International Commission on Radiological Protection

Task Group 102: Detriment Calculation Methodology

1. Radiation detriment

Radiation detriment is a concept used to quantify the overall harm to health from stochastic effects of low-level radiation exposure of different parts of the body. The tissue-specific detriment is determined from the nominal tissue-specific risk coefficient, **4.1. Outline of Chapters 2 and 3 (History and calculation of radiation detriment)**^[1]

Methodology for calculating radiation detriment has developed over decades since the concept was first introduced in ICRP Publication 22, and then in Publications 26, 27, 45 and 60.

weighted by the severity of the disease in terms of lethality, impact on quality of life and years of life lost. Total detriment is the sum of the detriments for separate tissues and organs. Detriment values are used to specify tissue weighting factors used in the calculation of effective dose.

2. Task Group Mandate

Calculating radiation detriment is a complex process that requires information from various sources and judgments on how the calculations are best performed. The current methodology is outlined in Annex A of ICRP Publication 103 (2007), but it is possible that future interpretation of available data, including the calculation of detriment from cancer incidence data, will apply revised methodology and different judgments in the light of developing evidence and understanding. To form a solid basis for future recommendations, the process of detriment calculation is reviewed and documented in a reproducible manner, considering ways in which different approaches might be applied when new data become available. The latest method in Publication 103 consists of two main parts. The first part is the calculation of a nominal risk, which is an average estimate of the lifetime cancer risk and the risk of heritable effects associated with radiation exposure. The lifetime risk of cancer is calculated separately for four reference populations (males and females of Euro-American and Asian populations) except for bone and skin cancers, and results are averaged across sexes and regions. The second part is the adjustment for the severity of the consequences. All calculation steps are executed separately for individual organs or tissues, and the resulting values are added up to give the total radiation detriment.

Calculation procedure of the nominal cancer risk is composed of sequential steps. The procedure taken in Publication 103 is summarized as below.

- Cancer risk models were developed from the analysis of cancer incidence data from the life span study (LSS) of the atomic bomb survivors. The excess relative risk (ERR) and the excess absolute risk (EAR) were modeled with modifying effects of sex, age at exposure, and attained age.
- The minimum latency period assumed was 5 years for solid cancers and 2 years for leukemia.
- The risk of exposure-induced cancer (REIC) was calculated for an acute exposure of 0.1 Gy and multiplied by 10 to obtain the lifetime risk at 1 Gy for each cancer site. It was computed for each age at exposure, 0–84 years for the whole population and 18–64 years for adult workers, by

3. Membership

Nobuhiko Ban (Chair), Nuclear Regulation Authority (NRA), Japan

Tamara V. Azizova*, Southern Urals Biophysics Institute (SUBI), Russian Federation **Simon Bouffler***, Public Health England (PHE), UK

Enora Cléro*, French Institute for Radiological Protection and Nuclear Safety (IRSN), France

Donald A. Cool*, Electric Power Research Institute (EPRI), USA

Wolfgang Dörr, Med. Univ. Vienna, Dept. Radiotherapy/RadOnc, ATRAB - Applied and Translational Radiobiology, Austria

Nobuyuki Hamada*, Central Research Institute of Electric Power Industry (CRIEPI), Japan

John D. Harrison*, Oxford Brookes University and Public Health England, UK

Dominique Laurier, IRSN, France

Dale Preston*, Hirosoft, USA

Ludovic Vaillant, French Nuclear Protection Evaluation Center (CEPN), France

Wei Zhang, PHE, UK

* Corresponding Members

4. Current status of the draft report

In May 2019, the Main Commission approved the draft report for public consultation. The draft report is now under final amendments.

- cumulating the risk until the attained age reaches 90 years.
- The weighted mean of REIC for each age at exposure was calculated to give the age-averaged lifetime risk, the weight being proportional to the age distribution of the reference population.
- The lifetime risks were weight-averaged according to weighting specified for each cancer site.
- The lifetime risk estimates were adjusted downward by a DDREF of 2, except for leukemia for which the linear-quadratic model was used.
- Unweighted mean of the resulting values between the four reference populations yielded a nominal risk for each cancer site.
- The global nominal risk was calculated as the sum of nominal risks estimated for 13 categories of cancer with the consideration of additional risk reflecting heritable effects.



4.2. Outline of Chapter 4 (Sensitivity of detriment calculation)^[2]

It will be available for public consultation in due course.

The main body of the draft report consists of six chapters: 1) Introduction, 2) History of detriment calculations, 3) Calculation of radiation detriment, 4) Sensitivity of detriment calculation, 5) Potential evolution and 6) Summary and conclusions. An outline of Chapters 2 to 4 is provided on the right.

[1] Cléro E, Vaillant L, Hamada N, Zhang W, Preston D, Laurier D, Ban N. History of radiation detriment and its calculation methodology used in ICRP Publication 103. J. Radiol. Prot., 39: R19–R35, 2019.

[2] Zhang W, Laurier D, Cléro E, Hamada N, Preston D, Vaillant L, Ban N. Sensitivity analysis of parameters and methodological choices used in calculation of radiation detriment for solid cancer. Under review.

A sensitivity analysis was conducted to examine the impact of 12 different parameters or methodological choices on the calculation of solid cancer detriment, for each of 10 solid cancer sites, by changing each one of the parameters in turn.

The analysis demonstrated a large impact on estimated detriment from DDREF, age-at-exposure, sex and lethality, a noticeable impact of risk transfer model associated to variation of baseline rates, and a limited impact of risk calculation method, survival curve, latency, attained age, quality of life and relative years of life lost.