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Radiation Protection Program in Nuclear Industry- A Short Review

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Abstract

Radiation protection concepts are the primary methods used to prevent or appropriately limit the negative health impacts of irradiating individuals or populations. Here, radiation exposure is defined as exposure to ionizing or non-ionizing radiation from natural or artificial sources because of personal or professional activity, including radiation exposure from medical tests and treatments. The enormous number of people who are exposed has turned into a public health concern, despite the fact that the individual danger associated with radiation exposure from medical imaging is typically modest and the benefit great. As a result, they frequently receive radiation exposure during internal X-ray examinations, thus they must maintain radiation usage safety. Besides that, the radiation risk level, and the control structure of the radiation protection risk of nuclear power project need to be optimized. This study aims for a deeper understanding about the radiation protection program and its effectiveness towards the nuclear field. This study also reviews the specifics objectives, methods of the radiation protection towards the nuclear power industry and covers the elements that contributes to protection and safety in facility and practice.

Keywords: Radiation Protection, Radiation, Nuclear, Safety, Risk

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1. Introduction

Daily exposure to background radiation for humans comes from a variety of sources, including cosmic rays, mobile phones, televisions, building materials, agricultural products, and even their own bodies. Radiation is essentially energy that is emitted from a source travelling through space as electromagnetic waves or as moving subatomic particles, and it can pass through a variety of materials. The creation of radiation protection standards is a collaborative effort between numerous organizations and authorities. These groups are also involved in creating new rules to safeguard people from the dangers of ionizing radiation used in the medical industry. International organizations that are involved include the National Council on Radiation Protection and Measurements (NCRP), United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), International Commission on Radiological Protection (ICRP) and National Academy of Sciences Advisory Committee on the Biological Effects of Ionizing Radiation (NAS-BEIR) [1]. In many departments, including radiology, interventional cardiology, surgery, patients, doctors and staff are concerned about radiation safety. The largest radiation dosage for medicalprofessionals is caused by radiation that is released during fluoroscopic procedures.

Healthcareworkers are exposed to low levels of radiation through diagnostic imaging modalities such computed tomography, mammography and nuclear imaging. But any radiation exposure carriesa possible risk for both patients and medical personnel. Radiation protection seeks to lessen ionizing radiation's detrimental effects by reducing needless radiation exposure. The Atomic Energy Licensing Act of 1984 (Act 304) governs the use of ionizing radiation in Malaysia and covers both medical and non-medical purposes. The Ministry of Health's (MOH) Director General of Health has the power to use medical applications. The Atomic Energy Licensing (Licensing) Regulations of 1986, Atomic Energy Licensing (Basic Safety Radiation Protection - BSRP) Regulations of 2010 and Atomic Energy Licensing (Radioactive Waste Management) Regulations of 2011 are a few regulations that fall under Act 304. Patients, radiation workers and members of the public are all given detailed explanationsof the ideas and principles of radiation protection under Act 304 and its related laws [1]. The Malaysian Nuclear Agency (Nuclear Malaysia) is the leading organization in Malaysia for establishing and promoting the use of nuclear science technologies. Major nuclear facilities including reactors, irradiation plants, and radioisotope production labs are made available by the government specifically for research and commercialization.

It is mandatory to monitor and evaluate the radiation exposure to the personnel when working with ionizing radiation. By analyzing their Thermoluminescence Dosimeter (TLD) dosage readings monthly, radiation employees' personal doses were recorded [2]. Justification, optimization, and dosage limitation are the three central principles of radiation protection. Understanding the advantages and disadvantages of employing radiation for operations or treatments is necessary for justification. Patients' education of the possible negative effects of radiation exposure is largely the responsibility of doctors, surgeons, and radiologic staff. The medical community ought to be aware of and supportive of the advantagesof exposure. The advantages frequently outweigh the dangers in operations that subject patientsto relatively larger radiation doses, such as interventional vascular procedures. The federal code of regulations' As Low as Reasonably Achievable (ALARA) principle was developed to ensure that all precautions to decrease radiation exposure have been followed while recognizing that radiation is a crucial component of patient diagnosis and treatment. Anyexposure to radiation will raise the risk of stochastic consequences, specifically the likelihoodof acquiring cancer after radiation exposure. There is not a set threshold that can be used to predict consistently whether malignancy will develop in this effect's linear model. Due to these factors, the radiologic community promotes the ALARA principle while teaching protective measures.

