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# A Review of the Status of Diagnostic Reference Levels for Radiology in Iran

## Running title: A Review of the Status of Diagnostic Reference Levels for Radiology

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***A R T I C L E I N F O***

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***ABSTRACT***

**Background & Objective**: In recent years, extensive research has been focused on patient dose reduction. In 1996, diagnostic reference level (DRL) was introduced by the International Commission on Radiological Protection (ICRP). Many countries and international organization, including ICRP, use DRLs in radiological investigations, which serve as a guide for patient dose reduction. The concept of DRL involves the optimization of diagnostic practices and patient dose reduction in radiology. The present study aimed to review the studies on the DRLs in Iran.

**Materials and Methods:** This mini-review was conducted to explore the status of DRLs in Iran. A comprehensive literature search was performed without time constraints in databases such as Google Scholar, Medline, Embase, PubMed, Irandoc, Iran Medex, Magiran, and SID using mesh keywords, including diagnostic reference level, medical imaging, radiation protection, and radiology.

**Conclusion:** Data on the radiation dose to patients is complex in various hospitals, proposing several influential factors. According to the studies on radiography, the third quartile of radiation dose is considered as the DRL, which is calculated on the local, regional or national levels. DRL is considered to be a dose-related determinant compared to the DRL published by the ICRP. Several possible reasons could be discussed with regard to higher DRL than the standard limit**.**

**Unstructured Abstract**

The present study aimed to review the studies focusing on the diagnostic reference level (DRL) in Iran. In recent years, extensive research has been focused on patient dose reduction. In 1996, DRL was introduced by the International Commission on Radiological Protection (ICRP). Many countries and legal institutions use DRLs in radiological investigations, which serve as a guide for patient dose reduction. The concept of DRL involves the optimization of diagnostic practices and patient dose reduction in radiology. This mini-review explored the studies on the status of DRLs in Iran. A comprehensive literature search was performed without time constraints in databases such as Google Scholar, Medline, Embase, PubMed, Irandoc, Iran Medex, Magiran, and SID using mesh keywords, including diagnostic reference level, medical imaging, radiation protection, and radiology. Data on the radiation dose to patients is complex in various hospitals, proposing several influential factors. According to the studies on radiography, the third quartile of radiation dose is considered as the DRL, which is calculated on the local, regional or national levels. DRL is considered to be a dose-related determinant compared to the DRL published by the ICRP. Several possible reasons could be discussed with regard to higher DRL than the standard limit.

**Keywords:** Diagnostic Reference Level, Medical Imaging, Radiation Protection, Radiology

**Introduction**

X-ray examinations involve the use of conventional radiography. Despite the advancement in medical imaging technologies, such as ultrasound and magnetic resonance imaging (MRI), fluoroscopy and computed tomography (CT) remain the major modalities in diagnostic medicine. Medical X-ray has long been applied as one of the main sources of radiation in the human population (1).

In 1996, diagnostic reference level (DRL) was introduced by the International Commission on Radiological Protection (ICRP) (2). Several studies have investigated the variants in the patient dose in each radiological examination. DRLs could bridge the gaps in this regard, serving as a guide for the optimization of the practices in the radiation protection of patients. In radiation protection, radiological techniques should be optimized in order to minimize the radiation dose to patients to as low as reasonably achievable (ALARA).

Appropriate indices associated with patient dose, such as the film-focus distance (FFD), radiation field geometry, tissue thickness, and body mass index, are of paramount importance for the easy measurement of the radiation dose and clear definition of the related criteria. In this regard, definition encompasses diagnostic imaging modalities, such as conventional radiography, dental radiography, fluoroscopy, CT-scan, and nuclear medicine. Selection of these values should be performed by licensed institutions in accordance with regional or national regulations (3).

Many countries, as well as international or non-governmental organizations (e.g., ICRP), have drafted DRLs for all the examinations that are performed with ionizing radiation for the reduction of radiation exposure in patients in diagnostic radiology centers. Every radiology center must evaluate the received radiation dose by the patients in each radiological examination for comparison with the recommended DRL values (4). In many countries, these measurements are carried out on a regular basis, while in Finland, the measurements are performed every two years (5).

DRLs are defined separately for routine radiological procedures in adult and pediatric patients. In other words, DRL depends on the weight, height, and age of individuals. DRL is not only employed for patient dose reduction, but it also provides the necessary data on disease diagnosis. Therefore, the resulting images should be of acceptable quality or good contrast (6).

**Factors in the Estimation of DRL**

In most DRL measurements, the mean doses are measured as the local DRL. According to the DRL regulations of the European Commission, DRL estimation requires the calculation of dosimetry in a minimum of 10 patients with standard specifications (4). However, depending on the statistical significance of the study, the mean dose is determined in large populations in order to record the drastic increments in the measurements. In some studies, the measured quantities are calculated to estimate the DRL depending on the type of the test, which could be one of the following:

1. The entrance surface air kerma in mGy is calculated for each specific material

that is under the radiographic test, as well as the X-ray tube output.

