Dose-Response:
An International Journal
July-September 2021:1

DOI: 10.1177/15593258211027755
journals.sagepub.com/home/dos
SAGE

Major Challenges in Improving the System of Radiological Protection

Bobby R. Scott[1]

Keywords
radiation, protection, risk assessment, LNT, threshold, hormesis

The current **s**ystem of **r**adiological **p**rotection (SRP) is founded on principles linked to the hypothetical **l**inear-**n**o-**t**hreshold (LNT) risk model for health detriment from low-dose radiation exposure.[1] This letter relates to needed improvements in the SRP due to scientific deficiencies (eg, missing thresholds, nonlinear dose responses) and to major challenges in achieving the improvements. There now is extensive radiobiological evidence[2,3] that the LNT model is invalid for cancer induction (main contribution to health detriment), as chemico-biological interactions and their systemic consequences after low radiation doses (e.g., < 100 mGy) are consistently showing no adverse health effects and possible health benefits.[2] The health benefits (eg, cancer prevention) occur above an adaptive response threshold but below a second dose threshold for harm.[3,4] Radiation-stimulated, hierarchical-natural-defenses models (with deterministic or stochastic thresholds) have been researched (but insufficiently) and are more credible than LNT for low radiation doses.[2-4] Related to the deficient LNT-based SRP, it has been stated[5] "*Preconceived concepts impede progress; in the case of the LNT model, they have resulted in substantial medical, economic, and other societal harm.*" Indeed, the SRP-based, very stressful population evacuation following the 2011 Fukushima nuclear incident led to many lives lost unnecessarily.[6]

Developing a more scientifically credible SRP based on **n**onlinear **d**ose-**r**esponse (NDR) relationships (eg, single-threshold-sigmoidal; hormetic-two-thresholds; other) for harm or benefit/harm[2-4] to health is however *much more challenging.* A largely trusted organization [eg, the International Commission on Radiological Protection (ICRP)] will be needed to achieve the goal of an improved and widely accepted SRP based on NDR relationships. Questions that need to be addressed in a timely manner via research in order to develop an improved SRP include the following: *a*, what dose-response models will be best to use for the NDR curves; *b*, how will mixed radiations (e.g., alpha + beta + gamma) be addressed given that the current LNT-based, fixed radiation weighting factors (and linked equivalent doses) are unlikely to be reliably applicable to NDR relationships; *c*, if new radiation weighting factors (for NDRs) are to be developed and justifiably used, won't they need to vary as absorbed dose increases or will some form of averaging over dose ranges be credible (validation likely needed); *d*, how will repeated exposures and dose-rate-history (when dose rate changes over time) effects be accounted for; *e*, won't LNT-related, whole-body effective dose need to be abandoned and if so will tissue-specific, weighted (eg, via RBE) doses be adequate. Whether some organization (eg, ICRP) or organizations will be willing to take on such challenging questions via research is unclear. Hopefully, such questions will be timely addressed for the benefit of future generations.

ORCID iD

Bobby R. Scott https://orcid.org/0000-0002-6806-3847

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[1] Lovelace Biomedical Research Institute, Albuquerque, NM, USA

Corresponding Author:
Bobby R. Scott, Lovelace Biomedical Research Institute, 2425 Ridgecrest Drive SE, Albuquerque, NM 87108, USA.
Email: bscott@lovelacebiomedical.org