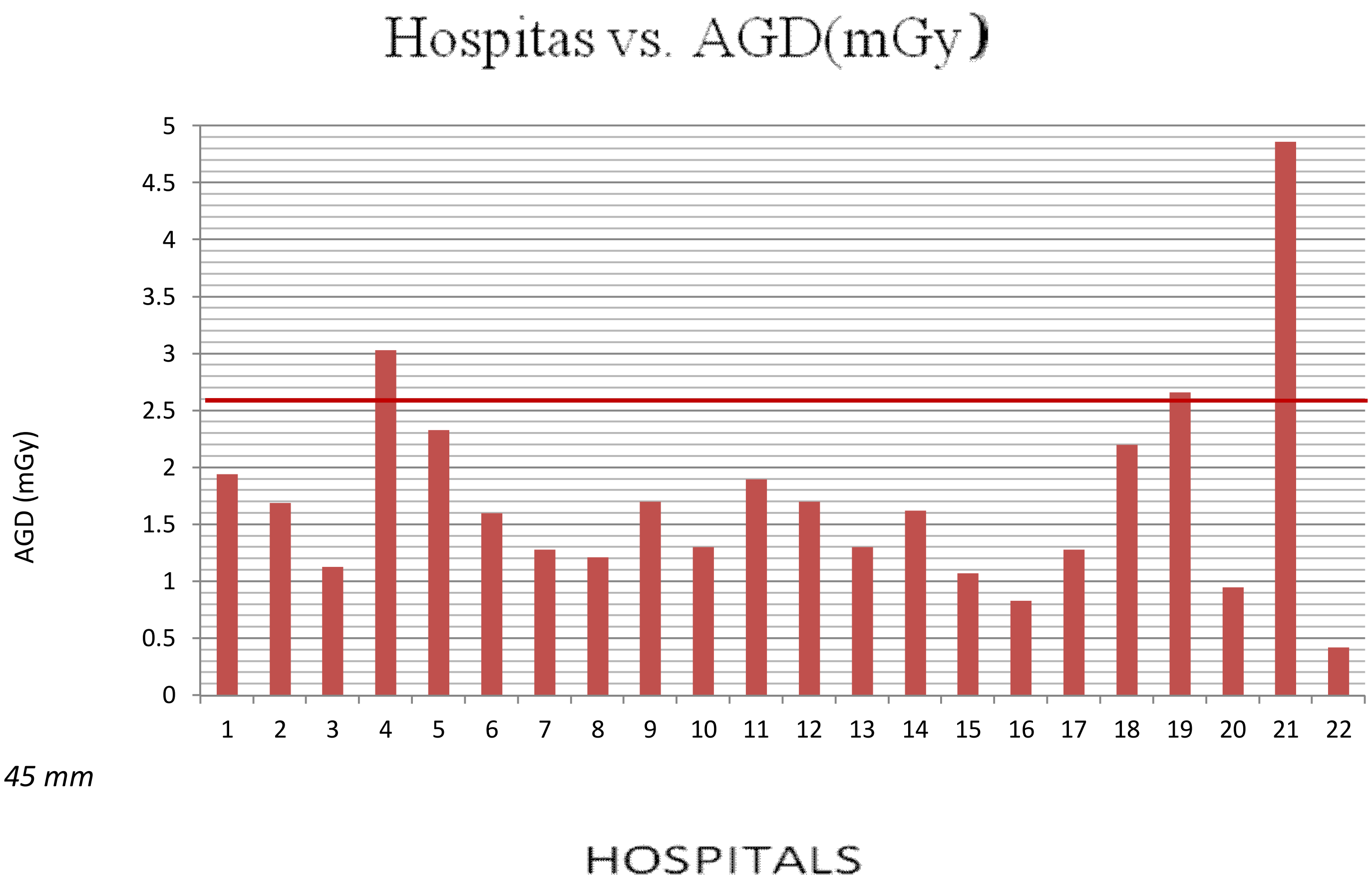
Hospitals		1 (2 machines)		2	3	4		5		6		7	8		9			10	11	12	13	14	15
A/F comb.		Mo / Mo	Mo / Mo	Mo / Rh	Mo / Mo	Mo / Mo	Mo / Rh	Mo / Mo	Mo / Rh	Mo / Mo	Mo / Rh	Mo / Mo	Mo / Mo	Mo / Rh	Mo / Mo	Mo / Rh	W / Rh	Rh / Rh	Mo / Rh	Mo / Mo	Mo / Mo	Mo / Mo	Mo / Mo
kVp		28	29	28	29	31	30	27	27	26	26	26.5	26	26	27	27	27	29	28	28	28	27	23
mAs		84.2	73.1	65	96.0	57.4	59.5	70	70	160	100	100	160	100	71	63	90	50	100	140	56.3	118	40
Contrast-to-Noise Ratio (CNR)	Phantom Thickness (cm)	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	CNR value	4.62	5.06	6.66	4.5	2.87	6.68	5.5	4.93	-	-	5.23	-	-	3.08	3.11	2.94	7. 2	-	2.4	3.63	-	-
	Min. CNR Required [Ref.1]	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91	4.91
$K_{a,e}$ [mGy]		9.92	9.87	5.66	15.5	11.9	7.5	6.55	4.94	7.82	5.32	8.78	7.82	5.32	6.05	4.38	2.7	5.01	8.97	13.5	4.87	18.1	2.52
Determined AGD [mGy]		1.94	1.69	1.13	3.03	2.33	1.66	1.28	1.21	1.7	1.3	1.9	1.7	1.3	1.62	1.07	0.83	1.28	2.2	2.66	0.95	4.86	0.49
AGD [mGy] Generated by the mammography system		2.08	1.59	1.42	2.66	2.24	1.85	NA	NA	NA	NA	14.4	NA	NA	NA	NA	NA	1.12	NA	NA	NA	NA	NA
% Difference between determined and generated AGD		6.7 %	6.2 %	20.4 %	13.9 %	4 %	10.2 %	NA	NA	NA	NA	86 %	NA	NA	NA	NA	NA	14.2 %	NA	NA	NA	NA	NA

N. K. ALmazrouei[1], F. Alkaabi[2], J. Janaczek[2], S .A .Gilani[1], A. Zitouni[1], J. AlSuwaidi[1], S. Alkalbani[1]

[1]Dubai Health Authority/Dubai Hospital/Medical Physics department, Dubai, UAE
[2] Tawam Hospital/Medical Physics department, AlAin, UAE

Dubai Health Authority (DHA) Experience
Mammography

Conventional Mammography



Brest Thickness 45 mm

Dubai Health Authority (DHA) Experience
Mammography

Table 1. **Digital Mammography** / DHA Average Glandular Dose (AGD) and Max AGD classified according to patient breast thickness.

