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EDITORIAL

Dear reader, with great pleasure we provide you with the third issue of Atom Indonesia in 2016, namely Volume 42, No. 3 (2016). The number of articles submitted to Atom Indonesia has significantly increased for the past few years. Therefore, only the articles that fulfill our requirements and qualifications will become our priority. Atom Indonesia has been trying to improve its services by keeping publication timeline on time and also by providing articles in press by using the Digital Object Identifier (DOI) for each article.

As previously mentioned, Atom Indonesia has been indexed by Google Scholar, DOAJ, Crossref, ISJD, and IAEA INIS. By this indexing, it is expected that Atom Indonesia become better known among the researchers from around the world and easier to access. It would also increase the impact factor of the journal. Indonesian Institute of Science (LIPI) has approved our journal as one of the international reputed journals, besides reaccrediting it in the A category. Another important news is that Atom Indonesia has been reaccredited by the Ministry of Research, Technology and Higher Education with the number of 36b/E/KPT/2016, with the highest mark (A). This information can be found in the Atom Indonesia website, http://aij.batan.go.id. A further target of our journal is to be indexed by Scopus. Therefore, we have submitted the application to Scopus at the end of November 2015. Presently, this journal is under review by Scopus.

The Atom Indonesia Vol. 42 No. 3 (2016) contains seven articles discussing various applications of nuclear science and technology, such as nuclear power plant monitoring and control, development and characterization of nuclear fuels, radiation application in medical diagnostics, characterization and production of radiopharmaceuticals, and analysis of environmental radiation contamination on organisms.

"Preliminary Values of Diagnostic Reference Level for Selected X-Ray Examinations in Indonesia" was explored by E. Hiswara and his colleagues from Center for Radiation Safety Technology and Metrology, National Nuclear Energy Agency. The diagnostic reference levels form an efficient, concise, and powerful standard for optimizing the radiation protection of a patient. With an aim to contribute toward the establishment of the Indonesian National Diagnostic Reference Levels (NDRLs), a nationwide survey of the entrance surface doses received by adult patients during the most typical X-ray examinations has been performed. A number of 44 hospitals in 21 cities located in Java, Bali, Sumatera, Kalimantan, and Sulawesi islands were selected randomly to participate in this survey. Eight most common adult X-ray examinations in 13 projections, as well as four children X-ray examinations in six projections, were included in the list of procedures under consideration.

"An Online Non-Invasive Condition Monitoring Method for Stepping Motor CRDM in HTGR" was investigated by S. Bakhri and N. Ertugrul. It represents a collaborative work between National Nuclear Energy Agency and the School of Electrical & Electronic Engineering, University of Adelaide, Australia. The control rod drive mechanism (CRDM) based on stepping motor is one of the components applied in high-temperature gas-cooled reactors (HTGRs) to control the reactivity as well as to maintain the safety of reactor. The stepping motor requires a unique condition monitoring to avoid any failures especially due to the specific environments of CRDMs in the HTGR such as the allowable limits of high temperature and high radiation, as well as the location of a stepper motor inside a pressure shell. The online condition monitoring is carried out by direct pattern matching of the output signals of logic generator block and the output signals of motor driver. The online method utilizes signature patterns of voltage and stator current signals of the healthy motor as a baseline for healthy motor.

"Development of ^{99}Mo/^{99m}Tc Generator System for Production of Medical Radionuclide ^{99m}Tc using a Neutron-activated ^{99}Mo and Zirconium Based Material (ZBM) as its Adsorbent" was written by I. Saptiama and colleagues from Center for Radioisotope and Radiopharmaceutical Technology, National Nuclear Energy Agency, and A. Mutalib from the Faculty of Mathematics and Natural Science, Padjadjaran University, Sumedang, Indonesia. Molybdenum produced from fission of ^{235}U is the most desirable precursor for ^{99}Mo/^{99m}Tc generator system as it is not carrier added and has high specific activity. This report deals with development of ^{99}Mo/^{99m}Tc generator system where zirconium-based material (ZBM) is used as adsorbent of neutron-activated ^{99}Mo. The system was prepared by firstly irradiating natural Mo in the G.A. Siwabessy reactor to produce neutron-activated ^{99}Mo. The target was dissolved in NaOH 4 N and then neutralized with 12 M HCl.

