

Effectiveness Management of Radiation Protection Programme: A Short Review

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ABSTRACT

An effective radiation protection programme requires an effective oversight and feedback mechanism to management. The main objective of the radiation protection programme is to decrease radiation doses wherever and whenever reasonably possible, hence lowering the health risk that is thought to be proportionate to the radiation dosage. Justification of operations requiring radiation exposure, as well as the use of minimal radiation exposure simply adequate for diagnostic and interventional procedures, should all be part of a radiation protection policy. National authorities must support the development and implementation of radiological safety and security in organisations that employ radiation sources. Maintaining a high level of competence is critical for developing future safe ionising radiation applications. Patients, physicians, and employees across many departments, including radiology, interventional cardiology, and surgery, are concerned about radiation safety. Radiation released during fluoroscopic operations is the source of the highest radiation dosage for healthcare workers. Radiation from diagnostic imaging modalities such as computed tomography, mammography, and nuclear imaging are minimal factors to healthcare personnel's cumulative dose exposures. Radiation exposure, on the other hand, poses a risk to both patients and healthcare professionals. The medical use of ionizing radiation is a huge and growing global activity. While ionizing radiation in medicine provides enormous advantages to the worldwide population, the inherent hazards of stochastic and deterministic effects necessitate safeguarding patients from potential injury. Current issues in radiation protection of patients include not only the rapidly increasing collective dose to the global population from medical exposure but also the fact that a significant percentage of diagnostic imaging examinations are unnecessary, and the cumulative dose to individuals from medical exposure is increasing.

Keywords: Radiation protection program; Risk; Radiation; Safety; Health.

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INTRODUCTION

In the 1990s, around a century after the revelation of X-rays and natural radioactivity, radiation protection had advanced significantly regarding the depth and complexity of its background science, procedural features, and social effect (1). A radiation protection programme is a way of putting proper management structures, policies, procedures, and organisational arrangements in place to implement occupational radiation protection. For medical staff in X-ray imaging, topics such as the need for local rules and procedures for personnel to follow, arrangements for the provision of personal protective equipment, a programme for radiation protection education and training, arrangements for individual monitoring, and methods for periodically reviewing and auditing the performance of the radiation protection programme should be included (2). To lessen the negative consequences of ionizing radiation, radiation protection seeks to avoid needless radiation exposure. Ionizing radiation is now an indispensable instrument in medicine, used to diagnose and treat various illnesses. Both patients and healthcare providers' lifetime radiation doses have increased in tandem with its evolving use (3). The need for maintaining competency in radiation protection is emerging and focusing on the qualification of Radiation Protection Officers (RPO) in Malaysia. For all activities sought to be licenced, Regulation 23 of the Malaysian Radiation Protection (Basic Safety Standards) Regulations 1988 requires the applicant to employ an RPO with the necessary knowledge, skill, and training to enable effective protection of individuals and minimise danger to life, property, and the environment. An RPO must demonstrate that they have attended RPO courses offered by a recognised agency and passed the RPO certification test. The training's major goals are to provide critical information and abilities, as well as to create the proper attitudes toward radiation safety and the safe use of radiation sources (4). Although the role of RPO is not legally defined in the UK, it is typically used by colleges and educational organizations. Under these conditions, the RPO usually oversees the administrative (executive) aspects of radiation protection. Dosimetry provision and collection, record-keeping, radiation safety audits in the workplace, critical inspections of research XRF/XRD systems, risk assessments, purchasing radioactive materials, and the accumulation and disposal of radioactive waste are a few examples. In addition, the RPO can be in charge of providing radiation safety training

sessions on-site and making sure newly authorised local users of radioactive materials are properly supervised (5).