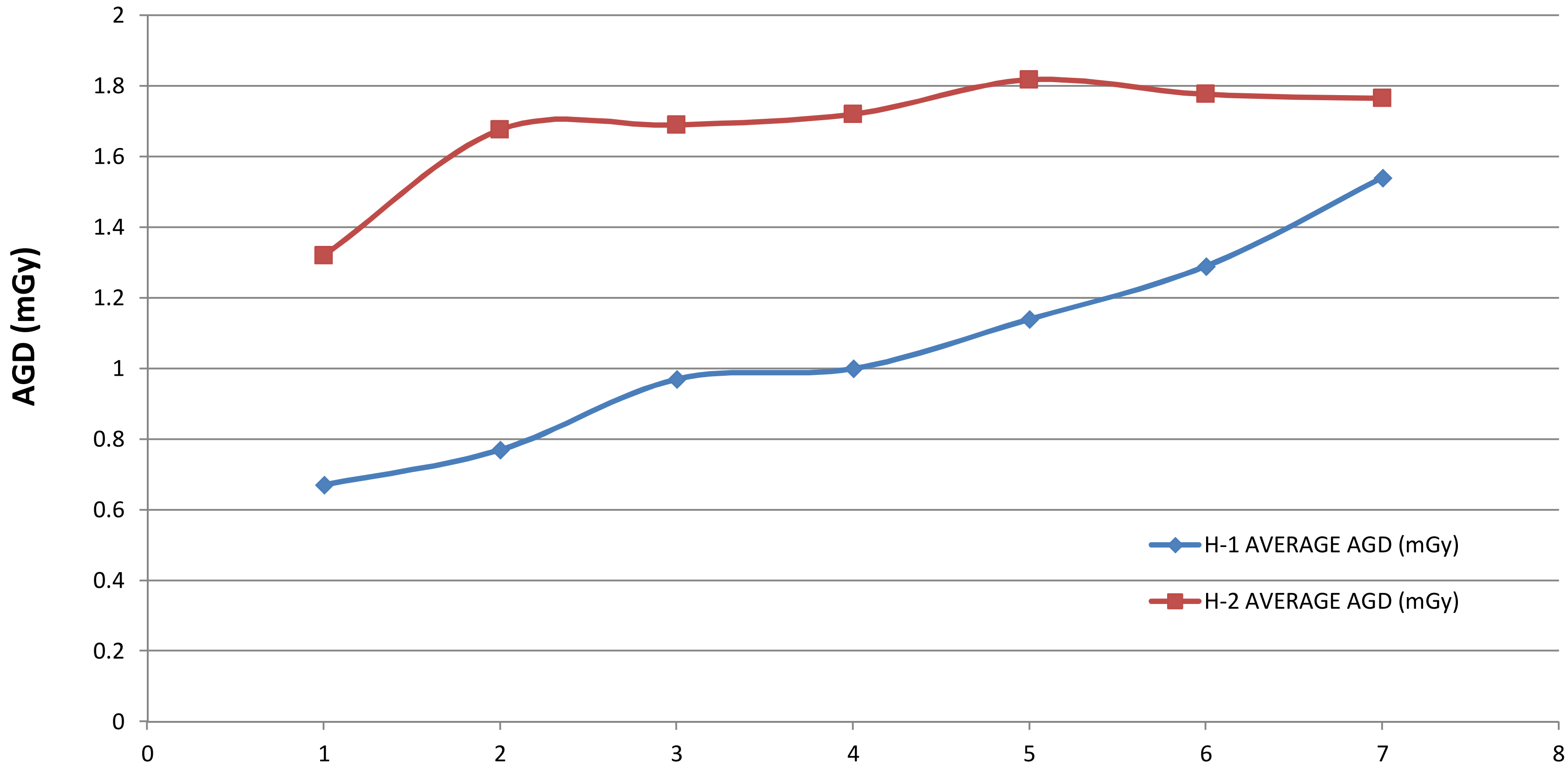
Breast Thickness (mm)	H-1 AVERAGE AGD (mGy)	H-2 AVERAGE AGD (mGy)	H-1 MAX (mGy)	H-2 MAX (mGy)	EUROPE REF LEVEL AGD in mGy
20-30	0.67	1.32	0.98	1.42	1
30-40	0.77	1.68	0.83	1.76	1.5
40-45	0.97	1.69	1.05	1.80	2
45-50	1	1.72	1.07	1.78	2.5
50-60	1.14	1.82	1.21	1.91	3
60-70	1.29	1.78	1.4	1.87	4.5
above 70	1.54	1.77	1.69	1.84	6.5

Dubai Health Authority (DHA) Experience

Mammography

Digital Mammography

DHA Mammography Dosimetry - March/May 2013



Breast Thickness Groups (1= 20-30mm, 2=30-40mm, 3=40-45mm, 4=45-50mm, 5=50-60mm, 6=60-70mm & 7= above 70mm)

Fig. 1. Average Glandular Dose (AGD) at Hospital-1 at the DHA.

Dubai Health Authority (DHA) Experience
Mammography

Digital Mammography

H-1:

Thickness cm	AGD mGy (our measurement)	AGD mGy (System)	%
2	0.752	0.6	20.2
4.5	1.51	1.39	7.9
7	3.399	3.09	9.09

H-2

Thickness cm	AGD mGy (our measurement)	AGD mGy (System)	%
2	**1.053**	**0.577**	**45.2**
4.5	**2.379**	**1.4**	**41.15**
7	**3.04**	**2.47**	**18.75**

Dubai Health Authority (DHA) Experience

Interventional Radiology – Cardiac Paediatrics & Adults / Cardiac DH

XR-RV2 Gafchromic films / Patient Dose Collection (Cumulative Air Kerma and DPA)

Task-1 Interventional Radiology

Patient Skin Dose Results in Interventional Cardiology (IRDH05, 2008), using XR-RV2 Gafchromic films:

Range of Peak Skin Doses incurred by 34 Angioplasty patients **(Adults)**

PSD ranges	<0.5Gy	0.5-1Gy	1–2Gy	2–4Gy	>4Gy
No. of patients	18	8	5	3	None
Percentage	53%	24%	15%	8%	0%

DHA Team worked on this task:
Sheela Dorairaj, S Jimmy, R. Sasidhran , **Azza Mustafa Habra** , Abderrachid Zitouni
Jamila Salem AlSuwaidi,

Ms.Azza Mustafa Habra
WC2009 - Muncih

Dubai Health Authority (DHA) Experience
Interventional radiology / Cardiac DH

IAEA TC Project: RAS/9/034, RAS/9/040 & RAS/9/055 Patient Dosimetry Data Collection:

Form 2. Patient doses for adult interventional cardiac procedure

Procedure: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

		Patient data				Plane A				Plane B (if Biplane)				Cine mode						
Patient No	Data of examination	Gender (m/f)	Age	Height (cm)	Weight (kg)	Fluoro time (min)	KAP fluoro* (unit?)	KAP cine* (unit?)	Cumulative Air kerma to IRP** (mGy)	Fluoro time (min)	KAP fluoro* (unit?)	KAP cine* (unit?)	Cumulative Air kerma to IRP** (mGy)	Total (131 Plane) Number of series	Number of images	Frame rate (fr/s)	Exposure control - Automatic or Manual?	Anti-scatter grid used - Yes/No?	Any protective shielding used? Yes/No	DAP mhy cm^2
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				

Page 1

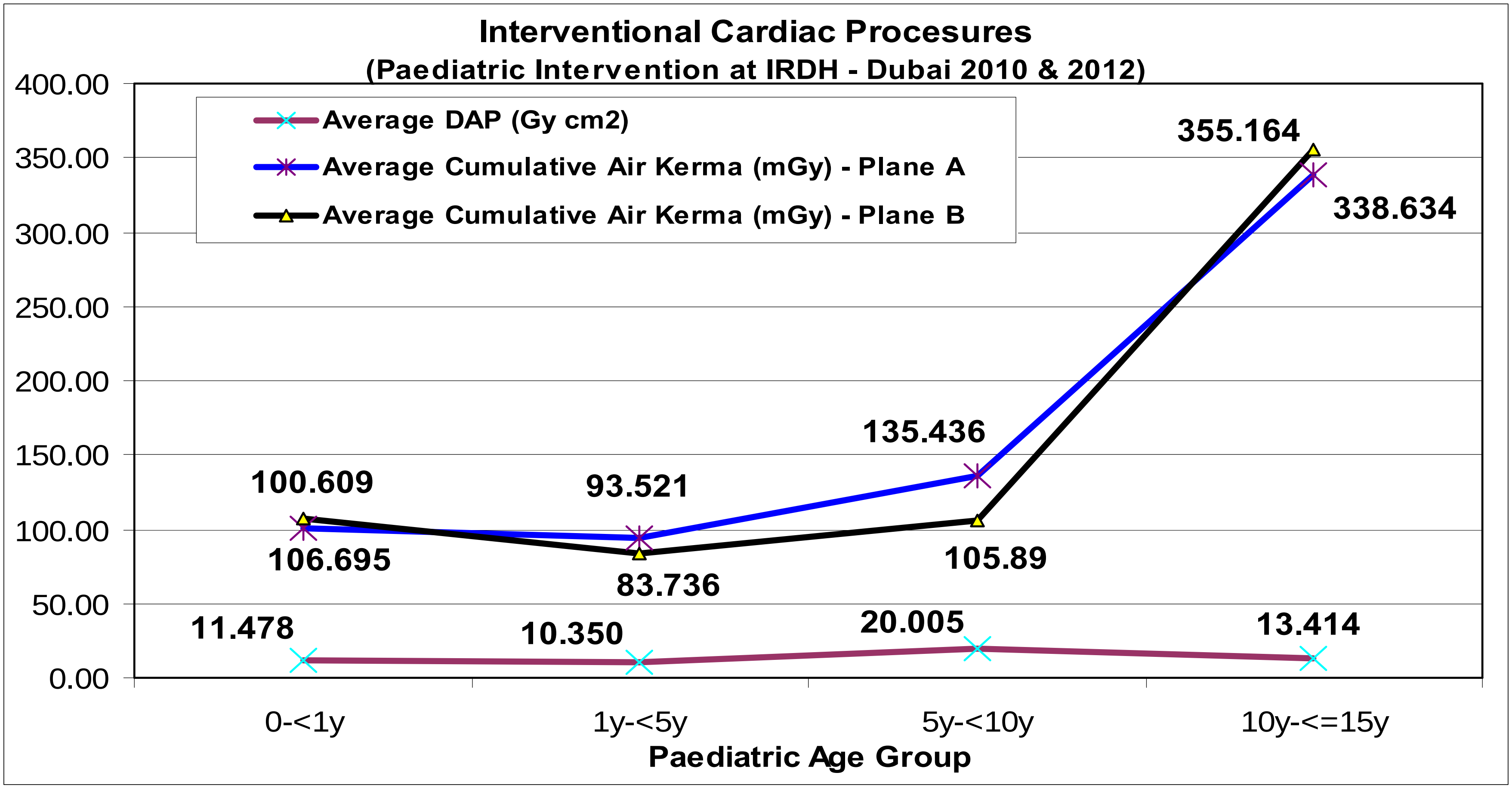
Dubai Health Authority (DHA) Experience
Interventional radiology (Paediatric) / Cardiac DH

