RISK COMMUNICATION: HOW TO CONSIDER RISK AND BENEFIT IN JUSTIFICATION OF EXPOSURE

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1. Introduction

The radiological judgement of a practice which might lead to detrimental effects as operation of sources possibly emitting ionizing radiation is still a very sensitive subject leading to public discussion and political controversies. In addition, recent European standards require the execution of the concepts of justification and optimization. The present radiobiological background indicates a stochastic induction of possible detrimental effects by a radiation, and so called *stochastic effects* are the main issue in radiation protection at doses in the order of dose limits. This in turn implies that there is no immediate perception of possible radiation effects, where the benefit can be either immediately perceived (a radiological technique > diagnosis > treatment > healing of the disease) or also not perceived (industrial use of radiation source > improvement of quality in welding). This implies that the use of the subject „risk" is necessary, and probability considerations have to be carried out. The present biological background gives well-proved figures on radiation risks. The realisation of Justification and optimization procedures requires, however, the expression of the non-radiological risk of alternatives, non-application of the procedure or the practice and also for the benefit. It is therefore an immediate need for quantitative and objective procedures to compare at least in the first approach non-comparable issues, namely

- a possible harm associated with the implementation of a practice leading to an exposure
- the harm associated with the non- implementation of the practice
- the benefit associated with the practice,

even when they are not immediately perceivable.

In order to carry out reasonable calculations, some suggestions on the quantities used in the required procedures can be done are discussed. The present situation in not satisfying and leads to useless controversies producing headlines as "Wieviel Tote durch Röntgenstrahlen?" /Bi 95/. This lead to the requirement that the justification procedure has to satisfy scientific requirements, but has to fulfill also requirement of risk communication.

2. General considerations

In order to carry out a transparent and objective cost -benefit analysis , both the detriment of a given exposure (i.e. the fictive *cost*), but also the ***benefit*** have to be expressed in common terms, and the application is justified only when the following conditions apply

A) for ***one practice***

$$\text{Benefit} >> \text{Risk} \quad (1)$$

B) for ***different alternative practices***

$$\text{Benefit of practice a / Risk of practice a} >> \text{Benefit of practice b / Risk of practice b} \quad (2)$$

where „ practice" includes also non- application.

To prove this conditions, it is required that both sides of the equation have the same unit, i.e. a common language has to be developed in order to express the possible detrimental effects and

the benefit of the considered practice. The problem of expressing harm is rather easy for each individual part, but difficult for both sides of equations (1) and (2).

3. Importance of the term „risk"

In order to carry out reasonable consideration, it might be reasonable to have a short look to the term „risk":

The term „ risk" has a general meaning, but is frequently used to express specific purposes not covered by the common meanings. The development in time was from something unexpected to something bad. /Li 94/. Today, some synonyms as danger, peril, jeopardy, hazard are used as to have the same meaning than risk as: *„ the state or fact of being threatened with loss of life or property or with a serious injury to health or moral integrity or the cause or source of such a threat"* These meanings (might be called as *everyday meanings*) do not include any quan-titative assessment, neither to likelihood nor to the consequence.

For *scientific* application, a quantitative approach is required as suggested by /Li 94/, as risk has to have two characteristic attributes:
i.) the probability of the possible dreaded event
ii.) the consequence of that event

Both terms have to be combined, and the product is the ***mathematical expectation of the consequence under consideration.***

4. Radiobiological considerations

The basic process which might lead to the possible development of detrimental effects/ IC 90/ is mainly by ionisation. This process might modify the structure of molecules containing them permanently or transiently, where the most important process take place in living cells, in particular in the DNA. Damage in the DNA may prevent survival or reproduction of the cell, but frequently the damage is repaired by the cell.. When the repair is not perfect, a modified cell may survive. This view indicates that a number of independent processes have to take place in the sequence from the ionisation of an atom to the development of cancer, and therefore the effects are called *stochastic.*

In order to develop a common terminology, it seem reasonable to have a look to possible expression of risk as used for ionizing radiation and to check the applicability for the other side of equ. (1)

5. Presentation of radiation risk

The presentation of radiation risk can be done by
i.) *scientific directed presentation (original data to estimate risk)*
ii.) *user directed presentation (derived data to perceive risk)*

The assessment of radiation risk leading to a *scientific directed presentation* has the goal to prove a scientific basis for radiation protection standards. The presentation of the results of these investigations has high level professionals as the target group and has to be in the most extent complete, precise and will hence become complex because of description of limitations of the model and predictive power. As a result, the knowledge will become forwarded only to a few fellow experts. A simple user will be lost in the complexity of the presentation as demanded by the requirement of an indisputable scientific presentation, and eventually resign.