Radiation protection is an integral part of every hospital's setup. Every hospital is required to have a radiation safety programme that includes a Radiation Safety Committee (RSC) and a Radiation Safety Officer (RSO) (6). It is suggested that a committee be formed to examine the program's execution regularly, as well as any pertinent and corrective measures, and to follow up on any concerns until they are resolved. A radiation protection committee is a term used to describe this organization (5). According to the National Committee for Certification of Radiation Protection (NCRP), the RSC should include a radiologist, a medical physicist, a nuclear medicine specialist, a senior nurse, and an internist (7). RSC is responsible for conducting routine radiation protection surveys and monitoring radiation safety measures. The justification of the technique requiring radiation exposure, as well as the use of minimal radiation exposure simply adequate for diagnostic and interventional procedures, should all be part of the radiation protection program. Regular radiation exposure surveillance, protection, and instructional efforts should be part of the RSO's and other hospital administrative authorities' responsibilities (6).

Malaysian Radiation Protection Association (MARPA)

MARPA (Malaysian Radiation Protection Association) was established as a non-governmental organization on September 15, 2002. It is made up of a group of professionals in the field of radiation safety and protection. MARPA may be viewed as a national asset and a resource for radiation protection and safety professionals and specialists. Through teaching, research, and the gathering and dissemination of information helpful to members and beneficial to the general public, MARPA strives to promote radiation-related scientific and technological knowledge and skills.

The founding of MARPA also aims to forge connections with other technical, safety, and scientific organizations in the distribution and sharing of information to improve the promotion, progress, and recognition of radiation safety practices in Malaysia. In 1997, at the Second RPO Conference, the proposal for

MARPA was proposed. After that, a committee was constituted to carry out this plan. Regular meetings were arranged to gain the support of potential members. The Department of Registrar of Societies authorised MARPA's registration on June 19, 2002, and the inaugural AGM of MARPA was held on September 15, 2002, during the Fifth RPO Conference in Kuching, when the first Members of the Council/Board were chosen. MARPA was welcomed into the International Radiation Protection Association as the 46th member and the Asian and Oceanic Association of Radiation Protection (AOARP) as the 7th member in 2006.

The major purpose of the association is to provide a platform for expanding scientific and technical knowledge and competence in the field of radiation safety by undertaking education research and accumulating and sharing vital information with members. It is also hoped that the association would catalyse promoting national and international connections and collaboration among individuals working in the field of radiation protection, which encompasses relevant parts of research, medicine, engineering, and legislation. Hopefully, the efforts will result in the safe use of radiation and nuclear energy, as well as the prevention of man and his environment from the risks of ionizing and non-ionizing radiation.

The association's primary goal is to create a forum for increasing scientific and technical knowledge and expertise in the field of radiation protection by conducting educational research and compiling and disseminating critical information to members. It is also hoped that the Association would catalyze promoting national and international connections and collaboration among individuals working in the field of radiation protection, which encompasses relevant parts of research, medicine, engineering, technology, and legislation. Hopefully, the efforts will result in the protection of man and his environment from the dangers of ionizing and non-ionizing radiation, as well as the beneficial use of radiation and nuclear energy. The activities of the Association are those appropriate to the accomplishment of its primary objective, namely to support national and international corporations and networking in radiation protection, encourage research and educational opportunities in those scientific and related disciplines which support radiation protection, encourage national and international publications dedicated to radiation protection, encourage the establishment and continuous review of universally acceptable radiation protection

standards or recommendations through the international bodies concerned and undertake any other matters appropriate to the Association (8).

Overview of Radiation

Radiation, whether ionizing or non-ionizing, affects all living things to some level, while the susceptibility of organisms and tissues varies greatly. The harmful effects of exposure on living species, particularly humans, depend on the amount of radiation received. The entire quantity of radiation received (per unit area) on a sensitive substance is called exposure (9).

Ionizing Radiation

Ionizing radiation has a frequency range of 10¹⁶ Hz to 10²⁶ Hz. When in the form of a particle, ionizing radiation can cause biological changes in cells, tissues, or organs, and it is an occupational danger that requires protection. The medical use of radiation accounts for around 19.7% of the global average radiation dosage. In 2014, around 700,000 X-ray exams were conducted (10). Ionizing radiation contains enough electromagnetic energy to separate atoms and molecules from tissue and affect chemical processes in the body. X-rays and Gamma rays are examples of ionizing radiation. Because this radiation are known to cause harm, a lead vest must be worn when X-rays of our bodies are taken, and nuclear power facilities should be surrounded by solid shielding. Natural sources of ionizing radiation continuously expose living beings to low quantities of ionizing radiation.

