NCRP Report No. 181: Evaluation of the Relative Effectiveness of Low-Energy Photons and Electrons in Inducing Cancer in Humans

National Council on Radiation Protection and Measurements

Overview

The National Council on Radiation Protection and Measurements (NCRP) has published NCRP Report No. 181 entitled *Evaluation of the Relative Effectiveness of Low-Energy Photons and Electrons in Inducing Cancer in Humans*.

In the past, considerable data had been collected in various kinds of biological systems suggesting that lower-energy photons and electrons may have higher biological effectiveness, so it has been recognized for several decades that there is a need to better understand the relative effectiveness of lower-energy photons and electrons in inducing cancer in humans.

For this Report, evidence was collected on biological effectiveness in each of five radiation-health related specialty fields, called lines of evidence (or research threads), namely the specialty fields of:

- microdosimetry;
- deoxyribonucleic acid (DNA) damage;
- radiobiologic studies in cell systems;
- radiobiologic studies in laboratory animals; and
- human epidemiology.

For each research thread, the collected evidence was evaluated for the biological effectiveness of lower-energy photons and electrons for five combinations of low-LET (linear-energy transfer) radiation type and energies (referred to as lower-energy groups), namely:

- photons of energy ~1.5 keV;
- photons of energy in the range of 15 to 30 keV;
- photons of energy in the range of 40 to 60 keV;
- photons of energy in the range of >60 to 150 keV; and
- electrons produced in beta-particle decay of tritium.

In this Report, that state-of-knowledge on biological effectiveness is then evaluated through a four-step strategy (described in detail in the Report) for the potential for lower-energy photons and electrons to increase the likelihood of cancer in humans compared with those of higher energy. This increase is expressed in this Report by a quantity named effectiveness ratio,* which is given the symbol ρ_L when derived for the five defined lower-energy groups (L) of photons or electrons.

* The effectiveness ratio for each of the lower-energy groups of low-LET radiation (ρ_L) is a modifying factor that represents the ratio of the increase in the likelihood of cancer in humans for the lower-energy group to that for a higher-energy reference radiation at equal absorbed doses.

Because of considerable uncertainty about the true values of ρ_L, the derived values are expressed by probability density functions (PDFs) which represent the present state-of-knowledge and express the relative likelihoods of alternative values and the range in which the true values are presumed to lie.

The PDFs of ρ_L, derived by an expert elicitation method and a Bayesian-based analytical decomposition method (described in detail in the Report) are graphically presented in the following figure (Figure 1.1 in the Report).

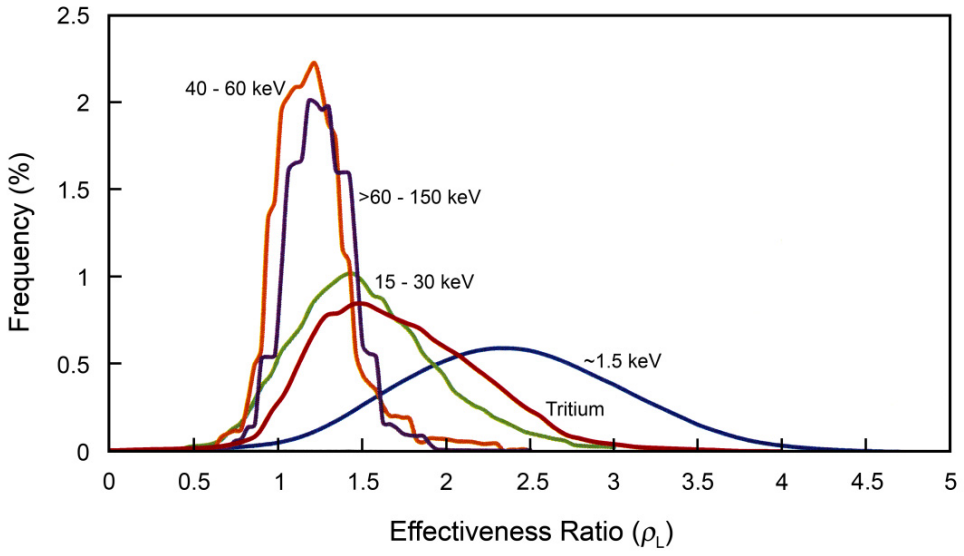

Fig. 1.1. Aggregated probability density functions (PDFs) of ρ_L for the five lower-energy groups derived from the decomposition elicitation method.

The Report does not recommend or endorse point values for ρ_L, because of uncertainty in the true values. NCRP believes that the derived PDFs of ρ_L could be used to propagate uncertainty in probabilistic human cancer risk assessments for exposure to such sources of ionizing radiation.

This Report makes no recommendation with regard to changing the current value of the radiation weighting factor (w_R = 1) for photons and electrons of all energies used in the radiation protection system. The PDFs of ρ_L, presented in this Report are intended solely for the purpose of quantitative uncertainty analysis for specific cancer risk assessments where lower-energy photons and electrons are involved.