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What we have learned from the session "Malaysia-Thailand Collaboration on DRL: Moving Forward" in the Malaysian Congress of Radiology Meeting 2024

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Abstract

The session highlighted the collaborative efforts between Malaysia and Thailand in optimizing diagnostic reference levels (DRLs) for radiation exposure in medical imaging. The councils also emphasized the differences in approach: Malaysia's top-down mandatory system versus Thailand's voluntary cooperation model. Challenges such as funding, protocol establishment, and training were identified as barriers to effective DRL implementation. The importance of collaboration among radiologists, medical physicists, and technology developers was stressed to enhance patient safety and optimize radiation doses. Future strategies proposed included developing updated guidelines, sharing anonymized dose data, and organizing workshops to foster knowledge exchange. The session concluded with a call for legislative support in Thailand to make national dose surveys mandatory, aiming for improved radiation safety standards in both countries.

Keywords: Diagnostic reference levels, Malaysia, National DRLs, Radiation dose, Thailand.

The meeting was held on 27 July 2024 in Kaula Lumpur, Malaysia. The panelists were Professor Dr. Norzaini Rose Mohd Zain (Head of Radiological Service of Malaysia), Professor Dr. Norlisah Mohd Ramli (Present President of Malaysian Congress of Radiology, MCOR), Professor Dr. Kartini Rahmat (Organizing Chair), Associate Professor Dr Farhana Fadzli (Scientific Chair), Mdm Nurmazaina Md Ariffin, MMedPhys (Senior Principal Assistant Director Medical Radiation Surveillance Division, Ministry of Health), Professor Kwan Hoong Ng, PhD (Department of Biomedical Imaging, Faculty of Medicine Universiti Malaya (UM) and Supika Kritsaneepaiboon, M.D in the representative of Radiological Society of Thailand (RST).

The first dose survey in Malaysia was initiated in 1993-1995 including only 12 public hospitals and reported in United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2000. The first national dose survey was conducted by the Ministry of Health, Malaysia in 2007-2011 covering diagnostic and interventional radiology, nuclear medicine and dental radiology. It was conducted in 437 public and private hospitals, medical centers or GP clinics, and 329 public and private dental hospitals. Whereas the first dose survey in Thailand was initiated in 2017 and first reported in 2018 which was conducted only with general and dental radiography. It was obtained only from 250 X-ray machines in the total of 6189 machines including from public and private hospitals and medical centers. A potential source of bias may arise from the use of different types of machines between urban and rural areas. The national dose survey in Malaysia is under the control of the Medical Radiation Surveillance Division, Ministry of Health and it is the top-down approach. The hospital recruitment and dose survey are regulated and mandatory. On the contrary, the dose survey in Thailand is voluntary and manipulated from the cooperation of many organizations.

The diagnostic reference levels (DRLs) were introduced by the International Commission on Radiological Protection (ICRP) in ICRP publication 73 to improve CT dose optimization by identifying unjustified levels of radiation doses [1, 2]. The department of Medical Science, Ministry of Public Health is principally responsible for the main responsibility for the National Diagnostic Reference Levels

(DRLs) in Thailand. The other dose surveys of CT, interventional and cardiovascular X-ray machines are also conducted to and supported by the Royal College of Radiology of Thailand (RCRT), the Office of Atoms for Peace, the Thai Society of Vascular and Interventional Radiology (TSVIR) and the Cardiovascular Intervention Associated of Thailand. For example, the Projects THA6043 supported by the Office of Atoms for Peace conducted the CT dose survey in both adults and children. Although the hospital recruitment from more specific professional organizations (e.g. RCRT, or TSVIR) had a smaller number of hospitals (25-30 hospitals), they could provide more specific details of the study, for example, computed tomographic angiography (CTA) of coronary in prospective and retrospective electrocardiogram (ECG) gating; CTA of aorta categorized in whole aorta, thoracic aorta, and abdominal aorta; CTA for stroke fast track categorized into brain in 3 phases, brain and neck in 1 phase; and CT for urinary stone categorized into single energy and dual energy. Thailand also conducted National CT dose index registry reported by the Office of Atoms for Peace and The Royal College of Radiology of Thailand (RCRT) in which the CT protocol names were categorized into body regions and non-contrast and contrast studies regarding to the American College of Radiology's Dose Index Registry. After the other organizations complete their dose survey, they will report back to the Ministry of Public Health. It is like a bottom-top approach which is different from the Malaysian system. We suggested the Ministry of Public Health in Thailand cooperate with radiologists who deal with radiation optimization and national DRLs in the representatives of public/ government hospitals, private hospitals, and medical school hospitals and legislate the National Dose Survey as a mandatory or legally bound to obtain more recruited hospitals, which resembles the Malaysian models.