"Neutronic and Thermal-Hydraulic Safety Analysis for the Optimization of the Uranium Foil Target in the RSG-GAS Reactor", is an interesting article written jointly by S. Pinem and T.M. Sembiring from Center for Nuclear Reactor Technology and Safety, National Nuclear Energy Agency, and P.H. Liem from the Nippon Advanced Information Service (NAIS Co. Inc.), Tokaimura, Ibaraki, Japan. The G.A. Siwabessy Multipurpose Reactor (Reaktor Serba Guna G.A. Siwabessy, RSG-GAS) has an average thermal neutron flux of 2×1014 neutron/(cm^2 sec) at the nominal power of 30 MW. The calculation results show that the optimum LEU foil target is 54 g corresponding to the reactivity change of less than the limit value of 500 pcm. From the safety analysis for the case when the primary flow rate decreased by 15% from its nominal value, it was found that the peak temperatures of the coolant and cladding are 69.5°C and 127.9°C, respectively, as described in this paper.

"Temperature and Salinity Effects on Bioaccumulation, Gill Structure, and Radiation Dose Estimation in the Milkfish Chanos chanos Exposed to ^{137}Cs" was written by W.R. Prihatiningsih, H. Suseno, N.P. Zamani, and D. Soedharma. It is a collaborative work between the Department of Marine Science and Technology, Bogor Agricultural University, Bogor, Indonesia, and the National Nuclear Energy Agency, Indonesia. The present trend of global warming has led to an increase in seawater temperature and salinity. The effects of increasing salinity and temperature on the accumulation of ^{137}Cs by milkfish Chanos chanos was studied under laboratory conditions to obtain information on Chanos chanos adaptability under environmental changes. This study links radionuclide bioaccumulation data and monitoring data obtained in the field and laboratory experiment with radiation dose determined by ERICA Tools, an approach that will enable better linkages to be made between exposure and dose in Chanos chanos and its marine food web.

R. Sigit, H. Suwarno, and B. Soegijono showed their results on "Characterization of Zircaloy-4 after Gaseous Hydriding at the Temperature Range of 350-600°C". It represents a collaborative work between the Department of Physics, Faculty of Mathematics and Science, University of Indonesia and National Nuclear Energy Agency, Indonesia. The degradation of the mechanical properties of zircaloy-4 as nuclear fuel cladding is inevitable due to its interaction with hydrogen during normal reactor operation. This experiment observed the occurrence of hydride phases after gaseous hydriding with hydrogen at elevated temperature, and their effects were evaluated based on the material's microstructure and mechanical properties. The results from optical microscope and scanning electron microscope confirmed the presence of hydrides at the specimens, identified by the growth of needle-like structure at those temperatures.

The "Uptake and Cytotoxicity Characterization of Radioiodine in MCF-7 and SKBR3 Breast Cancer Cell Lines" was explored by A. Elliyanti, *et al.* It is a collaborative work involving Medical Physics/Radiology Department of Faculty of Medicine, Andalas University, Dr. M. Djamil Hospital, Department of Nuclear Medicine and Department of Biochemistry, Padjadjaran University, Bandung, and National Nuclear Energy Agency of Indonesia. Radioiodine is an effective and low-risk therapy modality in well-differentiated thyroid cancer patients post near-total thyroidectomy. Extra thyroidal tumors such as breast cancer are known to be able to uptake radioiodine. The aim of this study was to analyze the uptake, efflux and cytotoxicity of radioiodine for two molecular types of breast cancer cell lines. These findings

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could potentially lead to the use if I-131 for ablative therapy in breast cancer, similiar to its use in the treatment of thyroid cancer.