Table-1: DHA IR Cumulative Air Kerma and DAP results.

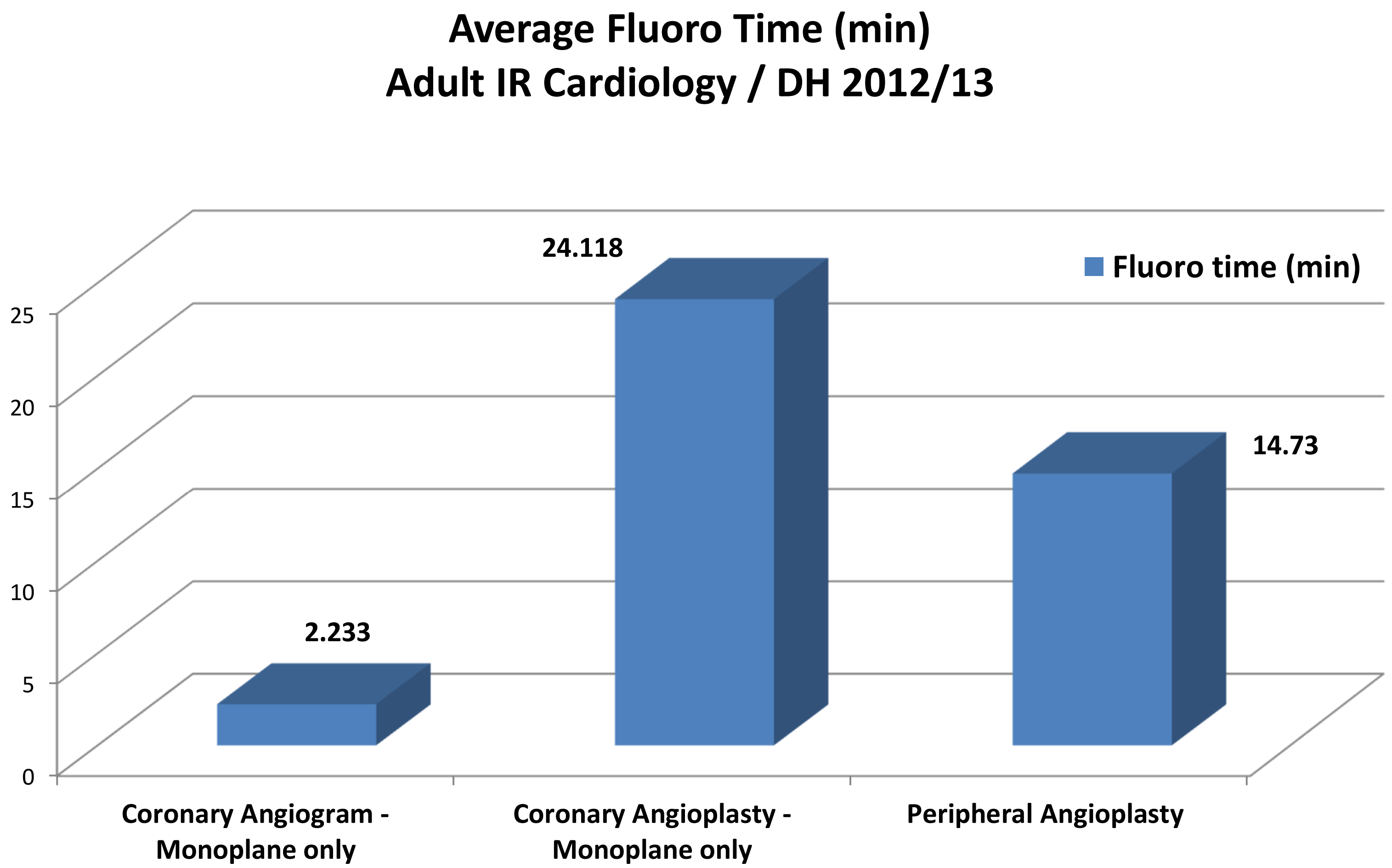
	Plan A	Plan B			
Age Group	Cumulative Air kerma to IRP** (mGy)	Cumulative Air kerma to IRP** (mGy)	DAP mGy cm^2	DAP Gy cm^2	No of Patients
0-<1y	100.608	106.694	11478	11.478	29.000
1y-<5y	93.521	83.736	10345	10.350	23.000
5y-<10y	135.435	105.89	20005.25	20.005	16.000
10y-<=15y	338.634	355.164	13414	13.414	4.000

Dubai Health Authority (DHA) Experience
Interventional radiology (Paediatric) / Cardiac DH

