COLLECTIVE DOSE :
IRSN VIEW ON ITS INDICATIONS AND CONTRAINDICATIONS

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INTRODUCTION

The concept of collective protection appeared in 1959 in the first report of the International Commission on Radiological Protection (ICRP). During the course of the next decades, ICRP gave details on the use of the collective dose, in particular on its role in the process of optimisation of protection. In 1991, ICRP outlined that the collective dose takes account of the number of people exposed to a source by multiplying the average dose to the exposed group by the number of individuals in the group.

At present, the collective dose is currently used by those who practice radiological protection, in a prospective and retrospective way. Its use with respect to the management of the protection of workers scarcely raises any debates. On the other hand, its use to assess the public exposure or to estimate the health effects of exposure to ionizing radiation (workers or population) raises numerous criticisms. Some of these criticisms, relating to ethical nature, underline that the collective does not reflect the inequities among the exposed individuals. Criticisms, scientific in nature, concern the linear-nonthreshold dose effect relationship hypothesis, which enables the collective dose to be represented in terms of risk of the occurrence of stochastic effects. Other criticisms, of an operational nature, relate to the feasibility and the reliability of some collective dose calculations.

The former Institut de Protection et de Sûreté Nucléaire (IPSN), being aware of the problems raised by the use of the collective dose, formulated an opinion on this question, which formed the subject of a publication within the set of « Documents IPSN », in December 2001. Institut de Radioprotection et de Sûreté Nucléaire (IRSN), which was created in February 2002, take up the this publication. It is devoted to radiological protection practitioners, whatever their level of responsibility is (operators, employers, authorities).

1 Report by an IPSN Working Group : Françoise Bretheau, Dorothée Conte, Françoise Rancillac, Catherine Rommens, Annie Sugier, Sylvie Supervil (Secretary), Michèle Viala, Didier Champion, Patrick Gourmelon, Philippe Hubert, Dominique Laurier, Jean François Lecomte, Jacques Lombard, Henri Métivier, Jean-Claude Nénot (Chairman), André Oudiz and Daniel Quéniart
CRITERIA FOR USE OF THE COLLECTIVE DOSE

In order to examine the relevance of the collective dose as an indicator with a view to clarifying a decision, it is necessary to examine the following three aspects:

- the relevance of this indicator in the risk management,
- the feasibility, the nature and reliability of calculation,
- the relevance of the link between collective dose and risk.

Confusion between these three aspects has been the cause of numerous misunderstandings in discussions on the collective dose. Consequently these three aspects must be considered separately.

The use of the collective dose is particularly relevant in the following cases:

- to compare the various protection options in the context of framework of optimisation (for example, for managing work sites in an industrial environment);
- to estimate the number of expected effects (either to appreciate the feasibility of an epidemiological study, even to avoid carrying out such a study or in order to compare them with the results obtained from field observations);
- to evaluate the global impact (collective detriment) in relation to an activity or a source (nuclear fuel cycle, radon, fallout from nuclear weapons atmospheric tests, waste, etc.). The evaluation of the global impact of an activity or a source may also be used with an objective of comparison (for example, to compare the effects of natural exposure to those due to artificial sources of ionising radiation).

The use of the collective dose indicator presents the same limitations as any other collective indicator. As a matter of fact, it should be highlighted that collective indicators mask: the transfer of risk (the total collective dose does not take into account the transfer of the doses from one group to another), the inequalities in individual risk distribution, the disparities in various conditions of exposure.

The reliability of the collective dose calculation depends on its feasibility, its basis (direct exhaustive observations, sampling, complete models, approaches combining measurements and models) and on its uncertainty factors relating to the method used (over the long term, on the models and on the hypotheses). Reliability of the calculation cannot be absolutely assessed but in relation to the question posed. The various components of the collective dose (for example, dose levels, number of persons exposed, duration of exposure…) are as important as the result of the calculation.

The link between the expression of the effective collective dose and the risk can only exist if the calculation of the collective dose, sum of individual effective doses has been made
for a sufficiently large populations of a quite general demographic structure, using doses distributed homogeneously to the various organs. Contrary to this, distorsions may appear (for example, for the same collective dose, the risk of cancer is greater for a group of children than for a group of old persons).

**IRSN POSITION**

The protection of a population exposed to ionising radiation implies that what must be considered and controlled is not only the risk run by each individual of this population but also the risk run by the whole population involved. IRSN considers that the collective dose, sum of the individual doses of the members of a given population, constitutes a useful, whilst not exhaustive, indicator, of the collective dimension of the risk, the use of which it recommends within the limits indicated below.

The collective dose, effective and/or equivalent, may be used:

- to assess the dosimetric impact of an activity or a source over a group of people,

- to assess the number of stochastic effects that could result from the exposure of a group of people.

The methods for calculation of the collective dose and its use must be adapted to the nature of the situation under consideration.

**Methods of calculating the collective dose depending on its use**

IRSN considers that before calculating a collective dose it is necessary to clarify the purpose for which the calculation is done. As a matter of fact, the difficulties encountered, particularly in the interpretation of the results, vary in nature according to whether it is a question of assessing the level of exposure of a given population or the health effects in this population.