Non-Ionizing Radiation

The same sort of non-ionizing radiation source is constantly present in human daily life. The frequency range of non-ionizing radiation is 0 to 10¹⁵ Hz. Non-ionizing radiation is produced by electrical and electronic equipment such as cordless phones, cellular phones, microwave ovens, computers, video games, televisions, and other similar devices (11). The effect of non-ionizing electromagnetic radiation was examined, as well as its impact on human existence. Exposure to electromagnetic fields has the potential to cause alterations in bodily tissues. This scientific review is designed to raise awareness about what occurs in everyday life when non-ionizing electromagnetic radiation

interferes. This assessment will also help to pave the road for future research into the possible dangers of electromagnetic radiation on human health (12). Protection against non-ionizing radiation hazards may be achieved by combining administrative control measures, engineering control measures and personal protection. However, administrative and engineering control measures should be prioritized to reduce the requirement for, and issue related with personal protection (13).

Radiation Sources

Radiation sources are all around us at all times. Some are natural, while others are artificial. Uranium and thorium are primordial radionuclides, which are naturally found in the earth and are the source of terrestrial radiation. Uranium, thorium, and their decay products are in trace levels worldwide. Although the procedure for assessing possible radiological threats to the human body is less formal than that for assessing chemical hazards, background radiation is still a concern that should be addressed as a potential site-related consequence (14). The amount of uranium and thorium in surface soils varies by location. However, places with more significant uranium and thorium concentrations in surface soils have higher dosage levels. A dose is a measurement of how much radiation a person has absorbed. The quantity of radiation energy the body receives is referred to as a dose. Governments are responsible for safeguarding their population, including employees and the general public, against undesirable threats like those caused by ionizing radiation sources.

Radiation Protection to Medical Staff and Patient

Because of the relationship between factors such as pregnancy, duration of radiation exposure, and degree of radiation damage, a physician's lack of awareness of radiation protection can have a significant impact on a patient's health. According to studies, physicians and medical students have a poor understanding of the harmful consequences of radiation applied in clinical trials (15). In a recent study, a lot of medical students may face a variety of emotional and academic obstacles during clinical trials, but little is known about their experiences (16). This emphasizes the significance of radiation safety training for medical personnel. The strengths and limitations of educational programmes may be recognised by examining the effectiveness of training sessions. Many scholars have looked into

the usefulness of educational interventions in various sectors, but few have looked into the effectiveness of radiation safety training (13). ALARA (As Low as Reasonably Achievable) has become an essential component of radiation protection plans. ALARA is merely a more formal commitment to the core idea of radiation protection, which has typically been most conservative in reducing radiation exposure to employees.

Occupational Radiation Protection

The main objective of radiation protection is to keep the amount of radiation received to a minimum, protecting everyone in the department. Knowledge and understanding of radiation sources, as well as the methods that can be used to limit exposure to these sources, is an integral part of this process. This knowledge can be deployed to minimize external exposure and prevent internal and external contamination. Restriction of exposure duration, maximization of distance from the source, and shielding are the three fundamental approaches to limit the external radiation threat. The optimization of these fundamental techniques is required for good radiation protection measures.

Internal radiation exposure happens when a radionuclide contaminates the body internally. Internal radiation protection is focused on preventing or reducing radioactive material accumulation in personnel (14). These reductions result from improved human-made source control, practise optimization, and exposure justification. Where there has been an increase in the usage of radiation technology, more employees are being monitored, increasing the collective dosage.