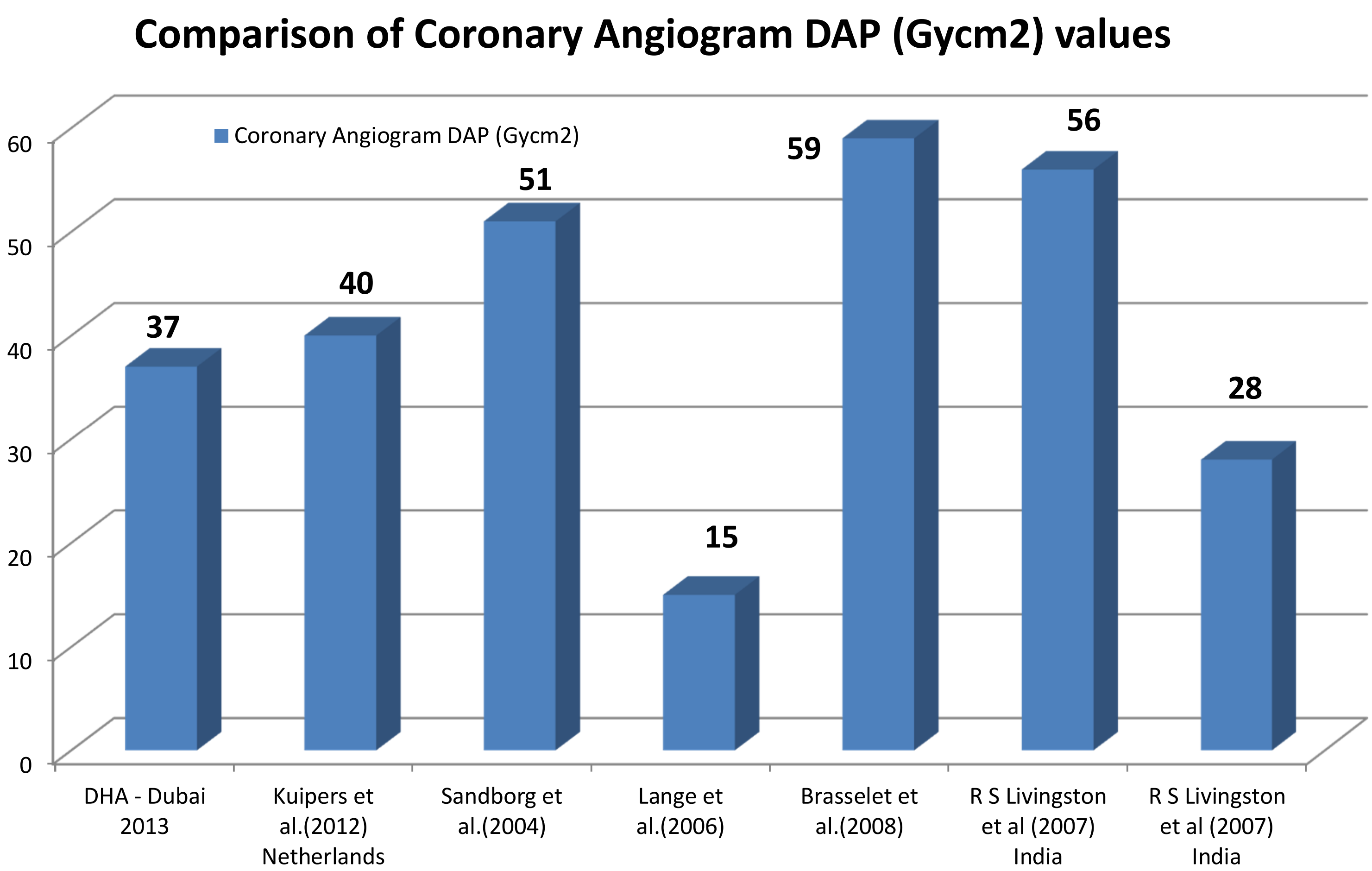
Figure-3: DHA Paediatric IR doses.



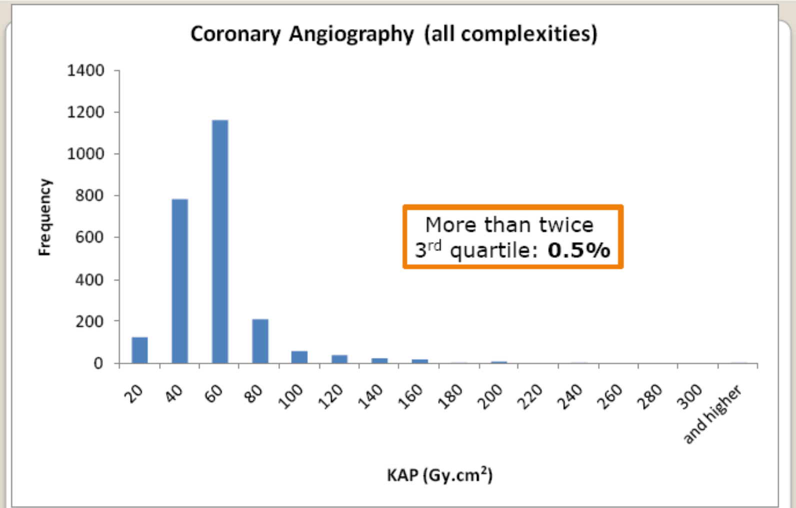
Dubai Health Authority (DHA) Experience
Interventional radiology (Adult)



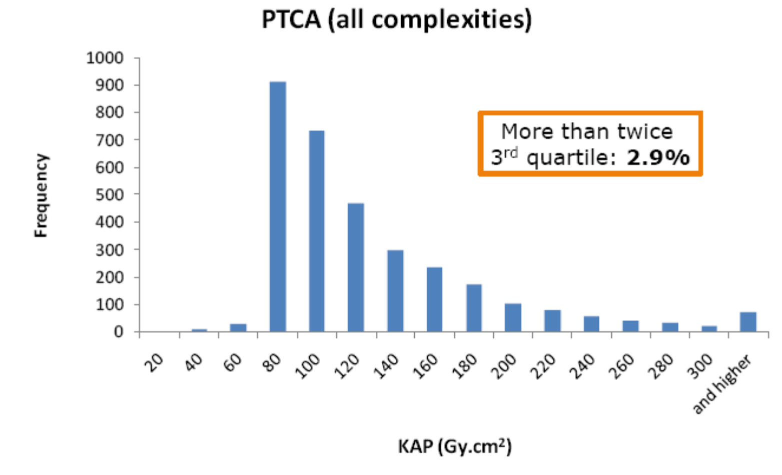
Dubai Health Authority (DHA) Experience
Interventional radiology (Adult)



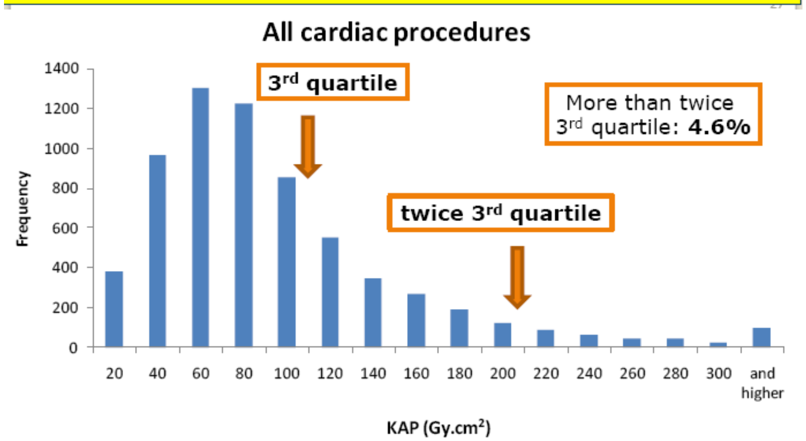
References on
Cardiac Dosimetry in Interventional radiology



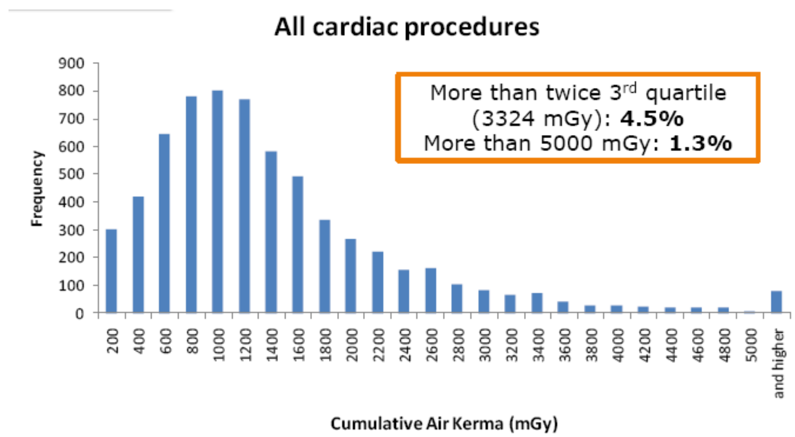
Sample	Median	Mean	SD	Min	Max	3rd quartile
2407	46	48	26	1	536	56