We are glad to inform you, that the 8th Atom Indonesia Best Paper Awards (AIBPA) have been successfully conducted. The number of articles submitted for the competition has significantly increased this year to 55 papers. Finally, the referees have agreed to choose the best five winners among them. The first winner entitled "A Novel Method for ^{57}Ni and ^{57}Co Production using Cyclotron-Generated Secondary Neutrons" was written by H. Suryanto and I. Kambali from Center for Radioisotope and Radiopharmaceutical Technology (PTRR), National Nuclear Energy Agency, Serpong, Indonesia. The second and third place were "Micronucleus Frequencies and DNA Repair Gene XRCC3 Polymorphism in Radiation Workers of Center for Multi Purpose Reactor (PRSG), BATAN" and "Technetium-99m Labeled Diethyl Carbamazine Citrate (^{99m}Tc-DEC) as a New Diagnostic Agent for Lymphatic Filariasis Detection in Nuclear Medicine", respectively. The following articles, "An Experimental Analysis on Nusselt Number of Natural Circulation Flow in Transient Condition Based on the Height Differences between Heater and Cooler" and "The Analysis of Hierarchical Structure of Mesoporous Silica in Nanometer Scale by Small Angle Scattering Method", were the fourth and fifth place. The AIBPA prize was awarded to the winners by Head of Batan at the 58th anniversary BATAN Serpong, Indonesia, December 5, 2016.

Further information on AIBA 2016, and the full articles of, Atom Indonesia Vol. 42 No.3 (2016) can be downloaded from http://aij.batan.go.id.

Editor in Chief

Atom Indonesia

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Preliminary Values of Diagnostic Reference Level for Selected X-Ray Examinations in Indonesia

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ABSTRACT

The diagnostic reference levels form an efficient, concise, and powerful standard for optimizing the radiation protection of a patient. With an aim to contribute toward the establishment of the Indonesian National Diagnostic Reference Levels (NDRLs), a nationwide survey of the entrance surface doses received by adult patients during the most typical X-ray examinations has been performed. A number of 44 hospitals in 21 cities located in Java, Bali, Sumatera, Kalimantan, and Sulawesi islands were selected randomly to participate in this survey. Eight most common adult X-ray examinations in 13 projections, as well as four children X-ray examinations in six projections, were included in the list of procedures under consideration. Hospitals of different sizes and levels using different X-ray machines were represented in the survey. Standard thermoluminescence dosemeters were applied to measure entrance surface dose (ESD). A total of 1493 patients, consisting of 1208 adults and 285 children, were included in this study. The data were analyzed statistically and the minimum, median, mean, maximum, first quartile, and third quartile values of ESDs were reported. The ESDs calculated (third quartile) for adults varied from 0.18 mGy (for extremities AP) to 5.84 mGy (for lumbar spine LAT), and for children they varied from 0.16 mGy (for chest AP/PA) to 1.46 mGy (for skull AP/PA). Considering the geographic spread and size of Indonesia, those third quartile values calculated can only be regarded as preliminary DRL values for Indonesia. Compared with data from other countries, the calculated ESDs in this study are in general lower than the ESDs in those countries.

INTRODUCTION

In 1996, the International Commission on Radiological Protection (ICRP) in its Publication 73 introduced the term "diagnostic reference level" (DRL) to describe a concept of identification of abnormally high doses in diagnostic radiology. It is defined as "a form of investigation level, applied to an easily measured quantity, usually the absorbed dose in air, or in a tissue-equivalent material at the surface of a simple standard phantom or a representative patient" [1].

The ICRP also recommended that the values should be selected by professional medical bodies, reviewed at intervals that represent a compromise between the necessary stability and the long-term changes in observed dose distributions, and be specific to a country or region [1].