Establishing a consistent radiological and non-radiological risk management culture can assist in ensuring that workers are appropriately protected. To achieve this, educational programmes with employees, management, regulators, the media, and the public must begin in schools and continue in didactic programmes (15). There are a few guidelines that workers may follow to reduce their X-ray exposure (16). Most of them are based on some fundamental X-ray notions, which are time, distance and shielding. Decreasing exposure time can directly reduce radiation exposure and reduce radiation dose. Doubling the distance between your body

and the radiation source will reduce exposure. Lead or lead equivalent shielding for X-rays and gamma rays is an effective way to reduce radiation exposure. There are various types of shielding used in the reduction of radiation exposure, including lead aprons, mobile lead shields, lead glasses, and lead barriers. To decrease their radiation exposure, those exposed to radiation should employ time, distance, and shielding wisely.

Radiation Protection in Industrial Radiography

As a result of their occupations, many people are or have been exposed to ionising radiation, and epidemiological studies of occupationally bombarded groups give an essential opportunity to augment estimates of health hazards from radiation exposure acquired from other populations, such as Japanese survivors of the 1945 atomic bombings of Hiroshima and Nagasaki (16). The use of several imaging modalities to help in illness diagnosis is known as diagnostic radiology. Diagnostic radiology is further subdivided into several subspecialties. Interventional radiology employs diagnostic radiology imaging technologies to conduct minimally invasive operations. General radiography, mammography, fluoroscopy, angiography, bone mineral densitometry (BMD), dental radiology, CT, magnetic resonance imaging (MRI), and ultrasound are examples of imaging modalities (17). Client organizations in industrial radiography can pressure radiography enterprises to enhance their radiation protection practices and culture. As a result, increasing the client companies' understanding of radiation safety problems is beneficial. Providing checklists of the radiation protective measures to expect when a radiography firm operates on its premises might be advantageous. Our objective should be to get to a point where over-exposure is so rare that we can concentrate on improving routine exposure. Regarding industrial radiography, it was reported that in many cases, it may be preferable to require industrial radiographers to operate in two-person teams as a check and balance mechanism to guarantee procedural adherence, such as the timely completion of radiation surveys. In addition to wearing personal dosimeters regularly, radiographers should wear personal alarm dosimeters. Finally, the capacity of regulatory authorities to persuade radiographers to understand the benefits of radiation exposure management during source operations beyond regulatory requirements may well determine the effectiveness of any action aimed at reducing

radiation exposures among industrial radiographers.

Employing competent experts, either as external consultants to user organisations or as internal personnel, is particularly advantageous. It was also recognised that users of radiation sources require sufficient training. It is vital to develop need-based training programme that are precisely adapted to diverse industrial and scientific applications of radiation. Adequate training and retraining enhance the probability that operators will follow safety protocols in typical circumstances and will be better prepared to respond to accidents and unexpected situations.

Education and Training

Nuclear Malaysia and Atomic Energy Licensing Board (AELB) aim to maintain radiation doses for employees who utilise radiation sources in Malaysia as low as reasonably attainable (ALARA). There are also suitable procedures and resources for education, training, and public information, as well as proper methods for notifying the public, its representatives, and the media about health and safety problems. For the last 40 years, Nuclear Malaysia has provided radiation protection training courses and has vast expertise in developing training materials. A wide range of radiological protection training courses are presently offered by training organisations both nationally and worldwide, and considerable work has gone into defining suitable levels of training, training delivery methods, course material, and training infrastructure (18). Professionals must get initial and ongoing education and training in occupational safety and radiological protection. This is especially true regarding safety culture and the correct use of imaging and radiation protective equipment. Moreover, the use of real-time active dosimeters not only aids in the optimisation of protection during certain high-dose operations but also aids in the teaching of experts on the dose levels received. Hospital staff in charge of occupational protection, dosimetry services staff, clinical applications specialists from suppliers, and regulators require knowledge of clinical practice, the x-ray equipment used in interventions, strategies for occupational exposure assessment, protection methods, and selection and testing of protective garments, and also to basic radiological protection knowledge (19).

External Radiation

In 2001, five individuals were afflicted by unintentional exposure in a hospital in Poland. Following a power outage in the department, an accelerator was turned off automatically. When power was restored, the accelerator was restarted. Specific tests were performed without any sign of a problem, save for a low dosage rate indication, which caused personnel to increase the filament current limiting to a high level. The last of the treatments were performed. During therapy, two of the patients reported feeling a burning sensation. After the final patient was treated, the accelerator was removed from clinical usage, and a physicist assessed the absorbed dosage on the unit. The reading was astronomically high (20).

