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Nuclear and radiological emergencies: Building capacity in medical physics to support response

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ABSTRACT

Medical physicists represent a valuable asset at the disposal of a structured and planned response to nuclear or radiological emergencies (NREs), especially in the hospital environment. The recognition of this fact led the International Atomic Energy Agency (IAEA) and the International Organization for Medical Physics (IOMP) to start a fruitful collaboration aiming to improve education and training of medical physicists so that they may support response efforts in case of NREs. Existing shortcomings in specific technical areas were identified through international consultations supported by the IAEA and led to the development of a project aiming at preparing a specific and standardized training package for medical physicists in support to NREs. The Project was funded through extra-budgetary contribution from Japan within the IAEA Nuclear Safety Action Plan. This paper presents the work accomplished through that project and describes the current steps and future direction for enabling medical physicists to better support response to NREs.

1. Introduction

A nuclear or radiological emergency (NRE) is defined as an emergency in which there is or is perceived to be a hazard due to (a) the energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction; or (b) radiation exposure. The term "radiation emergency" may be used in case an explicit distinction in the nature of the hazard is not needed [1].

Due to the inherent complexity and urgency of NREs, response efforts are usually wide and require the co-ordination of diverse groups of experts spanning the fields of emergency planning, radiation protection, emergency medical management, communication and even law enforcement [2]. The collaborative nature of NRE response efforts demands involved individuals to have a wide understanding of NRE and usually their knowledge and skills span multiple of the above mentioned fields. National and international organisations have realised that there is a shortage of experts with the required skillset to support response to NREs and have embarked in producing a series of publications, resources and training programmes providing necessary knowledge, tools and skills as required [2–11].

Due to their education and training medical physicists (MPs) have a substantial knowledge of radiation protection and of the

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potential effects of radiation on human health and well-being. Medical physicists qualified in radiation physics and its medical applications have a unique skillset and carry a range of responsibilities regarding the use of ionizing radiation. Because of the multidisciplinary nature of their work medical physicists are well adapted to complex collaborative environments in which communication with professionals of other specialties is necessary. The priority of medical physicist professional involvement is the daily routine in the clinical setting, e.g. radiation dosimetry, handling radiation measurement equipment, optimization of imaging, radiotherapy treatment planning and delivery, implementation of new methods in the clinic, quality assurance and radiation protection, as clearly specified in national and international standards on education and training of medical physicists. These diverse skills and contributions of medical physicists in healthcare and radiation protection make them a potential asset at the disposal of national NRE response mechanisms.

The European Federation of Organisations for Medical Physics (EFOMP) published policy statements Nos. 9 and 10 [12,13] and No. 12.1 [14] which has been adapted according to the recent European Council Directive 2013/59/EURATOM [15]. According to Article 82 of the European Commission COUNCIL DIRECTIVE 2013/59/EURATOM, one of the tasks of the radiation protection expert is preparedness and response in emergency exposure situations. Article 83 of the same directive [15] defines that Member States shall require the medical physics expert to act or give specialist advice, as appropriate, on matters relating to radiation physics in the context of medical exposures. Accidental exposures would require special analysis and investigation. The medical physicist should liaise with the radiation protection expert where appropriate. EURATOM guidance explicitly mentions the need for collaboration between medical physicists and radiation protection experts in issues of the clinic. Naturally, a medical physicist trained in NRE preparedness and response would become a valuable resource and collaborator of the radiation protection expert in case of NRE events.

Globally relevant publications have been issued by the International Organization for Medical Physics (IOMP) [16] and the International Atomic Energy Agency (IAEA) [17]. The IAEA General Safety Requirements specify that "The government shall ensure that arrangements are in place for the provision of appropriate medical screening and triage, medical treatment and longer term medical actions for those people who could be affected in a nuclear or radiological emergency" [18]. Medical physicists possess the relevant skills and training and are systematically involved in radiation dose assessments in the context of informing patient management in a clinical setting. They are also expected to develop plans of action to be followed in the event of such occurrences and carry out drills to verify that they can be implemented correctly [17]. Managing radioactive contamination and waste is often part of such events. It is, therefore, natural to expect that a clinical medical physicist could be trained to provide rapid dose assessments for efficient medical screening and triage in NRE conditions.

