

(3) Dosimetric quantities and risk

J.D. Harrison

*Oxford Brookes University, Faculty of Health and Life Sciences, Oxford, OX3 0BP.
Public Health England, Centre for Radiation, Chemical and Environmental Hazards, Chilton, Oxon, OX11 0RQ.
John.harrison@phe.gov.uk*

Abstract—The dosimetric quantities used in radiological protection are absorbed dose (D), with the special name of gray (Gy), and equivalent dose (H) and effective dose (E), both with the special name of sievert (Sv). D is the primary scientific quantity from which E is calculated and is the most appropriate quantity for use in setting limits on organ/tissue doses to prevent tissue reactions (deterministic effects). H to organs and tissues is obtained by multiplying organ/tissue absorbed doses by radiation weighting factors (w_R) to account for the relative effectiveness of different radiation types in causing stochastic effects at low levels of exposure, and can be seen as an intermediate step in the calculation of E . It is argued that the current use of H to set limits to prevent tissue reactions should be discontinued. E is calculated as the sum of organ/tissue equivalent doses multiplied by tissue weighting factors (w_T) which provide a simplified representation of fractional contributions to total stochastic detriment from cancer and hereditary effects, expressed as sex-, age-, and population- averaged values of detriment-adjusted risk (Sv^{-1}). E was originally developed by ICRP for use in the radiological protection of workers and the public. In these applications, it is used as a risk-adjusted dosimetric quantity to manage protection against stochastic effects, comparing planned or received doses with dose limits, dose constraints, and reference levels expressed in the same quantity. Its use allows all radiation exposures from external and internal sources to be considered together and summed, relying on the assumptions of a linear non-threshold dose-response relationship, equivalence of acute and chronic exposures at low doses or low dose-rates, and equivalence of external and internal exposures. While age- sex-, and population- related differences in risks per Sv are recognised, the use of constraints and reference levels that apply to all workers and all members of the public, together with optimisation, provides a pragmatic and workable system of protection that does not distinguish on an individual basis. In medical applications, estimates of E are used for comparing doses from different diagnostic and interventional imaging modalities (e.g. CT and nuclear medicine) and exposure techniques that give different spatial distributions of radiation within the body tissues. E is used to provide a generic indicator for classifying different types of medical procedure into broad risk categories for the purpose of communicating risks to clinicians and patients. E is also used to inform decisions on justification of patient diagnostic and interventional procedures, planning requirements in research studies, and evaluation of unintended exposures. Bearing in mind the uncertainties associated with risk projection to low doses or dose-rates, it is considered reasonable to use E as an approximate indicator of possible risk in such applications, with the additional consideration of variation in risk with age, sex and population group. For medical procedures or other situations in which a single radiosensitive organ receives the majority of the dose, such as the breast in mammography, or the thyroid from therapeutic administration of iodine, mean absorbed doses to the tissues of interest should be used rather than effective dose. The use of E as an approximate indicator of possible risk is not a substitute for risk analysis using best estimates of organ/tissue doses, appropriate information on the relative effectiveness of different radiation types, and age- sex- and population- specific risk factors, with consideration of uncertainties. Collective effective dose is a valuable tool in the optimisation of protection, particularly for occupational exposures. However, its use to predict possible health effects should be treated with great caution, and judged in relation to background incidence rates.