Sample	Median	Mean	SD	Min	Max	3rd quartile
3237	98	118	63	26	764	139



Sample	Median	Mean	SD	Min	Max	3rd quartile
6558	70	86	68	1	924	106



Sample	Median	Mean	SD	Min	Max	3rd quartile
6557	1079	1325	1039	1	12683	1662

Vano presentation, 2012

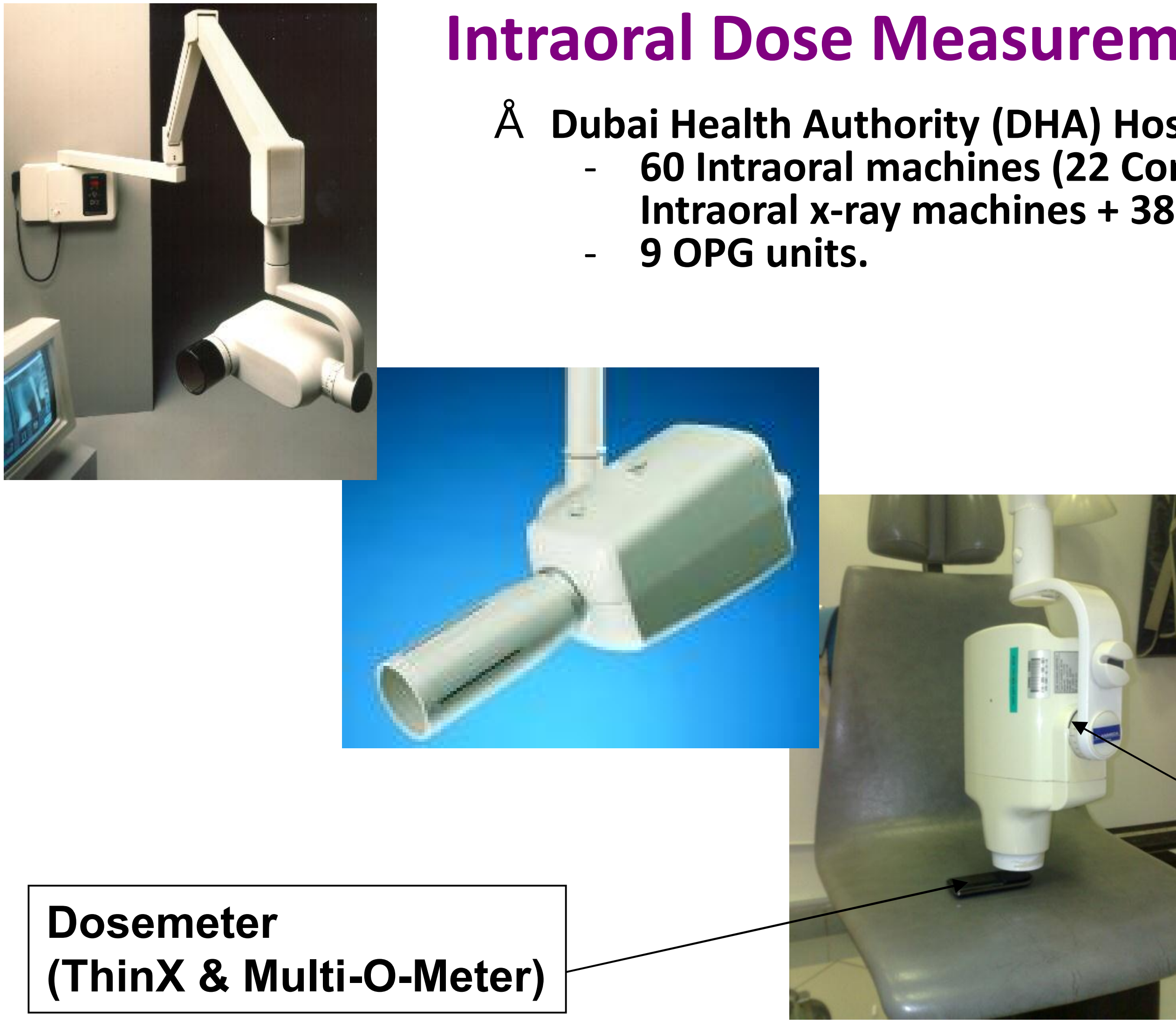
https://rpop.iaea.org/RPOP/RPoP/Content/Documents/Whitepapers/conference/S5-Vano-Diagnostic-reference-levels.pdf

International Conference on
RADIATION PROTECTION IN MEDICINE
Setting the Scene for the Next Decade
3–7 December 2012
Bonn, Germany

Dubai Health Authority (DHA) Experience
Dental Radiology (Paediatrics and Adults)

2nd ICRP International Symposium on the System of Radiological Protection
October 22-24, 2013, ABU DHABI, UAE

Dubai Health Authority (DHA) Experience
Dental Radiology (Paediatrics and Adults)



Intraoral Dose Measurements

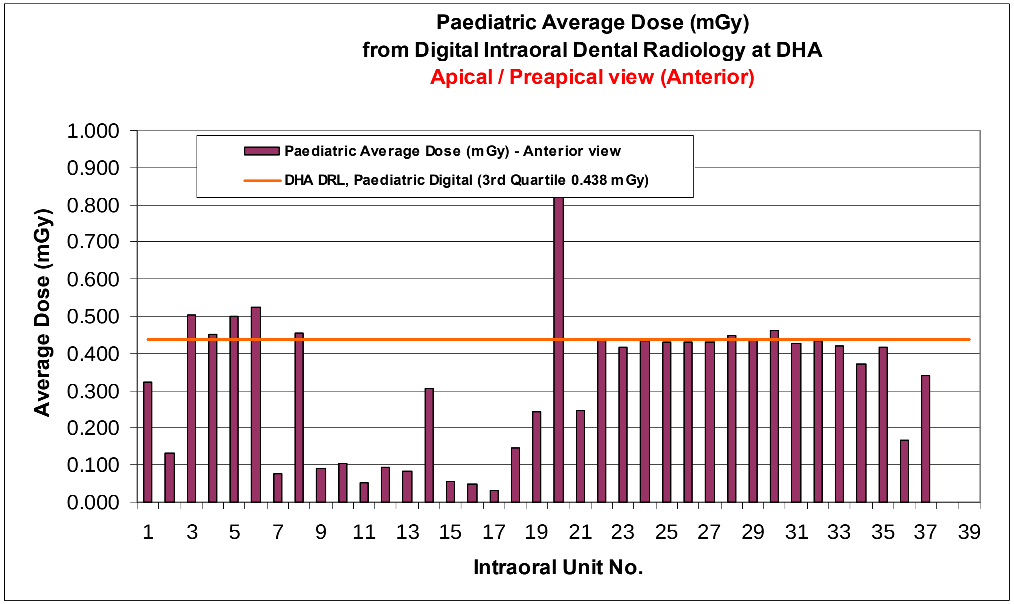
Å Dubai Health Authority (DHA) Hospitals:
- 60 Intraoral machines (22 Conventional Film Based Intraoral x-ray machines + 38 Digital x-ray machines)
- 9 OPG units.

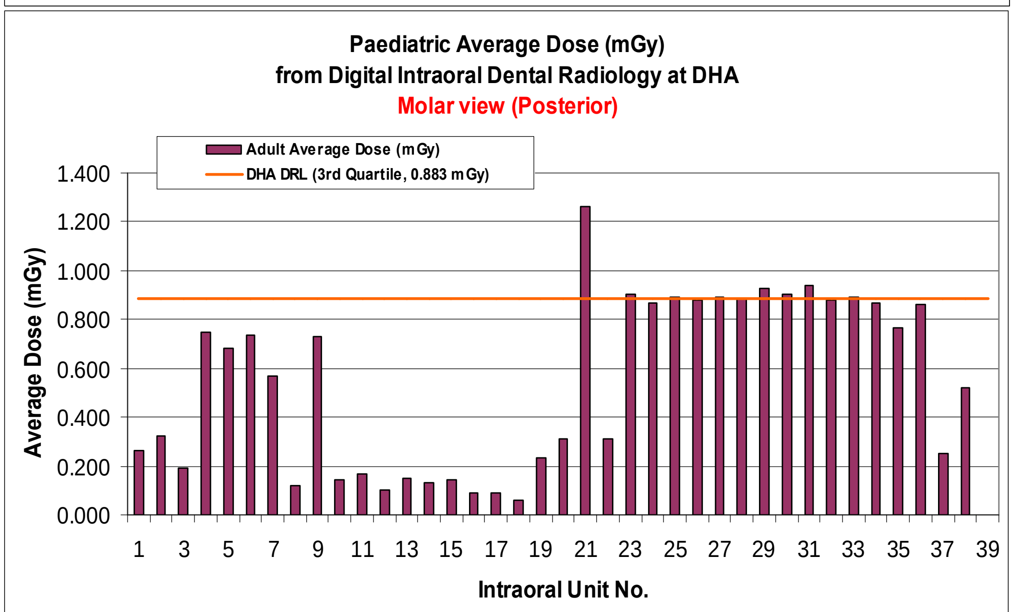
Dosemeter (ThinX & Multi-O-Meter)