Many research has been done in Malaysia that study about the risk and protection of radiation towards radiation workers and people that exposed to it. Most of the study's objectives are to determine the knowledge of occupational radiation exposure and safety among the workers. In the current climate of renewed interest in nuclear power, the Chernobyl disaster and the prospects for nuclear branch development has opened access to various types of information was followed by an increase in public concern about environmental issues. Environmental disasters and risks, as well as the potential benefits of nuclear power development, are the focus of public attention in one instance of information policy implementation [3]. Most of existing nuclear power plants (NPP) will continue to operate in the twenty first century, and new construction projects are currently underway. There are prestigious institutions and authors who argue that nuclear power is required for long-term power supply. There are compelling reasons to continue working to ensure and improve nuclear safety [4]. The acceptance of radiation risks by society is conditional on the benefits gained from radiation use. Nonetheless, the risks must be limited and mitigated through the applicationof radiation safety standards [5].

2. Radiation protection program (RPP)

A radiation protection program (RPP) is concerned with all phases of a practice or the lifetime of a facility, from design to process control and decommissioning. The operational aspects of the RPP are highlighted in this section. The overarching goal of RPPs is to reflect the application of management responsibility for radiation protection and safety through the implementation of management structures, policies, procedures, and organizational arrangements that are proportionate to the nature and scope of the risks [6]. A radiation protection program should include the following components: the surveillance and monitoring of workers engaged in radiation work, the work area, the ergonomic study of the radiation protection provisions, the assessment of working methods in terms of health and safety, the establishment of contaminated areas, the ongoing assessment ofprotective measures, the classification of workers engaged in radiation work based on workingconditions, the provision of advice on decontamination, and the provision of advice on decontamination [7].

The general concepts of radiation protection are to reduce the effects of radiation to people and the environment. Specifically in medical imaging, radiation protection is use to reduce the effects of radiation to patients, staffs and general public. While there are three aspects of the Islamic essence that are introduced to medical imaging professionals. Islam's guiding principlesof Ihsan, Itqan, Fitrah, and Istiqomah, as well as spirituality, religion, the idea of retribution, Maqasid and Qawaid Al-Shariah, might influence Muslim practitioners to view radiation protection as more than just a legal need [8]. From 2014 to 2017, 348 articles were published in the "Medical and Health" category.The talks may be roughly divided into dosimetry, dose effects, radiation protection management, education, training, awareness, innovations, models for radiation protection, research of radiological practices and radiation protection ethics. The implementation of justification and optimization principles, improvement of the safety culturein healthcare, reinforcement of safety requirements, encouragement of benefit-risk discussions regarding radiation exposure, and promotion of a strategic research agenda for radiation protection in medicine are all included in the study. Biological systems are dangerously affected by ionizing radiation. The stochastic and deterministic effect are the two main types of radiation effects on human health.

Cancer and other diseases can be brought on by the stochastic effect, which is an independent-dose effect. Radiation burn and acute radiation sickness are two examples of the immediate consequences of dependent-dose effects known as deterministic effects. Islam also emphasized that each practitioner must continuously remind himself of his duties and commitments to maintain a profession that is secure and current. Other than that, to keep the danger from radiation workers at levels that are equivalentto those of other jobs is one of the objectives of a radiation safety program by Ministry of Health Malaysia (MOH). In the context of radiation, safety or protection refers to limiting everyone's exposure to radiation. However, medical treatment provides a special circumstance when individuals are purposefully exposed to radiation. The advantages of the radiation to which a person is exposed must be considered while developing a protection philosophy. The objective is to carry out diagnostic procedures that minimize radiationexposures while maintaining the integrity of the diagnostic data. Patients and employees must be treated differently. Afterward, the safety measures are strengthened by valuing the Islamic worldview, putting Islamic principles and morals into practice according to the Maqasid Al-Shariah and Qawaid Al-Shariah, and embracing the idea of retribution. It would also be helpful in shapingthe Muslim practitioner to accept the idea of radiation protection as a Muslim personal trait to accept it in accordance with the notion of Ibadah or worship.

The responsibility for maintainingsafe practice in the area of medical imaging that deals with saving lives and improving qualityof life rests on the Muslim practitioner.

