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The role of radiation protection professionals in the landscape of low dose radiation

Armin Ansari

Emergency Management, Radiation, and Chemical Branch, Division of Environmental Health Science and Practice, NCEH, Centers for Disease Control and Prevention; MS:F59, 4770 Buford Highway NE, Atlanta, GA 30341-3717, United States of America.

Abstract

Radiation protection professionals benefit from using and applying a robust system of radiological protection that has evolved and matured through decades of research and experience. Nevertheless, uncertainties in potential health effects from low doses and low dose rates of radiation continue to remain. This uncertainty, coupled with complex jargon and nuances, has created an environment where the system of radiological protection can be misrepresented, even by radiation safety professionals, and by extension, misunderstood by the public. While it is universally agreed that the linear-no-threshold model cannot adequately explain or predict health effects of low dose radiation for all cancers, all individuals, or all exposure situations, the recommendation of authoritative scientific bodies to use this model for managing risks of radiation exposure is unequivocal. The role of individual radiation protection professionals in communicating radiation health and risk information is critical and consistent with the primary objective of professional organisations that represent them, mainly to promote best science and practice of radiation protection. If radiation protection professionals provide advice contrary to the recommendations and advice of regulatory and authoritative scientific bodies, it can erode public confidence in the system of radiological protection and harm the credibility of our profession.

Keywords

low dose radiation; linear-no-threshold assumption; public communication

1. Introduction

Over the last several decades, the radiation protection community has benefited from a large volume of research from molecular, cellular, and animal experiments as well as large epidemiological studies investigating the health effects of radiation exposure. This large body of research on health effects of ionizing radiation, perhaps larger than the volume of

AAnsari@cdc.gov .

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data for any other potentially harmful agent [1, 2], has informed and improved the system of radiological protection for workers and the public, and it continues to do so.

Nevertheless, uncertainties in potential health effects from low doses and low dose rates of radiation continue to remain. This uncertainty, coupled with complex jargon and nuances, has created an environment where the system of radiological protection can be misrepresented, even by radiation safety professionals, and by extension, misunderstood by the public. Consequently, instead of promoting confidence in the system of radiological protection, these mischaracterisations can increase anxiety and erode public confidence.

This paper examines the role of radiation protection professionals, beyond the best practice of radiation safety, in the accurate and effective communication of the system of radiological protection to the larger community.

2. The role of radiation protection professionals

Radiation protection, also known as health physics, is the discipline responsible for the protection of humans and their environment from the harmful effects of ionizing radiation while providing for its beneficial uses [3]. Radiation protection professionals are actively engaged in the practice of radiation protection in the nuclear industry, academia, medical and public health systems, local, state and federal government, the military, and other arenas. As expected, their specific roles and responsibilities vary widely across these sectors and occupational disciplines. However, a shared responsibility, and one of the most fundamental functions of radiation protection professionals is to communicate radiation health and risk information. This communication is often with co-workers and managers, sometimes with students, and most critically with members of the public. Communication with the public may be through an intermediary (e.g. the media), or it can be direct for those who are on the front lines of the practice with direct public contact. As the foundation of our radiation protection practice is based on sound scientific principles, the health and risk messages we communicate also need to be based on the best scientific information available.

It is informative to examine the core mission of various organisations that represent the radiation protection profession throughout the world. The mission of the US Health Physics Society ((HPS), as stated in its 2017 Strategic Plan, is ‘excellence in the science and practice of radiation safety’ [4]. The mission of the United Kingdom’s Society for Radiological Protection (JRP), as stated in its Royal Charter, is to ‘promote the science and art of radiation protection and allied fields for the public benefit’ [5]. Similarly, the mission of the International Radiation Protection Association (IRPA), which is an association of 52 national and regional societies in 66 countries, is to promote ‘excellence in radiation protection by providing benchmarks of good practice’ [6]. Clearly, promotion of excellence in science and practice of radiation protection is a core mission of organisations with preeminent role in this field.