Intraoral Unit

Dubai Health Authority (DHA) Experience
Dental Radiology (Paediatrics and Adults)

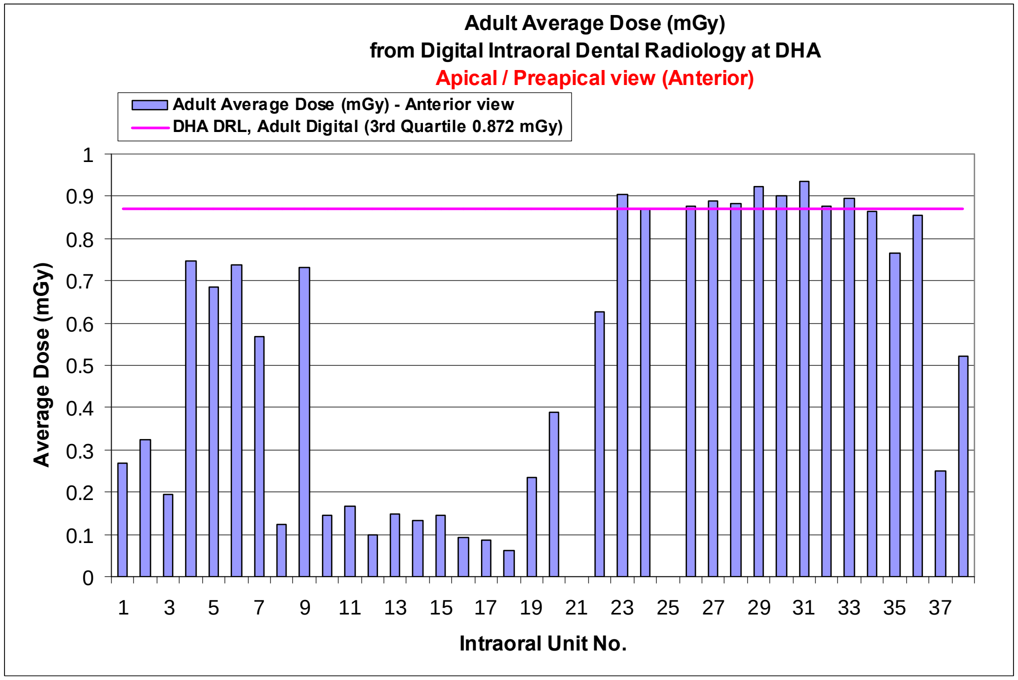
DHA Local DRLs (Paed.)

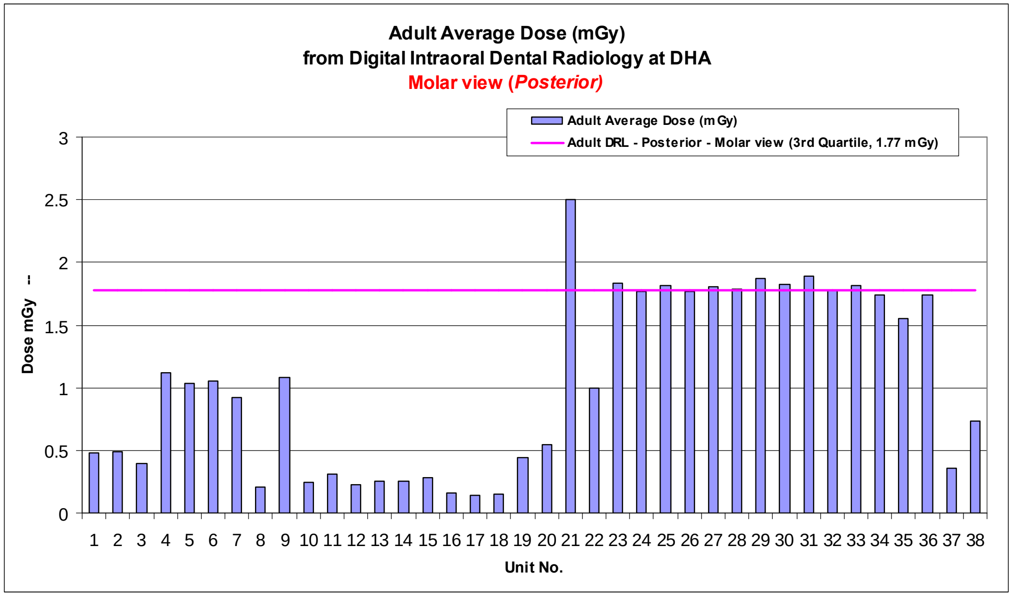




Dubai Health Authority (DHA) Experience
Dental Radiology (Paediatrics and Adults)

DHA Local DRLs (Adult)





Dubai Health Authority (DHA) Experience
Dental Radiology (Paediatrics and Adults)

DHA Intraoral Dosimetry Results (Digital I.O. x-ray machines) 2010/2011		
Dental Imaging View	**3rd Quartile Dose (mGy) Paediatric**	**3rd Quartile Dose (mGy) Adult**
Apical / Preapical (Anterior View)	0.438	0.872
Molar (Posterior View)	0.882	1.777
Bitewing View	0.712	1.452
All views	0.642	1.294

IAEA (5 & 7 mGy)- 1996, Denmark 3.5 mGy - 1995, Greece 5 mGy- 1998, Spain 3.5 mGy- 2001, EU 4 mGy-2004 and the UK (Adult 2.3 mGy & Paed 1.5 mGy) (1)(3) (7). The Diagnostic Reference Levels (DRL) for intraoral dental radiographs of 4mGy was approved by the Ireland Dental Council in 2010 (6), USA Bitewing 1.6 mGy (NCRP 172, 2012)

Table-1: Film Based and Digital Intra Oral dosimetry results of the DHA- Paediatric, (2010/2011)

Dental Imaging View	Paediatric 3rd Quartile Dose (mGy) (Film Based x-ray)	Paediatric 3rd Quartile Dose (mGy) (Digital I.O. x-ray)
Apical / Preapical (Anterior View)	2.154	0.438
Molar / Premolar (Posterior View)	2.540	0.882
Bitewing View	2.923	0.712
All views	2.635	0.642

Dubai Health Authority (DHA) Experience
Dental Radiology (Paediatrics and Adults)

Table-2: Film Based and Digital Intra Oral dosimetry results of the DHA- Adult, (2010/2011)

Dental Imaging View	Adult 3rd Quartile Dose (mGy) (Film Based x-ray)	Adult 3rd Quartile Dose (mGy) (Digital I.O. x-ray)
Apical / Preapical (Anterior View)	3.547	0.872
Molar / Premolar (Posterior View)	5.190	1.777
Bitewing View	4.694	1.452
All views	4.5925	1.294

Dubai Health Authority (DHA) Experience
Dental Radiology (Paediatrics and Adults)

Implementation of Digitization System

- **State-of-the-art dental imaging plate system dedicated for dental practices is implemented at the DHA to digitize the analogue I.O. and OPG systems.**

