Radiation Dose and Cancer Risk

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As a result of many decades of research, the health impacts of radiation are very well-understood. In a 2016 report, "Radiation: Effects and Sources," the UN Environment Programme (UNEP) noted:

> We know more about the sources and effects of exposure to [ionizing] radiation than to almost any other hazardous agent, and the scientific community is constantly updating and analysing its knowledge.... The sources of radiation causing the greatest exposure of the general public are not necessarily those that attract the most attention.

Current radiation-protection standards assume that any dose of radiation, no matter how small, involves a risk to human health. This assumption, a deliberately highly conservative assumption that runs counter to scientific knowledge, is the basis for the linear no-threshold (LNT) dose-response model, which is increasingly being questioned by the scientific community.

Dr. Edward Calabrese of the University of Massachusetts School of Public Health & Health Sciences in Amherst has extensively documented the flawed origin of the LNT model. The Health Physics Society offers a series of videos, The History of the LNT Episode Guide (hps.org), with Dr. Calabrese, to examine the history of this controversial radiation-effects model.

My previous article, Dispelling Irrational Fear of Radiation, addressed a derived ionizing radiation metric called the *equivalent dose*, which is defined as the product of *radiation absorbed dose* and the radiation *quality factor*. The quality factor accounts for the general interaction differences of each radiation type with biological matter.

Another derived metric, called the *effective dose*, defined as the product of equivalent dose and a specific biological tissue weighting factor, was introduced by the International Commission on Radiological Protection (ICRP) in 2007 (ICRP Publication 103). Its purpose was to set radiation-protection limits for exposure to radiation and intakes of radionuclides by workers and members of the public.

Both equivalent dose and effective dose are derived metrics because they are not directly measurable. Moreover, they imply a known relationship between measured physical quantities and their biological effect. An underlying assumption is that random probability effects of low-dose radiation increase linearly with equivalent dose. And while tissue-weighting factors are intended to account for organ and tissue radiosensitivities, they represent only *approximate* contributions to the assumed total risk of radiation damage.

According to ICRP Publication 103, effective dose is to be used for "prospective dose assessment for planning and optimization in radiological protection, and demonstration of compliance with dose limits for regulatory purposes.” In practice, however, effective dose has been incorrectly applied to predict cancer risk among exposed individuals using the LNT model.

Not only do the ICRP committee-selected tissue-weighting factors incorporate substantial uncertainties, but the linearity of the LNT model for low radiation doses is highly disputed. In other words, there are substantial uncertainties associated with the assumptions underlying both the LNT model and the formula for calculating effective dose.

While effective dose has its proper place in radiation protection for comparing occupational exposure against primary standards and for optimizing good radiation safety practices, it is not valid for estimating future cancer incidence, as it presupposes validity of the LNT dose-response model over *all* dose ranges. Consequently, effective dose should not be used to predict individual or population risk of cancer at any dose level.

Former Canadian Nuclear Society president Dr. Jerry Cuttler serves on the board of scientific advisors to the American Council of Science. Quoted in the August 2017 *Health Physics* journal, in an article entitled “Appropriate Use of Effective Dose in Radiation Protection and Risk Assessment,” he states that the proper unit to characterize radiation dose should be the rad or the Gray, which is joules of radiation energy deposited in matter per unit mass of material.

He further states that the term *radiation absorbed dose* (rad) has been perverted, first into *equivalent dose* by applying biological effectiveness factors for each radiation type, and then by applying LNT ideology to calculate an *effective dose* that allegedly represents a calculated risk of cancer. Dr. Cuttler concludes that characterizing low dose and low dose-rate radiation in units of rem or Sievert is therefore invalid. Further discussion on the topic by Dr. Cuttler is available at the Scientists for Accurate Radiation Information website.

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