Exposure to penetrating radiation from a radiation source is referred to as external irradiation. People who are exposed to a high enough dosage of radiation can get radiation sickness, but they do not become radioactive. An x-ray machine, for example, is a source of radiation exposure. Following a chest x-ray, a person does not become radioactive or pose a risk to others (21). Irradiation happens when the entire body or a portion of the body is exposed to radiation from an unprotected source. A person does not become radioactive as a result of external irradiation.

Radioactive Contamination

When radioactive material is deposited on or in an item or person, this is referred to as radioactive contamination (22). Radioactive elements discharged into the environment can contaminate the air, water, surfaces, soil, plants, buildings, people, and animals. A person who has been polluted has radioactive elements on or within their body. People who are internally affected might expose those around them to radiation from the radioactive substances within their bodies. Internally infected people's bodily fluids (blood, sweat, and urine) may contain radioactive elements. Coming into touch with these bodily fluids can lead to contamination and/or exposure.

Radioactive emissions from operational Nuclear Power Plant (NPP) often result in minimal dosages to the general population. Yearly doses calculated for important groups used for NPP licensing and effluent management are normally regulated by an annual dosage limit of 200–300 μSv in most countries. In contrast, real doses are generally

substantially lower (23).

Incorporation of Radioactive Materials

Dealing radioactive material due to an accident or terroristic activity might result in the intake and assimilation of radionuclides, resulting in persistent radiation exposure. In this instance, a decision on countermeasures should be made as quickly as feasible to decrease the consequent radiation exposure (24). The uptake of radioactive elements by body cells, tissues, and target organs such as bone, liver, thyroid, or kidney is referred to as incorporation. Radioactive materials are often spread throughout the body based on their chemical characteristics. Incorporation cannot take place until contamination occurs.

The symptoms in the gastrointestinal system are frequently noticed at acute doses larger than 600 rads and occur from damage to the epithelial cells lining the digestive tract. The higher the level of exposure, the sooner the symptoms of nausea and vomiting appear. The appearance of these symptoms frequently coincides with the previously stated decline in cell count. As a result, sepsis, fluid and electrolyte loss, and opportunistic infections worsen the situation. Despite fluid and electrolyte replacement, persistent high fevers and bloody diarrhea are worrisome indicators (25).

CONCLUSION

Continuous action and dedication are required to maintain and improve safety culture. A program to assess, review, and audit health and safety performance against specified standards is required. A proper safety audit should precede the audit and evaluation of radiation protection programmes and activities to identify non-compliance with safety culture and deviations in management, individual and policy-level commitment. If the system is subjected to a radiation safety audit, the effectiveness of radiation protection can be improved. Management commitment is required for the Radiation Protection Program to be effective. In conclusion, the radiation protection training program successfully raised physicians understanding of radiation safety and may be used by a broader group of doctors. It is recommended that the retraining programs be provided periodically by healthcare providers to update and increase the physicians'

knowledge and awareness of the ionising and non-ionizing radiation protection.

As the hazards of reactor-generated by-product material and other types of radiation are similar, equal treatment of all ionizing radiation in medicine would be an acceptable national policy. However, because data on adverse events associated with the use of ionizing radiation are limited, it is challenging to compare risks associated with byproduct material to risks associated with machine-produced radiation or to compare overall risks associated with the use of ionizing radiation in medicine to those associated with other medical modalities. Regulation of reactor-generated byproducts outweighs all other elements of ionizing radiation in medicine in terms of intensity and load. The control of reactor-generated waste material is likewise more stringent than any other part of high-risk health care. Except for prohibited medications, it goes well beyond the regulation of chemotherapy, surgery, anaesthesia, and generic medicines.

CONFLICT OF INTEREST

The author(s) declare there is no conflict of interest present.

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SA: drafted the manuscript and contributed to the concept development and design of the article through literature collection, analysis and data interpretation for the article.

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