3. The International Atomic Energy Agency

In 1953, the United States proposed the establishment of an International Atomic Energy Agency (IAEA) to disseminate the benefits of nuclear technology. After three years of negotiations, this concept was eventually reflected in a crucial article of the IAEA's statute, which went into effect in 1957, and the IAEA began work in Vienna that same year [9]. The IAEA's safety services include design, siting, and engineering safety, operational safety, radiation safety, safe transport of radioactive material, and safe management of radioactive waste, as well as governmental organization, regulatory matters, and safety culture in organizations. The standards are also used by regulatory bodies and operators worldwide to improve safety in nuclear power generation and nuclear applications in medicine, industry, agriculture, education, and research [10]. The IAEA safety standards apply throughout the entire lifetime of all facilities and activities used for peaceful purposes, as well as to protective actions taken to reduce existing radiation risks. They can be used as a guide for their national regulations on facilities and activities [11].

4. Ministry of Health Malaysia

One of the quality improvement initiatives implemented by the Malaysian Ministry of Health was the MS ISO 9000 Quality Management System, which was established in 1996. The Ministry of Health's principal goal in adopting MS ISO 9000 was to create the groundwork andoffer an appropriate framework for internalizing and institutionalizing quality in the health care sectors. A study has discussed the strategy approach used by Ministry of Health Malaysia - Radiation Health and Safety Unit to create and carry out radiation protection programs for the use of radiation in medicine that is based on the MS ISO 9000 Quality Management System.The Government of Malaysia Development & Administrative Circular (GMDAC), which governs the administration section of the MOH, and the Quality Assurance Program, which governs the technical and professional sections, were both used in cooperation to design and execute quality programs [12]. Work processes, which include input components, value-added activities, and output delivery, are a part of radiation protection operations.

There is an input-output chain in every process. The effectiveness and practicality of MS ISO 9000 lay in its capacity to harmonize the organization's conventional functional system with the multiple interconnected work processesthat are necessary for the smooth and successful operation of day-to-day operations. Planning and preparing for radiological crises beforehand help reduce possible risks tothe public's health and the environment should one ever arise. Emergency response organizations consider their reaction to each type of crisis as well as the resources required during the planning stage. Planning, being ready for, and dealing with radiological crises include numerous stakeholders in Malaysia. Nuclear Malaysia, the Atomic Energy Licensing Board, and other federal agencies will collaborate with federal and local governments in the case of a radiological emergency and if it is declared a catastrophe to monitor the situation, control the leak, and clean up the contaminated site.

5. As Low as Reasonably Achievable (alara) concept

There are three underlying concepts of radiation protection in medical exposures which are justification, optimization, and dose limitations. Even though the radiation protection system is founded on the three principles in the case of medical exposures, dose limits are not applied because they could compromise thepatient's ability to receive an accurate diagnosis or effective treatment, which would be counterproductive. The amount effective dose is used to evaluate the risk or detriment of radiation exposure for the purposes of dose limitation and dose control. Applying variables tothe average absorbed dose in the body's organs and tissues allows for the evaluation of effectivedose. Radiology is a crucial diagnostic tool for many diseases and is crucial to the healthcare industry. The primary way that nurses and radiation workers contribute in a healthcare system is by accompanying patients through examinations. However, Malaysian research on the subject of radiation competency for nurses and radiation workers are still lacking. The International Commission on Radiological Protection (ICRP) eventually provided aprecise definition of the ALARA (As Low as Reasonably Achievable) concept in 1977. The International Commission on Radiological Protection (ICRP) established its radiation protection philosophy in Publication 26 based on three principles:

1. *Justification*: No practice shall be implemented unless its implementation results in anet benefit.
2. *Optimization*: All exposures must be kept as low as reasonably possible, takingeconomic and social factors into account.
3. *Limitation*: The dose equivalent to individuals shall not exceed the ICRP limits.

This principle can involve a variety of people at various levels. Legislators, but also managers,engineers, and workers, are examples [9]. The method by which an ALARA program is implemented is highly dependent on the complexity and magnitude of potential radiological hazards associated with the DOE (Department of Environment) activity. A formal ALARA plan or procedure should identify the elements of an effective ALARA program [13]. As low as reasonably achievable is abbreviated as ALARA, the guiding principle of radiation safety. Even if the dose is low, ALARA refers to avoiding radiation exposure that does not directly benefit you. Time, distance, and shielding are three fundamental radiation safety preventive measures that can be used to achieve this. The ALARA principle of safety is designed to cut down on radiation exposure and radioactive material emissions. ALARA servesas a baseline for all radiation safety programs, focusing on legal dosage limits for regulatory compliance rather than just best practice. The concepts of ALARA can be explain as firstly, the exposure times should be kept as short as is practically possible. Some employees can reduce the amount of time they are exposed by leaving the room when they can. Next, Other staff members should try to maintaina distance from the patient when irradiating, even though the doctor and an assistant nurse frequently need to be close by. The inverse square law states that doubling the distance will result in a quarter reduction in dosage rate.