According to Vassileva and Rehani [2], diagnostic reference levels are not dose limits. In contrast to occupational dose limits, diagnostic reference levels should not be applied to individual patients, because one patient's body mass and habits may require a higher dose than those of a standard one.

Walker and van der Putten [3] stated that the use of DRLs provides a simple method of comparison between X-ray units from various manufacturers across a variety of practices. Once DRLs were established, standard procedures under the as-low-as-reasonably-achievable (ALARA)

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principle were employed to continually ensure that patient doses were kept below this reference value.

Given the various procedures available in X-ray examinations, studies to determine the patient entrance surface doses for this particular medical application of radiation have been carried out in many countries and regions, *e.g*., the UK [4], Greece [5], Iran [6], Italy [7], Ghana [8], Saudi Arabia [9], India [10], and Switzerland [11]. Under IAEA projects, patient doses were also measured in 12 countries in Asia, Africa, and Eastern Europe [12], as well as in Latin America [13]. With a few exceptions, the majority of the reported entrance surface values were similar.

The introduction of reference dose levels [4] has extended the use of the DRL concept from common X-ray examinations into interventional studies. The radiation exposure to patients during interventional procedures has been quantified to establish national diagnostic reference levels in Kenya [14], while the diagnostic reference levels for pediatric interventional cardiology has also been sought [15].

In Indonesia, an estimation of patient doses in mammographic examination has been carried out [16]. The patient mean glandular dose obtained from this study was 1.6 mGy. Moreover, another study estimated that thymus and thyroid doses received by patient undergoing thorax examination were around 0.005-0.094 mGy and 0.009-0.104 mGy, respectively [17].

The present study is an attempt to evaluate the doses to patients undergoing general diagnostic X-ray examinations in several hospitals in Indonesia. The aim of the study was to calculate average patient doses and to contribute to the establishment of the national diagnostic reference levels for most typical adult and children X-ray examinations performed in Indonesia.

EXPERIMENTAL METHODS

The survey was carried out during the years of 2010-2014. A number of 44 hospitals in 21 cities located in Java, Bali, Sumatera, Kalimantan, and Sulawesi islands were selected randomly to participate in this survey, representing a reasonable geographic spread and the size of Indonesia.

A total of 1489 patients, consisting of 1208 adults and 281 children, were included in this study. Children are defined as those of ≤16 years old, which is slightly different from that applied in the UK (≤15 years old) [4].

Eight typical adult X-ray examinations (13 projections) were chosen for this study: chest (Anterior Posterior (AP)/Posterior Anterior (PA), lateral (LAT), abdomen (AP), cervical (AP, LAT, oblique), lumbar spine (AP/PA, LAT), skull (AP/PA, LAT), extremities (AP), shoulder (AP), and pelvis (AP). For child patients, only four typical examinations (eight projections) were chosen: chest (AP/PA, LAT), abdomen (AP), skull (AP/PA, LAT), and extremities (AP). For each patient and X-ray unit, the following parameters were recorded: sex, age, weight, height, focus-to-skin distance, field size, kVp, and mAs.

Measurements of entrance surface dose (ESD) were made using three individually-packed chips of TLD-100 from Thermo Scientific Harshaw. The chips were placed in the center of the beam on the patient's skin during examination, and then read using a Thermo Scientific Harshaw 3500 Manual TLD reader.

All the TLDs used were calibrated in the Secondary Standard Dosimetry Laboratory (SSDL) Jakarta at the Indonesian National Nuclear Energy Agency (BATAN). The standard deviation of the TLD batch was of the order of 5%, with the overall uncertainty being ≤20% at the 95% confidence level. To validate the results of its measurement, the standard dosemeter used in the SSDL Jakarta for TLD calibration is periodically calibrated in a Primary Standard Dosimetry Laboratory (PSDL) that is an affiliated member of the IAEA/WHO Network of Secondary Standards Dosimetry Laboratories.