Radiation safety and protection responsibilities are assigned to medical physicists in relation to patients, clinical staff and the general public. In particular, the input of medical physicists impacts radiological and radiation therapeutics within the hospital environment. Radiation safety and protection outside the clinical environment (e.g. in the nuclear industry), is the responsibility of the Radiation Protection Officer (RPO), as specified in the IAEA Basic Safety Standards [19]. Here, it is stated that the medical physicist must liaise with the RPO, where appropriate. However, quite frequently, typically in smaller hospitals and in low-medium income countries, the medical physicist must also fill the roles and responsibilities of the RPO. In those cases, as agreed by the International Radiation Protection Association (IRPA) and the IOMP [20], the medical physicist must complement training to fulfil multiple functions in hospitals, health facilities, and radiation protection advisory boards, as both an administrator and as an educator in radiation protection [17].

Due to potential technical failures, equipment malfunction, human error and even criminal acts, ionizing radiation and radioactive materials may pose health risks for patients in a radiological practice, working staff (e.g. in industry and hospitals), and the general public (e.g. when larger groups of a population are affected by nuclear power plant disasters). Numerous reports have been published regarding the clinical and industrial NREs - defined by the IAEA as "a non-routine situation or event that necessitates prompt action, primarily to mitigate a hazard or adverse consequences for human health and safety, quality of life, property or the environment" [18,21]. Patients may be overexposed to a radiation source when undergoing radiotherapy with medical accelerators, telegamma or brachytherapy units. Such radiation overexposures and contamination of patients have occurred also during interventional radiology and nuclear medicine diagnostic procedures, respectively. The dramatic images associated with nuclear meltdown events at Fukushima, Chernobyl and Three-Mile-Island are permanently imprinted in the public's collective memory. Other incidents such as the radiological accident in Goiânia have also had a wide impact on humans and society [22]. In order to minimize the impact of an NRE on humans and the environment, all professionals involved in the emergency, including members of medical emergency response teams, should be trained to respond appropriately and effectively. By virtue of their competence in radiation physics, dosimetry, individual dose assessment, radiation monitoring, radiation protection and radiation safety, medical physicists have the opportunity to play a critical role in NRE [21,23]. Accordingly, with reference to the IAEA Basic Safety Standards [19] the medical physicist should be integrated, after a specific training, in the emergency management system with clear allocation of responsibilities for emergency preparedness and response.

Although the above mentioned documents on medical physicist education and training include requirements for education and training in radiation protection in the case of NRE, most existing training curricula do not include specific medical physicist training activities in NRE radiation safety and protection. To fill this gap, IOMP and IAEA explored available options for a general frame of radiation protection training dedicated to the role of medical physicist in NRE. Discussions took place in joint meetings hosted during the XXIII World Congress on Medical Physics and Biomedical Engineering in Beijing (2012) and the International Conference on Medical Physics in Brighton (2013) [24,25]. Next, an IAEA Steering Committee was established to develop a curriculum for medical physicist training in NRE. Two (2) one-week courses based on that curriculum were held in Fukushima (2015) [26] and Atlanta (2016) [27]. The training programme handbook and relevant resources are freely available on the IAEA's Human Health Campus website [26–29].

To improve the medical physicists' preparedness for NRE response, the IAEA initiated development of a special NRE-kit for medical physicists that is comprised of a guidance pocket book and a list of instruments and tools that are recommended as a basic emergency kit for medical physicists. This publication is expected to be available by the end of 2017.

This paper aims to give an overview of the efforts made to date to improve the preparedness of the medical physicist to support response to an NRE, and in a more general sense, to emphasize the need to complement current education and training curricula in medical physics with modules that are designed to address the requirements for effective involvement of medical physicists in the management of NREs.