Lastly, a good technique to lower radiation exposureis to wear radiation protection clothing. Additionally, almost every interventional lab has extrashielding tools like bedside lead drapes and adjustable lead glass shields. There's study that aimed to establish the level of radiation protection and usage knowledge among Malaysian nurses. In this study, 395 nurses who worked in Malaysian hospitals, clinics, and other healthcare facilities participated in a cross-sectional survey. The Healthcare Professional Knowledge of Radiation Protection (HPKRP) scale, which was established, is the foundation of the survey. With a mean of 66.03 ± 2.59, Malaysian nurses hadthe highest level of radiation protection knowledge. Safe ionizing radiation guidelines come up at number two with 5.83 ± 2.77. Therefore, hospitals should improve the standards for all nurses who work with or are exposed to radiation [14]. Besides, there's another assessment that have been done among Malaysian's nurses to determine the effectiveness of a training program that have been provided by the hospital that aims to increase the knowledge and awareness of nurses.

A questionnaire was given to a total of 27 participants in a training session on radiation safety. The 16 items on the questionnaire were divided into two categories: general radiation knowledge and radiation safety. Before and after the training, survey data were gathered, and descriptive statistics and a paired sample t- test were used to assess the results. Respondents received a final score out of 16 points, with 8 points assigned to each section [15]. As of right present, nuclear medicine nurses have a modestlevel of education and awareness regarding radiation protection. The level of knowledge and awareness among all nuclear medicine nurses in Malaysia should be evaluated and it is advisedthat this be done through the implementation of a nationwide study. Radiation protection should be standardized to the highest level of safety, according tothe WHO, IAEA, and ICRP. The inability of nurses to adequately safeguard themselves and their patients against ionizing radiation can be a result of this ignorance. It is crucial that nursesunderstand the ALARA (as low as reasonably possible) principle of radiation safety [16]. By understanding and applying the three primary parameters of shielding, time, and distance, it is possible to adhere to the ALARA principles.

6. Radiation Protection of Workers

Based on extensive scientific research and recommendations from national and international scientific organizations, government agencies have established regulations that set limits for exposure to radiation and radioactive material [3]. Radiation protection for workers is intended for all those with responsibility in this field, both in the public and private sections, who may be called upon to write instructions on the subject. The basic elements of an RPP are defined in the IAEA Regulations for the Safe Transport of Radioactive Material Safety Guide on Advisory Material. Confirmatory monitoring should be performed in situations where the occupational dose is likely to be less than 1 mSv per year. In general, the RPP should include provisions for emergency dosimetry [17]. Individual dose limits for individuals exposed to ionizing radiation as a direct result of their employment are based on the philosophy that their total health risks should not be greaterthan the risks accepted by workers in comparable occupations or industries who are not exposed to radiation [18]. This level of RP training is only provided when the estimated potential doses are extremely low, and all work with radioactive materials is strictly supervised. As a result, the RP training can be brief and informal. Nonetheless, all contractor personnel are given a brief overview of radiological risks as well as a description of general good practices for working with radioactive material [19].

4. Conclusions

Without ionizing radiation, modern medicine would not be possible. X-ray imaging, computed tomography scans, therapeutic and diagnostic nuclear medicine, radiotherapy, the γ knife, and linear accelerators are just a few of the technological advancements that have transformed medical diagnosis and treatment. Thousands of lives saved and countless more people whose quality of life has improved each year by these technologies are two ways that radiation's advantages for human health may be quantified. Despite the fact that ionizing radiation is used in medicine, there are possible concerns for patients, medical staff, and the general public. Chronic diseases like cancer and recent injuries can both be exacerbated by the diagnostic and therapeutic methods used to treat them. Radiation and radioactive substances have numerous beneficial applications, including power generation, medicine, industry, and agriculture. The radiation risks that these applications maypose to workers, the general public, and the environment must be assessed and, if necessary, controlled. That is why radiation protection is also important to learn and understand.

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