2. The entrance skin dose (ESD) and milliamperes of the X-ray device are determined. To this end, the X-ray device output is obtained with a suitable dosimeter (diode or ion chamber) connected to the electrometer, and its amount depends on the kilovoltage peak (kVp), X-ray tube filtration, and radiation field size (7). Measurement is determined in mGy for all the patients undergoing (or those who previously received) a radiographic examination. ESD value at the X-ray intersection and skin surface of the patient in at the center of radiation are verified as well. ESD covers the scatter rays and could be easily controlled by a thermoluminescence dosimeter, which is placed on the patient's body (8).
3. Dose area product (DAP) is the product of X-ray and dose to the skin. DAP is measured in $mGy.cm^2$ and is the most widely used parameter in fluoroscopy tests (9).
4. Dose length product (DLP) is measured in mGy.cm and is normally calculated in multi-stage examinations, such as CT-scan, which consists of an anatomical area. DLP is equal to the section length of the X-ray multiplied by ESD (10).
5. Specific activity is measured in MBq for medical imaging modalities with a specific drug, such as Technetium-99m, single-photon emission computed tomography or gamma camera (11).

## Materials and Methods

This mini-review aimed to assess the studies published on the status of DRL in Iran. Extensive literature search was conducted without time constraints in databases such as Google Scholar, Medline, Embase, PubMed, Irandoc, IranMedex, Magiran, and SID using various mesh keywords, including diagnostic reference level, medical imaging, radiation protection, and radiology.

## Discussion

Common radiological examinations involving anatomical regions (e.g., chest, pelvis, abdomen, and spine) may result in a collective effective dose after dosimetry. Chest X-ray should be incorporated into the studies focusing on DRL in radiography since chest X-ray is a common radiographic examination, which involves exposure to several radiosensitive tissues (12). In general, the DRL value is higher in some examinations compared to others, which is due to the variable sizes of radiation fields, tissue thickness, and factors associated with exposure circumstances, such as mA, kVp, and duration of exposure.

In a research in this regard, Bahraini et al. used seven routine radiographic techniques in eleven projections. DRL was estimated at 0.7 and 4.69 mGy in the chest X-ray (posterior-anterior view) and lumbar spine X-ray (lateral view), respectively (13). In addition, the findings of Pour Kaveh et al. indicated the ESD value of the chest X-ray (posterior-anterior view) to be higher compared to the proposed values by the International Atomic Energy Agency (IAEA) (14).

Training of radiology personnel has been recommenced in some studies. For instance, Bijari et al. has claimed that training could have several advantages, including the reduction of the absorbed dose to patients, use of less radiation fields, and appropriate selection of kVp and mAs. Therefore, training of radiology personnel could optimize patient doses (15).

Quality control/assurance plays a critical role in the ALARA principle (16). In this regard, Gholami et al. stated that quality control and monitoring of radiology centers are essential to effective patient dose reduction (17).

## Conclusion

According to the reviewed studies, changes in DRLs are affected by the factors that alter the radiation exposure in patients, while patient dose reduction by X-rays and improvement of imaging quality prevent the unnecessary repetition of radiological investigations. Furthermore, the findings of some studies suggest that the implementation of a quality assurance program based on the imaging quality and proper inspection of radiographic equipment could result in patient dose reduction, which is not properly observed in many radiology centers (18). Some of the measures to be taken in this regard include the correct application of kVp, investigating the proper devices for radiation exposure, linearity of irradiation and millisecond, repeated investigation of irradiance, and determining the half-value layer (HVL) (19).

In addition to radiographic contrast, total film density, and X-ray penetration, X-ray tube voltage is effective in patient dose reduction. Milliampere second (mAs), which is the irradiation time multiplied by millisecond, directly affects the amount of the emitted radiation from the X-ray tube. This quantity is used to measure the amount of exposure and is a direct indicator of the output of X-rays and patient exposure. In X-ray tubes, low-energy photons with an insignificant effect on image formation are removed. However, they may increase the dose to the skin and tissues of the patients; therefore, using a filter is necessary in such cases. Filters are metallic plates that are placed between the patient and X-ray tube. In practice, the average energy of the filtration of an inhomogeneous beam of particles crosses the radiation-absorbent material. Without filters, the radiation dose could increase by 90%, and HVL is measured to ensure the appropriate use of filters.The influential factors in the absorbed radiation dose by patients and DRL include geometric parameters (e.g., selection of film and FFD), radiation beam field size, composition of intensifying film screens, and speed of the film (20). Moreover, the absorbed dose and DRL could be affected by the weight and physique of the patient, type of radiographic technique, level of staff training, and type of film processing systems. According to the results of the present study, the average radiation dose to patients differs in various tests. Some researchers have reported that the DRLs in low-income countries are higher compared to developed countries (21). However, other experts believe that the radiation dose rates to patients in underdeveloped and developing countries are not higher than the rates in developed countries although they might be lower in some cases (22).

**Suggestions/Recommendations**

Firstly, it is recommended that a comprehensive program be implemented focusing on the DRLs in all the provinces in Iran since there are no such assessments available in some regions.

Secondly, due to the lack of adequate training on radiation protection for health physics advisors and radiation protection officers, these individuals are often incompetent in quality control tests. Health physics advisors should have a basic knowledge in this regard and be licensed in radiation protection practices and quality control tests for patient dose reduction. Thirdly, there should be a policy to discourage incompetence in radiation protection practices in order to ensure optimal international practices. Therefore, qualified radiation protection officers should be engaged in the drafting of DRLs for radiology centers.

Finally, conflict resolution must be proposed among the professionals that neglect radiation protection, particularly in Iran, so as to ensure efficient service delivery in radiation protection.

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