When it is a question of assessing the level of exposure of a given population, the variability of the collective dose components (dosimetric, demographic) governs the significance of the result. Difficulties in interpreting the collective dose essentially exist for the following cases: very low levels of individual exposures, exposures prolonged over very long periods and over several generations, individual exposures of a varying nature (for example external, internal, ...) or comparison of collective doses of populations having different characteristics of exposure.

When it is a question of assessing the health effects in a given population, uncertainties on the various risk factors available (for example the probability of the occurrence of cancer per unit dose) and the loss of information inherent to the calculation of the collective dose (for example, nature and severity of the effect) may compromise the accuracy of the result.
• **Assessment of the levels of exposure**

The collective dose must be calculated for homogenous segments, such that each segment corresponds to parameters that are adapted to the specific context being considered. It is necessary to avoid the use of a single collective dose, resulting from the summation of several collective doses corresponding to different segments; such a dose summation prevents the variation of individual doses and their distribution from being assessed. Segmentation of the collective dose must meet three conditions:

- to group together those individual doses that present no differences greater than a maximum of one or two orders of magnitude;

- not to group together periods of time that differ by more than one or two orders of magnitude, for example to evaluate the development over time (10, 100, 1 000 years…) of collective doses related to exposures of long duration. For very long periods of time, limit this to the duration of a few centuries and, in any case, always less than a thousand years, due to the wide range of uncertainties that accompany each forecast of dose beyond this time scale, for example to assess the global dosimetric impact of long-lived waste disposal;

- a priori do not neglect very low doses before ensuring that they have no substantial contribution towards the collective dose. The process of segmentation and evaluation of the segments constitutes a more realistic and more credible solution than using a generic de minimis dose.

• **Assessment of the health effects**

The dosimetric quantities used must be adapted to the risk corresponding to the considered exposure. Thus, to assess the risk of a specific cancer, it is necessary to use the equivalent dose to the relevant organ (thyroid, bone marrow). In the absence of knowing the location of the cancer, the effective dose may be used to estimate the risk of death by cancer, all cancers being considered together. If the risk to be assessed is the occurrence of a cancer before a given age, it is necessary to use an estimation of the dose truncated at the age attained (for example, dose to the bone marrow before the age of 15 for a risk estimate of childhood leukaemia).

As in the case of dosimetric assessment, the collective dose must be calculated for homogenous segments. This segmentation must meet three main conditions that are to be added to or substitute those mentioned above for a dosimetric assessment:

- do not group together those individual doses that represent different risks (for example: do not amalgamate effective doses with equivalent doses; do not amalgamate fatal cancers with high cure rate cancers);

- do not consider periods greater than some tens of years and in any case, periods greater than a century, because of unknowable changes in demographic and geographic conditions,
developments in knowledge on the dose-effect relationship and in the progress of medicine which might reduce the severity of some harmful effects and, consequently, might modify the risk factors;

- consider only those groups of population with identical biological conditions (age, condition of health…), notably due to differences in genetic susceptibility.

IRSN underlines the fact that all segments of the collective dose do not have the same importance. For example, for risk management, it is necessary to separate the collective dose relating to occupational exposure within an installation from that relating to the exposure of the public resulting from the operation of this installation, for several reasons: levels of individual exposures of workers differs from those for members of the public, age distributions (and often sex) are not the same, dose limits and regulations are different. With regard to the population, it is necessary to distinguish the sub-groups according to the distance from the installation considered, the lifespan of the installation, the length of exposure (short, medium or long-term), the distribution in age of the concerned population, etc.

**Confidence attributed to the calculation of the collective dose**

The individual doses used for the calculation of a collective dose originate either from assessments or measurements of individual exposures, or from estimates of the radionuclides transfer into the environment using a model or a code, or even from measurements in the environment. IPSN underlines that the degree of reliability of the calculation of the collective dose depends on the method used to assess individual doses.

Moreover, the components used to calculate the collective dose (populations considered, types of dose, temporal, geographical,… distributions), which have lead to an appropriate segmentation, confer degrees of varying uncertainty on the result (for example, disparities in the dose distribution in time and space, different organs exposed). When the calculation of some segments of the collective dose shows major uncertainties, IRSN recommends recording these uncertainties.

In a general manner, it is important, in order to evaluate a collective dose result, to correctly examine the bases of its calculation.

**Interpretation of the results of the calculation of the collective dose**

IRSN considers that, for the interpretation of the results of a collective dose calculation, it is essential to know the main components of this dose (number of people exposed, mean level of individual exposures…). It is also useful to know the individual doses of the most exposed people, in addition to the collective dose of a given population.

It is the presentation of the results for the various segments that promotes the discussion, for example between operators and national authorities, and enables decisions to be elaborated.

Within the framework defined previously, IRSN considers that the collective dose, calculated on the basis of individual effective doses from a large population notably mixing ages and
sexes, constitutes a correct indicator for the global risk of the occurrence of stochastic effects. Furthermore, in situations where homogenous groups of population are identified (children or adults in a given age range, pregnant women…), it may be useful to detail the risk incurred by these groups of specific populations. The collective doses calculated in such cases cannot be compared without care with collective doses of other groups. It is also necessary to distinguish between collective doses leading to an estimate of a risk of death by cancer with those that lead to the estimate of a risk of non-fatal cancers or hereditary effects.

IRSN reminds that the collective dose constitutes an indicator of the risk of stochastic effects, for example in the field of regulatory doses limits. Consequently, the collective dose cannot in any case constitute an indicator of the deterministic effects.