IRPA recognises ‘science’ and ‘principles of radiation protection’ as two ‘pillars’ of radiation protection [6]. In the next section, we examine what the authoritative scientific bodies have stated regarding the radiation protection principles as applied to low doses

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of radiation. It is expected that radiation protection professionals, consistent with the core mission of institutions that represent them, practice radiation protection according to the same principles.

3. Consensus science and best practices

Authoritative institutions in the field of radiation science and radiological protection have thoroughly examined the scientific data relevant to the health effects of radiation at low doses and low dose rates and have made recommendations on how best to apply this well-established science to radiation protection practices.

The International Commission on Radiological Protection (ICRP) considers the linear-no-threshold (LNT) model to be 'the best practical approach to managing risk from radiation exposure', and it states that LNT, combined with a judged value for DDREF (dose and dose-rate effectiveness factor) for extrapolation from high doses, remains a 'prudent basis for radiological protection at low doses and low dose rates' [7]. This is based on an assumption by the Commission that, at radiation doses below about 100 mSv, the probability of stochastic effects is not zero, but the effects occur with a vanishingly small probability and in proportion to decreasing radiation dose down to zero. The ICRP Publication 99 examined the data for the possibility of a low-dose threshold and concluded that while the existence of a low-dose threshold does not seem to be unlikely for certain radiation-related cancers, the evidence does not favor the existence of a universal threshold for all cancers, hence the prudence of applying the LNT model for radiation protection purposes [8].

In the United States, the congressionally chartered National Council on Radiation Protection and Measurements (NCRP) reviewed the latest epidemiological data specifically regarding their implications for the LNT model and radiation protection [9]. After this exhaustive review, the NCRP concluded that 'no alternative dose-response relationship appears more pragmatic or prudent for radiation protection purposes than the LNT model', and the LNT model should continue to be used for radiation protection purposes. This NCRP conclusion is consistent with judgments by other national and international scientific committees, such as the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) [10].

Approximately ten years prior to publications of ICRP 103 [7] and NCRP Commentary 27 [9], two influential reports were published by the US National Research Council of the National Academies of Sciences Engineering and Medicine and the French Academy of Sciences [11, 12]. Although these two reports appeared different in the focus of their discussions and interpretation of the underlying science, the final conclusion of both reports regarding the use of LNT model for radiation protection purposes were similar. The Biological Effects of Ionizing Radiation VII (BEIR VII) report concluded that the preponderance of evidence suggests there will be a small risk even at low doses of radiation and endorsed the LNT model for radiation protection [11].

The joint report of the French Academy of Sciences and Academy of Medicine elaborated the complexities of cellular response to ionizing radiation damage citing the latest molecular

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radiation biology research findings. The report suggested evidence for existence of a 'practical threshold.' However, it concluded that 'on the basis of our present knowledge, it is not possible to define the threshold level … or to provide the evidence for it' [12]. Furthermore, the value of this practical threshold is likely to vary with the cell type and age of the individual. The French Academy report expanded on the misuse of LNT and misapplication of LNT when calculating collective dose and predicting harm for individuals in large populations exposed to small doses. Nevertheless, for radiation protection purposes, the French Academy concluded that LNT 'should be considered as a tool which is useful for regulatory purposes because it simplifies the administrative task.'

Two more examples follow. The Nuclear Energy Agency (NEA) is an intergovernmental organisation under the framework of the Organisation for Economic Co-operation and Development (OECD). It consists of 33 countries from Europe, North America and the Asia-Pacific region, accounting for approximately 82% of the world's installed nuclear capacity. Its stated mission is to assist its member countries in maintaining 'the scientific, technological and legal bases required for a safe … use of nuclear energy' by providing 'authoritative assessments … on key issues as input to government decisions on nuclear energy policy' [13]. The NEA in its 2016 publication, Radiological Protection Science and Application, states that despite inherent limitations, 'the LNT model is, in regulation and practice, the most widely used and recommended approach for prospectively managing radiation risks' [14].