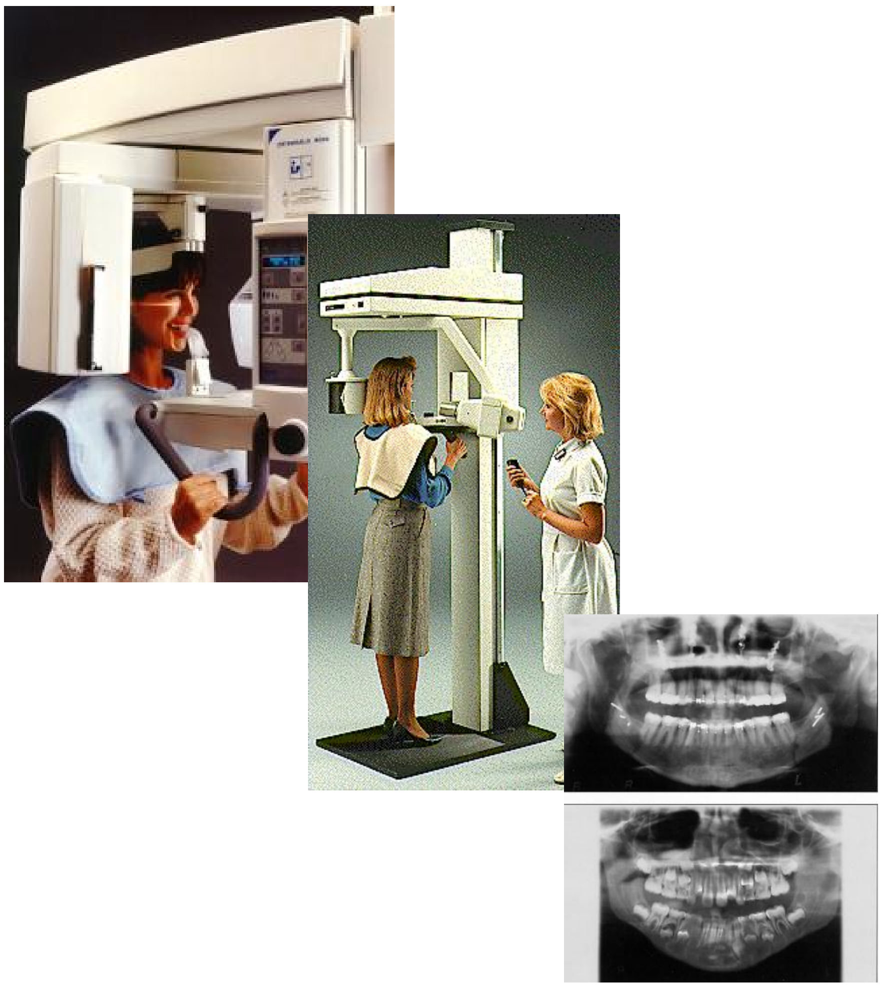
Å **Dental Dosimetry Results post the implementation of the digitization system:**

View	Paediatric Exposure Time Reduction (%)	Paediatric Dose Reduction (%)	Adult Exposure Time Reduction (%)	Adult Dose Reduction (%)
Apical / Preapical (Anterior View)	60	76.649	60	73.340
Premolar / Molar (Posterior View)	Same as Anterior View			
Bitewing View	Same as Anterior View			

- *Exposure time before the implementation of the digitization system was 1 s for both paediatric and adult. After the digitization implementation it was reduced to 0.32 s & 0.4 s for paediatric and adult patients group, respectively.*

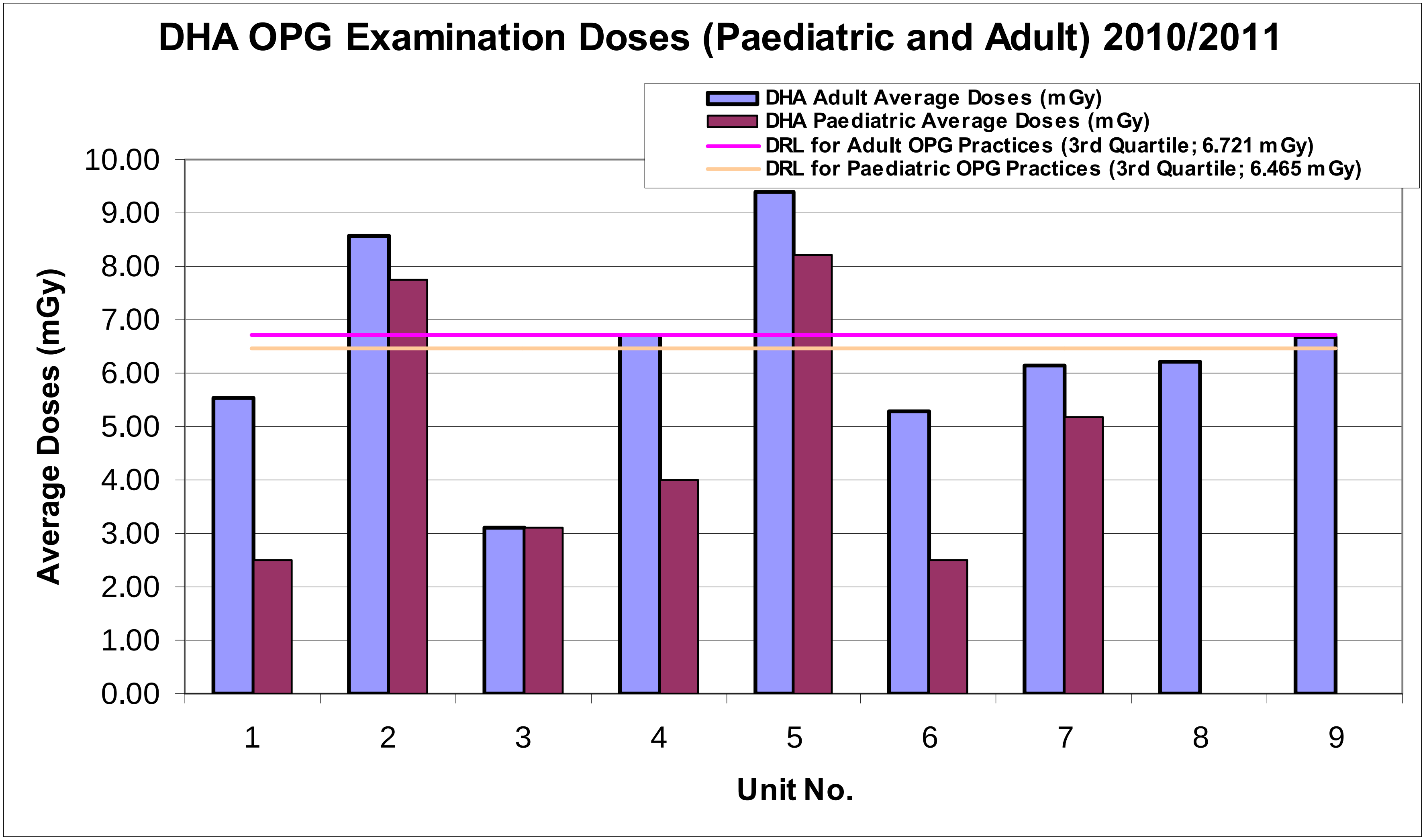
Dubai Health Authority (DHA) Experience
Dental Radiology (Paediatrics and Adults)

DHA Results for OPG Dental systems



Dubai Health Authority (DHA) Experience
Dental Radiology (Paediatrics and Adults)

DHA OPG Dosimetry Results (2010/2011)



Dubai Health Authority (DHA) Experience

- The necessity for local radiation protection educational programs and patient dosimetry monitoring and recording were emerged from our patient radiation dosimetry projects. These are considered as essential requirements to prompt radiation safety culture within the various healthcare communities.

DHA Radiation Protection Educational Program (RPEP)

Scientific Program Model

حكومة دبي GOVERNMENT OF DUBAI

هيئة الصحة بدبي DUBAI HEALTH AUTHORITY

DHA Radiation Protection Educational Program (RPEP):

Basics of Radiation Protection in Hospitals (Radiology Practices)