On the other hand, a person subject of both risk and benefit from the same source (e.g. a patient in medical exposure) or either risk or benefit (e.g. a member of the public) needs a simplified *user directed presentation* of radiation and other risk, where the scientific basis has to remain traceable, correct and unbiased . In particular, a presentation has to be used to permit a comparison between the alternatives e.g. between use and non-use of a certain source, the performance and non performance of a medical investigation or the risk and the benefit of a certain practice.

If the risk is expressed in a *scientific directed presentation*, a single figure is available, as a given exposure lead to a probability of 10^{-x} of induction of a malignant disease or to mortality. Information in this form is most important to compare derive risk factors to be incorporated into standards, but gives no idea at all on the importance of the consequences, because the relation to other risks is missing. To prove a relation, a reference risk has to be adopted.

If we consider again medical exposure as an example, the following references might be taken to get a better expression of the risk of a practice:

- comparison with the risk and benefit associated with non-radiological techniques
- comparison with the risk and benefit associated with other radiological techniques
- comparison with the consequences of doing no action (e.g. no investigation)
- relation to common risks

This indicates again that it is absolutely required to develop a common language and *common terms* to make quantitative comparisons.

This requires a *characterization of the risk* from some points of view as shown below, and an agreement has to be found on the most appropriate quantity.

1) unit dose or unit practice
The data has to refer either on a single practice, a practice as a whole, a practice in a year , individual or collective dose, annual dose etc. Both the dose and the practice have to be specified and recent dose quantities have to be taken / Ts 94/

2) property of the figure
because risk can be expressed in many forms: upper value, as mean (arithmetic, geometric, weighted), average over lifetime, both sexes, expressing mortality, incidence, annual risk, lifetime risk etc.

3) Reference quantity -absolute or relative
absolute terms
i.) total number of casualties per million persons per unit dose
ii.) annual mortality per million persons per unit dose
relative terms
iii.) relative annual mortality rate in relation to natural annual mortality rate (see table 1)
iv.) loss of life expectancy /Co 91/

Table 1. Calculated increment of attributable death probability of annual mortality rate from an annual dose of 1 mSv from birth over lifetime. (data from IC 91). The figures show that the increment of death probability rate at prolonged exposures of 1 mSv/a is well below one percent of the age specific annual death probability rate by all causes as well as below the standard deviation in the considered age, [1] After Table C-2a (IC 91)

age (years)	age specific natural annual death probability rate [per million and year](standard-deviation)	calculated attributable annual death probability by 1 mSv/a from birth over lifetime [1]	increment of attributable annual death probability by 1 mSv/a from birth over lifetime
5	230(15)	1	0.005
10	180(13)	1	0.006
20	860(29)	4	0.005
30	1080(33)	5	0.005
40	2000(45)	18	0.009
50	5300(73)	27	0.005
60	13500(116)	64	0.005
70	35000(187)	143	0.004
80	90000(300)	294	0.003
90	220000(470)	561	0.002
100	520000(721)	1010	0.002

These presentations have in brief the following properties /Ts 97/
i.) best available figure, no information on time - or age- dependence
ii.) no relation to natural annual mortality
iii.) clear and imaginable, unit perhaps difficult
iv.) even more imaginable, to be expressed in units of days

i.) is most realistic, because this quantity is based upon on most direct assessments. The other quantities are derived from i.) by introducing complementary data.

However, all these figures are in terms of a probability, and do not solve the fact that they are a collective risk, but individuals are interested in individual risk, which is not predictable by definition.

It is therefore necessary for improvement of risk communication and risk perception and hence justification to take advantage of a relative assessment where two different risks are set in relation, i.e. appear as quotient. Even possibly not justified for mathematical reasons, the probabilities can be considered as to go out and hence simplifying the equation, and the quotient remains as bare and expressive number.

This can be done, however only, when the benefit can be expressed in same terms.

6. Conclusions

The present knowledge on radiation risk is much better proved that the risk by other environmental factors, but includes still some systematical uncertainties. The stochastic relation between the dose and the implies the turn to think in terms of probability .

Regarding the procedure to express the benefit in comparable terms, the situation is more difficult. In medicine as the same person is affected by both risk and benefit, the communication in terms of lengthening or shortening of life expectancy can easily be used and easy expressed . In addition, as seen in fig.1, low doses can be considered as insignificant in relation to the mortality risk by natural and conventional reasons, and an individual Justification might be not justified (as e.g. by guidance levels in /IA 94/).

Some work will be required to make a reasonable justification of the practice and the optimization of protection. It seems a challenge to produce a consistent system for an objective justification procedure adopting terms already coined in radiation protection. However, it seems important to define areas below which low doses do not justify the evaluation, because it is going to become useless .

7. References

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