The third quartiles of the whole data of ESD obtained were then use to calculate the DRLs. Considering the geographic spread and size of Indonesia, the DRLs calculated in this study can only be regarded as preliminary DRL values for Indonesia

RESULTS AND DISCUSSION

Table 1 shows the patient information and exposure parameters for eight routine adult X-ray examinations in Indonesia. It is shown that the mean patient weight is 57-60 kg, which is important in reducing the variability of ESD.

Table 1 also shows that the mean patient age was 30-48 years, which is younger compared to the ones in the UK survey (ages 41-66 years) [4].

The distribution of individual entrance surface doses (ESDs) for eight routine adult X-ray examinations in Indonesia is given in Table 2. The table presents the minimum, first quartile, median, mean, third quartile, and maximum ESD values obtained for each X-ray examination. The X-ray machines that were sampled in this survey were first compliance-tested to ensure that the machines were in a good and reliable condition. Only those passing the test against the established reference values were used in this survey. The values of the third quartiles obtained were then taken to be the Indonesian DRLs.

The mean entrance surface dose values per X-ray examination measured in this study are presented in Table 3, together with the ESD values measured in several countries [4,6,8,12].

As can be seen in Table 3, most of the mean ESDs calculated in this study are lower than that in such developed countries as the UK, New Zealand, and Taiwan. Comparison with the Iranian data, however, also showed that the ESDs calculated in this study are lower, while the Ghanaian data showed that the ESDs are about the same in both studies.

The compliance test conducted to all X-ray machines before being used was believed to contribute to the low values of ESD measured. One can note, however, that the DRLs of chest AP/PA, chest LAT, and skull LAT are slightly higher than those of the UK. This might be due to tube voltage settings in this study being lower than those used in the UK. The voltage settings of chest AP/PA, chest LAT, and skull LAT in this study were between 40-117 kV, 67-96 kV and 41-70 kV, respectively (Table 1), while in the UK they were in the 62-125 kV, 70-125 kV, and 63-74 kV ranges. Another possibility is that the tube voltage settings are not adjusted properly according to patient chest thickness [4].

Table 1. Patient information and exposure parameters for eight routine adult X-ray examinations in Indonesia

Examination	Projection	Patient age*) (years)	Patient weight*) (kg)	Tube potential (kV)	mAs
Chest	AP/PA	40 (17-98)	58 (40-90)	40-117	9-80
	LAT	39 (19-70)	57 (41-76)	67-96	14-32
Abdomen	AP	43 (18-88)	60 (42-90)	44-88	12-80
Cervical spine	AP	45 (20-70)	59 (40-83)	46-77	6-40
	LAT	45 (20-71)	59 (40-84)	46-77	5-40
	Obliq	42 (34-71)	58 (58-60)	46-77	3-40
Lumbar spine	AP/PA	48 (18-79)	59 (35-86)	45-85	0.9-64
	LAT	47 (19-76)	58 (40-86)	45-98	0.6-50
Skull	AP/PA	46 (18-75)	60 (40-90)	41-85	4.95-80
	LAT	45 (18-73)	60 (46-90)	41-70	10-90
Extrimities	AP	41 (17-85)	58 (40-95)	40-75	3-50
Shoulder	AP/PA	45 (24-67)	57 (42-72)	48-65	2-13
Pelvis	AP/PA	47 (21-94)	58 (47-71)	59-81	4-48

*) Mean values and range (in parentheses).