Lack of funding for support, protocol establishment and training to understand DRL were the main common constraints for pre-implementation of the DRL. The limitations during data collection were manpower, variable machine technologies, and human errors. The post-implementation limitations lied with clinical practice and standardized protocols. We tried to encourage the DRL implementation without penalties for those whose radiation dose exceeds the DRL. The radiographers and technologists should understand how to implement DRLs into clinical practice. Furthermore, the medical physicists can help adjust image parameters and radiologists can help by providing clinical image quality requirements, particularly the CT images. Most radiologists are not familiar with the grainy image (high image noise), which can be solved by using image reconstruction software or deep learning image reconstruction. Iterative Reconstruction in Image Space [IRIS], Sinogram-Affirmed Iterative Reconstruction [SAFIRE], and Advanced Model-Based Iterative Reconstruction [ADMIRE], Siemens Healthcare; iDose and Iterative Model Reconstruction [IMR], Philips Healthcare; Adaptive Statistical Iterative Reconstruction [ASIR] and Model-Based Iterative Reconstruction [MBIR or Veo], GE Healthcare; and Adaptive Iterative Dose Reduction [AIDR], Cannon Medical Systems, have all demonstrated the potential to reduce radiation dose on various scanners [3]. Additionally, the U.S. Food and Drug Administration (FDA) has approved three CT vendors' deep learning algorithms for commercial use: TrueFidelity (GE Healthcare), AiCE (Canon Medical Systems), and Precise Image (Philips Healthcare) [4].

The reported DRL for plain radiographs between Thailand (2021) and Malaysia (2013) is presented in Table 1. One limitation is that we could not directly compare the reported Diagnostic Reference Levels (DRLs) between Thailand and Malaysia due to differences in radiographic techniques and measurement units. Thailand used digital radiography (DR) and reported patient dose in terms of entrance-surface air kerma (ESAK), while Malaysia used computed radiography (CR) and reported dose as entrance surface dose (ESD). ESAK measures the energy transferred to the skin surface during an X-ray procedure, whereas ESD represents the actual radiation dose absorbed by the patient's skin. In DR, ESAK is commonly used to evaluate patient exposure, while ESD is widely applied in both CR and DR. Both metrics are essential for optimizing the radiation dose while preserving the image quality.

The comparison of DRL for CT study between Thailand (2023) and Malaysia (preliminary report in 2024) is presented in Table 2.

Dual-energy CT (DECT) can provide certain patients benefits even when using lower radiation doses and less cancer risk compared to traditional single-energy CT (SECT), primarily due to improved image quality, material differentiation, and diagnostic efficiency. Moreover, it can provide more image information such as types of urinary stone and areas of decreased pulmonary perfusion or infarcts. The DRL of multiphase abdominal CT study was higher than that of Malaysia could be due to the multiphase study, including the delayed phase in Thailand.

There are several strategies and actions that Thailand and Malaysia could implement in the future to advance the field and improve patient safety. Firstly, guidelines that reflect the latest research and technological advancements can be developed and updated. The work can done be toward the protocol standardization across different regions and institutions. Secondly, anonymized dose data can be shared across institutions to build comprehensive databases, which can serve as collaborative research. Thirdly, relevant parties can organize or participate in workshops and conferences focused on DRLs, where professionals can share knowledge, experiences, and advancements. Lastly, there can be a collaboration with technology developers to develop new software tools or systems that can assist in dose data analysis.

Table 1. *The reported DRL for plain radiographs between Thailand (2021 and 2023) and Malaysia (2013) [5-7].*

		Thailand (2021)* ESAK (mGy)	Thailand (2023)* ESAK (mGy)	Malaysia (2013)† ESD (mGy)
Examination Type	Projection			
Chest	PA	0.3	0.4	0.87
Abdomen	AP	3.8	3.49	7.36
Pelvis	AP	3.1	3.15	5.80
Cervical	AP	- ‡	1.39	2.10
	Lateral	- ‡	1.36	2.05
Thoracic	AP	- ‡	3.74	6.80
	Lateral	- ‡	5.81	7.50
Lumbo-sacral	AP	3.8	3.4	7.50
	Lateral	9.8	9.18	13.4
Skull	AP	2.6	2.28	4.80
	Lateral	2.1	2.09	2.40

*Note: *Data obtained from Digital Radiography, † Data obtained from computed radiography (CR) ‡ Uncollected data, and, ESAK = entrance-surface air kerma, ESD = entrance surface dose.*

We were unable to compare the reported DRL between two countries because of different obtained radiographic techniques and different measured quality units.

Table 2. *The comparison of DRL (DLP unit mGy*cm) for CT study between Thailand (2018-2023) and Malaysia (preliminary report in 2024) [6, 8].*

Examination Type	Thailand DMSc (2018)	Thailand THA6043 (2018)	Thai RCRT and OAFP (2021-2022)	Thai CT-DR 9 hospitals (2023) (P75)	Malaysia (2024)
Brain, single phase	935 (C) 1028 (NC)	1166 (C) 1125 (NC)	-	1157 (NC)	960
Chest	655 (C) 417 (NC)	509 (C or NC)	-	451 (C) 452 (NC)	310 (routine)
Abdomen 1 phase with contrast	717	741	-	932	810
Abdomen Multi-phases	-	2307	-	2239	1350
Thorax & abdomen (one phase)	-	1001	-	1179	820
CT renal stone	-	-	625 (single energy) 544 (dual energy)	-	500
CTA coronary	-	-	233 (pro) 976 (retro)	-	860 (pro)
CTA brain	-	-	1095	-	1500
CT pulmonary angiogram			495 (single energy) 304 (dual energy)		300
Neck			504		400
Paranasal sinus			548		430

Note: Abbreviation C = contrast study, NC = non-contrast study, DMSc = Department of Medical Science, RCRT = Royal College of Radiology Thailand, OAFP = Office of Atoms for Peace, Pro = Prospective EKG gating, Retro = retrospective EKG gating.

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