The Use and Misuse of "Collective Dose"

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Some years ago, radiation and public health specialist recognized the need for a method for expressing the societal impact of the aggregate of radiation exposures to individual members of a population group. An outgrowth of this effort was the development of the concept of "collective dose," which is the product of the number of people exposed and the average dose, expressed in units of person-sievert.

Despite wide usage of collective dose, many health physicists appear to have lost sight of the fundamental limitations that are inherent in this concept, which implicitly assumes that are inherent in this concept, which implicitly assumes tat the linear hypothesis provides a valid representation of human radiation response with respect to stochastic effects. In other words, the collective-dose concept implies that there is a linear (non-threshold) relationship between the total dose to a population group and the associated societal impacts or risks. In this regard, application of the concept leads to a paradox. At high doses and high-dose rates where the risk coefficients are best know, the collective-dose concept cannot be applied since the dosed-response curve is nonlinear; at low doses and low dose rates where linearity between dose and the associated health effects is assumed to apply, the risk coefficients are far less certain or even unknown.

Additional restrictions in the application must be well known with respect to size and possibly, namely:

1. The exposed population must be well known with respect to size and possibly age, sex and temporal distributions;
2. The exposure pathways must be characterized for the population at risk; and
3. Individual contributions to the collective dose must consist only of doses to the whole body, or to specific organs or tissues for which stochastic risk coefficients are known over the dose and dose-rate range of interest.

In short, application of the collective-dose concept requires detailed knowledge of the exposed population and the radiation dose to its members. The concept is valid only if both of these factors can be described and quantified, and thus should be used for risk assessments only if the associated uncertainties are sufficiently small such that the calculated collective dose itself is within and acceptable range of uncertainty. Such uncertainties may well serve as a basis for truncating collective-dose calculations at very low-dose rates without adverse impacts on estimates of the associated risks. In addition, such uncertainties may also serve as a basis for placing limits on the number of years into the future that estimates of collective doses can realistically be projected.

Most experts agree that neither the size and characteristics of a population, nor the environmental pathways for, and behavior of, specific radionuclides, are predictable with any degree of confidence for more than a few generations. Projections of collective-dose estimates for periods of thousands of years are therefore to be discouraged because of the large uncertainties inherent in such estimates.

It is important also to recognize that a high-individual risk to a small number of people is not necessarily the same as low-individual risk to a large number of people, even though the collective dose may be the same. For this reason, expressions of societal risk in terms of collective dose should always include detailed data not only on the number of people exposed, but also on the number receiving exposures within each dose range. Although collective dose can be used as a surrogate for societal risk, its interpretation requires care.

Health physicists who desire additional background and discussion on this topic are encouraged to purchase a copy of Report No. 121, "Principles and Application of Collective Dose in Radiation protection," scheduled for publication in early summer by the National Council on /Radiation Protection and Measurements.

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