Table 2. Distribution of individual entrance surface dose (ESD) for eight routine adult X-ray examinations in Indonesia

Examination	Projection	Number	Entrance surface dose (mGy)					
			Min	First quartile	Median	Mean	Third quartile	Max
Chest	AP/PA	389	0.01	0.11	0,18	0.32	0.33	5.13
	LAT	30	0.05	0.37	0.73	0.95	1.18	4.09
Abdomen	AP	126	0.13	0.94	1.57	2.00	2.60	8.34
Cervical spine	AP	35	0.10	0.21	0.40	0.80	0.89	4.97
	LAT	28	0.02	0.24	0.38	0.66	0.92	2.05
	Obliq	21	0.16	0.25	0.58	1.29	2.08	4.04
Lumbar spine	AP/PA	81	0.08	1.35	1.99	2.45	3.41	8.01
	LAT	72	0.11	2.49	4.29	4.67	5.84	25.72
Skull	AP/PA	47	0.05	0.71	0.99	1.38	1.58	4.61
	LAT	27	0.13	0.50	0.77	1.08	1.38	3.32
Extrimities	AP	308	0.01	0.06	0.10	0.21	0.18	1.94
Shoulder	AP	13	0.01	0.05	0.13	0.14	0.20	0.43
Pelvis	AP	31	0.35	0.62	1.35	1.52	1.98	3.87

In comparison with the results for Iran, all minimum voltage settings in Iran were higher than those used in this study. The minimum settings in Iran were 70, 75, 85, and 85 kV for chest PA, chest LAT, skull AP/PA, and skull LAT examinations, while this study used 40, 67, 41, and 41 kV, respectively, for those examinations. The higher voltage used in Iran is possibly due to Iranians tending to have thicker bodies than Indonesians, so a higher X-ray energy is required to penetrate the patient's body to produce the good image that is needed.

From the comparison with the results from Ghana, it was found that whenever the ESD in Ghana was higher, the voltage setting was generally also higher. For cervical spine AP, for example, the Ghanaian values for ESD and voltage setting were 1.05 mGy and 60-80 kV, while those of this study were 1.02 mGy and 46-77 kV. In contrast, when the ESD and voltage setting for chest LAT in Ghana were 0.43 mGy and 65-90 kV, those from this study were 0.95 mGy and 67-96 kV.

These comparison results with developed as well as upper-middle-income countries, which showed that the ESDs calculated from this study were mostly lower than the ESDs from those countries, support the statement that "the common assumption or opinion that radiation doses to patients in developing countries are always higher than those in developed countries is not correct" [12].

Table 4 shows the patient information and exposure parameters for four routine children X-ray examinations in Indonesia. The mean patient weight is limited to 23-42 kg to obtain a good estimation of the typical dose delivered to an average Indonesian child patient.

The distribution of individual entrance surface dose (ESD) for four routine children X-ray examinations in Indonesia is given in Table 5. As with Table 4 for the adult patients, Table 5 presents the minimum, first quartile, median, mean, third quartile, and maximum ESD values for each X-ray examination obtained. The third quartile values are then taken as the proposed national DRLs for children.

Table 3. Comparison of the mean entrance surface doses (in mGy) calculated in this study with those of other selected countries

Examination	Projection	UK [4]	Iran [6]	Ghana [8]	This study	Taiwan [12]	New Zealand [12]
Chest	AP/PA	0.2/0.15	0.74	0.27	0.32	0.52	0.22
	LAT	0.5	2.21	0.43	0.95	-	-
Abdomen	AP	4	-	-	2.00	4.77	20.4
Cervical spine	AP	-	-	1.05	0.80	-	-
	LAT	-	-	0.45	0.66	-	-
	Obliq	-	-	-	1.29	-	-
Lumbar spine	AP/PA	5.7	-	3.25	2.45	5.91	22.8
	LAT	10	-	-	4.67	18.9	35.5
Skull	AP/PA	1.8	6.84	-	1.38	2.6	3.0
	LAT	1.1	7.89	-	1.08	-	-
Extremities	AP	-	-	-	0.21	-	-
Shoulder	AP	0.5	-	-	0.14	-	-
Pelvis	AP	4	-	1.31	1.52	5.13	21.4

Note: dash (-) indicates no data available.