Lastly, as another example of a national authoritative organisation, the Swiss Commission for Radiation Protection and Surveillance of Radioactivity concluded that 'the LNT model remains the best tool to manage the risk of radiation exposure' [15].

3.1. Risk management versus risk assessment

An important consideration to note is that the recommendation for use of the LNT model is for the 'management' of radiation risk, and not for 'assessment' of radiation risk. This is an important distinction that is often overlooked. While these authoritative organisations support the use of the linear assumption for radiation protection purposes and managing risk to workers and the public, they do not support applying those risk factors to assign health risks to individuals, retrospectively or prospectively. For example, when calculations based on collective dose are used to predict the number of cancers induced if millions of people were exposed to a few micro-sieverts, the results are misleading and UNSCEAR, ICRP, and NCRP explicitly advise against this misapplication of the LNT model.

As radiation protection professionals, we are keenly aware of challenges in communicating health effects of low radiation doses to individuals and populations, along with the uncertainties, in a manner that our audience finds informative. The perfect balance between clarity of the message and scientific accuracy of the information is not easy to maintain. The implication that the LNT model is appropriate for radiation risk management but not applicable to risk assessment at low doses makes the task of risk communication significantly more challenging.

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3.2. Assumption or model versus hypothesis

In science, a hypothesis is an idea or explanation that is proposed so its validity can be put to test. In the context of radiation protection practice and recommendations by the authoritative bodies, LNT is not a hypothesis. It is almost universally agreed that LNT cannot adequately explain or predict health effects of radiation for all cancers, all individuals, or all exposure situations. LNT in the context of radiation protection practice is a model or an assumption, and in this context, it should not be referred to as a 'hypothesis'.

4. Discussion and conclusions

Radiation protection professionals benefit from using and applying a robust system of radiological protection that has evolved and matured through decades of research and experience. A culture of safety is in place. Unnecessary exposures to workers, patients, and the public have been reduced. Our system of radiological protection is not perfect, however, and it has room for improvements [16]. Some principles of radiation protection such as ALARA (As Low As Reasonably Achievable) can be misapplied and dose *optimisation* may have been reduced to dose *minimisation* in some practices. This could result in misplaced priorities and expenditures, or create physical or emotional hardship for the people whom the system of radiological protection intends to serve. Concepts, such as collective dose, can be misused and result in exaggerated risks and unwarranted public anxiety. These issues or misapplication and misuse are not unique to the field of radiation protection, and it is not a fault of the system itself.

As practitioners of the profession, one role of radiation protection professionals is to provide accurate scientific information to stakeholders while realizing that, in many cases, decisions are multifaceted and other societal factors may play a role in making those decisions.

Routinely, matters of radiation protection with workers and the public involve low dose and low dose rate exposure situations. The endorsement of the LNT model for managing risks of radiation exposure by authoritative national and international scientific bodies is unequivocal. The foundation of radiation protection practice and national regulations rests on the valued recommendations of such organisations.

For the system of radiological protection to be effective, it needs to have the public's confidence. If radiation protection professionals provide information contrary to the recommendation and advice of regulatory and authoritative scientific bodies (such as UNSCEAR, ICRP, NCRP and numerous other radiation protection organisations) throughout the world, it can erode the public's confidence in the system itself.

The role of individual radiation protection professionals in communicating radiation health and risk information is critical and consistent with the primary objective of professional organisations that represent them, mainly to promote best science and practice of radiation protection. Doing so with a unified voice can facilitate public confidence.

While the landscape of low dose and low dose rate exposure, because of its uncertainties and complexities, provides many opportunities for misunderstanding, unintentional

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misrepresentation and mischaracterisations, it is incumbent upon us, the radiation protection professionals, to do our best to minimize such occurrences, and at the very least avoid unintentionally contributing to them. The credibility of our profession depends on it.

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