Department of Medical Education, DHA إدارة التعليم الطبي

DHA Radiation Protection Committee اللجنة المركزية للوقاية من الإشعاع

Session No. & Date	Session – 1 Monday	Session – 2 Tuesday	Session– 3 Wednesday	Session– 4 Tuesday	Session– 5 Wednesday ......
Lecture Titles **Time: 3:00–5:30 pm**	- Welcome and Introduction (15 min) - Pre-course Evaluation (1/2 hour) L1- Nature of Ionizing Radiation & Radiation Physics (1hour) Interactive Session (1/2 hour)	L2 - Radiation quantities and units (1hour) L3- Biological effects of ionizing radiation (1hour) Interactive Session (1/2 hour)	L4- X-Ray Machine and Production (1 hour) L5- Radiation Safety Regulations & The system of radiation protection: justification, optimization and limitation (1 hours) Interactive Session (1/2 hour)	L6- Operational radiation protection-I (1 hours) L7- Operational radiation protection- II (1 hours) Interactive Session (1/2 hour)	L8- Patient radiation protection (1.5 hours) Interactive Session (1/2 hour) - Post-course Evaluation (1/2 hour)
Lecture Description and Content	**L1-** Nature of Radiation, The Atomic structure, Penetrating Properties of Radiation, HVL and TVL concepts Radiation Interaction of radiation with matter: Bremmstralung and characteristic X-rays, Photoelectric effect, Compton effect & pair production	**L2-** Radioactivity, Exposure, absorbed dose, KERMA, Equivalent Dose, Effective Dose Related dosimetry quantities (surface and depth dose, backscatter factor..), **L3-** Classification of radiation health effects, Factors affecting radio sensitivity, Dose-effect response curve, Whole body response: acute radiation syndrome, Effects of antenatal exposure and delayed effects of radiation, Epidemiology	**L4-** X-ray production, x-ray imaging factors, Relationship between x-ray imaging factors and patient & staff Radiation Safety, Quality Assurance program at Radiology **L5-** National and International Radiation Protection systems (UAE Regulations, ICRP, BSS), Concepts and aims of Radiological Protection, The system of Radiation Protection. Justification and optimization criteria,	**L-6** External and Internal Radiation Hazards, Implementation of Dose Limits (Workers and Public), Dose constraints, Classification of controlled areas, Pregnancy and Radiation Measurements of Ionising Radiation, **L-7** Monitoring Techniques, Protective barriers, Warning signs and labels, Radioactive Contamination and waste management, Examples of practical radiation safety measures at Radiology	**L8-** Dose Quantities to be measured in simple and complex examinations, Relation of these quantities with organ and effective doses, Digital radiology and Factors affecting Patient doses, Diagnostic Guidance (or reference) levels (DRLs), Referral Guidelines
Lecturers & Coordinators	Course Coordinators/Lecturers: Dr Mohamed Abdelsattar Bayoumi, Ms Laila Ghuloom AlBalooshi, Ms Najlaa AlMazrouei, Dr Jacek Janaczek and Dr Jamila Salem Alsuwaidi.			Total Hours: 11 Hours (the Course is conducted by Medical Physicists / Radiation Protection professionals)	

Conclusions:

- **Variation in dose measurements** along with the variation in manufacture specifications reflected on the **wide range of DRLs** values in radiological examinations.
- Well **established and simple methods in dose evaluation** for DR systems are required to avoid patient overexposure.
- No enough **DRLs data on IR** procedures and on **Paediatric group**.
- **CBCT DRLs data is not widely implemented** yet, however, some DRL figures already quoted. EC, CBCT, RADIATION PROTECTION N° 172 , 2012
- Patient radiation exposure **auditing** is to be considered as part of Quality Assurance program and this not been fully implemented at our area yet. This will improve patient radiation safety.
- Standardization of automated dose evaluation among the manufactures is required. **Automated DICOM dose extraction techniques** are essential to handle large samples of patients dosimetry data.
- **Lack of qualified experts and medical physicists** obstruct the process in research work related to patient radiation dosimetry and safety.

Conclusions:

What Do We Need From ICRP In Medicine?

- **Education:** Educate and Instruct Radiology teams to avoid overexposure and "**Dose Creep**" in DR practices.
- **Re-evaluation** of DRLs for DR procedures.
- **Simple methods** for patient dose evaluation.
- Emphasis on **Dose Recording** within patients medical reports
- **Dose Registry:** Uniform, Accurate & Calibrated

Acknowledgments

- IR team at Dubai Hospital (Ms Jessy Philip, Ms Shella, Ms Sheeba)
- PHC Administration (Ms Amal Mohamad, Head of Medical Imaging Dept.)
- Latifa Hospital Administration (Ms Shifa Khamis, Dir CSA and Ms Ayda Abdulaziz, Radiology Superintend)
- Dubai Hospital Administration (Ms Farida Alkhaja, Dir CSA)
- Dubai Hospital Radiology Dept. (Dr Jassem Ibrahim, Head of Radiology and Mr Hashim AlAwadhi, Radiology Superintend)
- Members o the DHA Radiation Protection Committee.
- IAEA TC projects (M. Rehani).

Not Part of this Paper/Presentation.
Just a highlight on one of the important outcome of IAEA TC Project

Task-5 Computed Tomography (CT)

AJR Am J Roentgenol. 2013 Oct;201(4):858-64. doi: 10.2214/AJR.12.10233.

Continuous Monitoring of CT Dose Indexes at Dubai Hospital.

Alsuwaidi JS, Albalooshi LG, Alawadhi HM, Rahanjam A, Elhallag MA, Ibrahim JS, Rehani MM.

Source

1 Department of Medical Education, Dubai Health Authority, Dubai, United Arab Emirates.

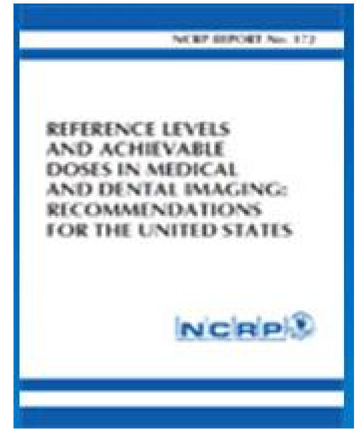
Abstract

OBJECTIVE. Experience of continuous monitoring and control of patient doses in CT in Dubai Hospital over a period of approximately 4 years (January 2008 through August 2011) is presented. MATERIALS AND METHODS. Dose measurements-in particular, weighted and volumetric CT dose index, dose-length product (DLP), and estimated effective dose-were regularly monitored using head (16 cm diameter) and body (32 cm diameter) CT phantoms. Patient radiation dose indexes were manually recorded during 2008 for common CT examinations: head, chest, and abdomen and pelvis scans. In 2009-2011, these CT dose data were recorded within the radiology information system and the PACS. Dose reduction actions were taken while maintaining a watch on image quality. The effects of these factors were monitored through change in average DLP on a monthly basis and third quartile annually. Adapted diagnostic reference levels were used for comparison. RESULTS. The reduction in adult dose indexes in 2010 as compared with 2008 was 52%, 16.4%, and 34.8% for head, chest, and abdomen and pelvis examinations, respectively. For the pediatric group, the reduction was 45.23%, 39.6%, and 43.34% for head, chest, and abdomen and pelvis examinations, respectively. CONCLUSION. Substantial reduction in DLP for common examinations of adults and children is shown through a program of continuous monitoring and action. The results indicate the need to introduce local diagnostic reference levels to substitute for the adapted ones.

PMID:
24059376

DRLs references

Report No. 172 - Reference Levels and Achievable Doses in Medical and Dental Imaging: Recommendations for the United States (2012)



HPA – RPD – 022, UK Dental radiology DRL, 2007

HPA-RPD-029

Doses to Patients from Radiographic and Fluoroscopic X-ray Imaging Procedures in the UK – 2005 Review

D Hart, M C Hillier and B F Wall **2007**

References / Dental Radiology

References for Further Readings:

(1) Technical Note: RADIATION EXPOSURE AND DOSE EVALUATION IN INTRAORAL DENTAL RADIOLOGY, B. POPPE ET AL, Radiation Protection Dosimetry (2006), 1 of 6(doi:10.1093/rpd/ncl113)

(2) IAEA website **http://rpop.iaea.org/RPOP/RPoP/Content/InformationFor/HealthProfessionals/6_OtherClinicalSpecialities/Dental/DentalPatientProtection.htm**

(3) Safety Standards, Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series, Report 115-1, IAEA, 1994.

(4) Radiation Protection 136, European guidelines on radiation protection in dental radiology: The safe use of radiographs in dental practice, European Commission, Directorate-General for Energy and Transport, Directorate H — Nuclear Safety and Safeguards, Unit H.4 — Radiation Protection (2004).

(5) **Journal of the American College of Cardiology © 2012 by the American College of Cardiology Foundation; the American Heart Association, Inc.; and the Duke University Clinical Research Institute, Published by Elsevier Inc.,Vol. 59, No. 20, 2012, ISSN 0735-1097/12/$36.00,doi:10.1016/j.jacc.2012.01.005,**

(6) Population Dose from Dental Radiology: 2010, Health Service Executive January 2011(Ireland)

(7) The British Journal of Radiology, 82 (2009), 1–12

Thank You

jsalsuwaidi@dha.gov.ae