Table 4. Patient information and exposure parameters for four routine children X-ray examinations in Indonesia

Examination	Projection	Patient age (years)	Patient weight (kg)	Tube potential (kV)	mAs
Chest	AP/PA	10-16	28-40	40-96	12-25
	LAT	10-15	20-35	44-68	3.5-6.3
Abdomen	AP/PA	7-12	25-40	40-63	15-24
Skull	AP/PA	9-16	28-42	44-72	15-50
	LAT	9-15	25-42	52-72	25-32
Extrimities	AP	11-16	29-40	40-68	24-50

Table 5. Distribution of individual entrance surface dose (ESD) for four routine children X-ray examinations in Indonesia

Examination	Projection	Number	Entrance surface dose (mGy)					
			Min	First quartile	Median	Mean	Third quartile	Max
Chest	AP/PA	137	0.01	0.06	0.09	0.16	0.16	1.57
	LAT	10	0.09	0.10	0.15	0.65	0.60	3.28
Abdomen	AP/PA	18	0.05	0.09	0.26	0.47	0.56	1.84
Skull	AP/PA	18	0.07	0.54	2.93	1.01	1.46	2.93
	LAT	14	0.29	0.47	1.38	0.66	0.84	1.38
Extrimities	AP	88	0.01	0.08	1.64	0.20	0.24	1.64

Table 6 shows the comparison between DRLs calculated for children in this study (third quartile values) with the DRLs for 5- to 9-year olds suggested in India [18]. This comparison shows that in general both sets of DRL values are about the same, albeit the range of patient ages in this study are slightly higher than that in India which is 5- to 9-years old [18].

For the UK data, the UK sets reference levels for children representing ages of 0, 1, 5, 10, and 15 years [4]. However, the reference levels are given only for micturating cystourethrography (MCU), barium meal and barium swallow, and are given in the unit of dose area product (DAP, Gy.cm^2). As such, the calculated DRLs resulted from this study that were given in ESD (mGy) cannot be compared to those applied in the UK.

Table 6. Comparison of DRLs for child patients in this study with Indian values (in mGy)

Examination	Projection	India [18]	This study
Chest	AP/PA	0.2	0.16
	LAT	0.3	0.60
Abdomen	AP	0.5	0.56
Lumbar spine	AP/PA	0.7	-
	LAT	1.3	-
Skull	AP/PA	0.6	1.46
	LAT	0.5	0.84
Extrimities	AP	-	1.64

As a summary, the values of diagnostic reference levels for selected X-ray examinations in Indonesia, as calculated from the third quartile values, are given in Table 7. However, since Indonesia is a large country, the sample size from this study is quite limited; thus, that the calculated DRLs can only be regarded as preliminary DRL values for Indonesia

Tabel 7. Preliminary values of DRL for Indonesia (in mGy)

Examination	Projection	Adult	Children
Chest	AP/PA	0.33	0.16
	LAT	1.18	0.60
Abdomen	AP	2.60	0.56
Cervical spine	AP	0.89	-
	LAT	0.92	-
	Obliq	2.08	-
Lumbar spine	AP/PA	3.41	-
	LAT	5.84	-
Skull	AP/PA	1.58	1.46
	LAT	1.38	0.84
Extremities	AP	0.18	0.24
Shoulder	AP	0.20	-
Pelvis	AP	1.98	-

CONCLUSION

This study presents the results of measurements of the doses absorbed by adult and child patients undergoing X-ray examinations in Indonesia, and calculated the diagnostic reference levels (DRLs) for most typical X-ray examinations performed. It has been seen that adult patient doses in Indonesia, which is often classified as a developing country, are in general lower than those in such developed or high-income countries as the UK, New Zealand, and Taiwan, as well as upper-middle-income countries such as Iran, but are about the same with those of Ghana. The suggested DRL values for children, however, are about the same as those calculated for India. In order to calculate DRLs comprehensively for the whole country, the sample size should be increased, both in terms of number of patients and types of examinations.

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