United Nations Scientific Committee on the Effects of Atomic Radiation

UNEP

Radiation Effects and Health Risks from Radiation Exposure at the Workplace

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EVALUATING SCIENCE FOR INFORMED DECISION-MAKING

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Content

- Basic aspects
- Deterministic (tissue) effects
- Stochastic effects
- What can be done, when knowledge is limited?
- Conclusions

Basic aspects

- First of all, one has to be very careful to distinguish „health effect“ (something that is actually observed) and „health risk“ (something that is expected).
- In general, health effects are related to the past and health risks to the future.
- In addition, it makes a difference to attribute a health effect to radiation in the individual case or in the case of a population.

Definition of dose categories

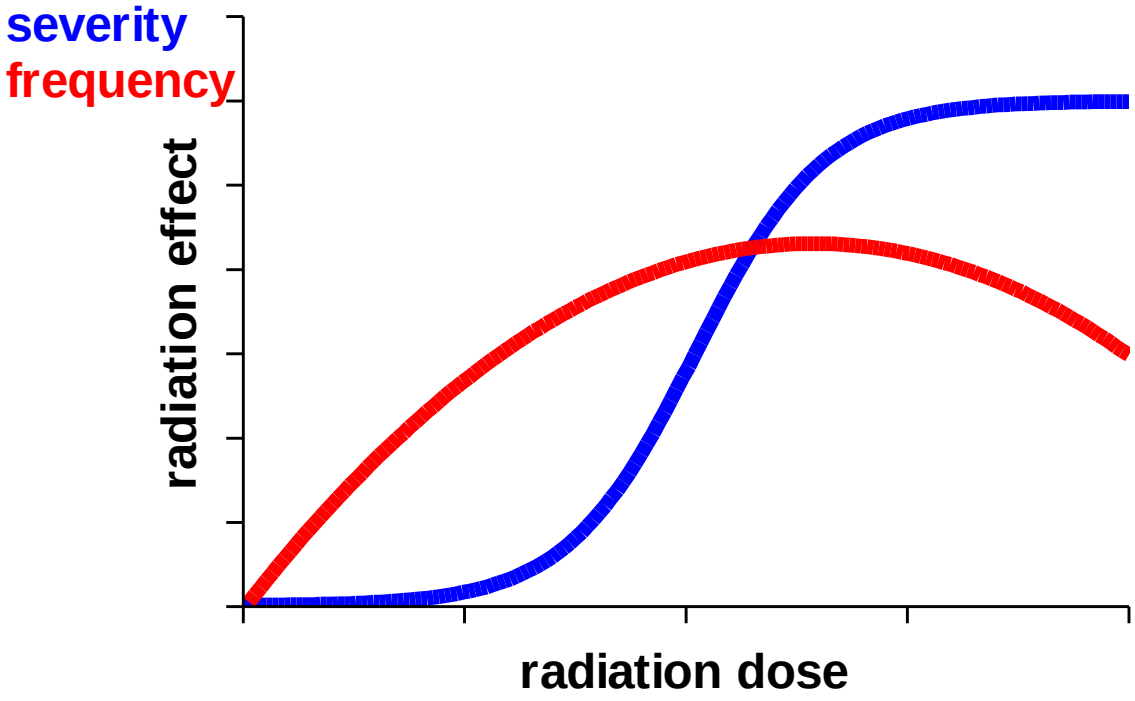
Dose category	Range of absorbed dose (for low-LET radiation)
High dose	> 1 Gy
Moderate dose	100 mGy – 1 Gy
Low dose	10 mGy – 100 mGy
Very low dose	< 10 mGy

For practical reasons, deterministic (tissue) and stochastic effects are distinguished

- Deterministic („inevitable“) effects:
  - Skin damage
  - Infertility
  - Epilation
- Stochastic („random“) effects:
  - Malignancies (solid cancer and leukaemia)
  - Heritable effects

Stochastic and deterministic effects

dose-effect-relations



deterministic effect

(requires many damaged (=**killed**) cells)

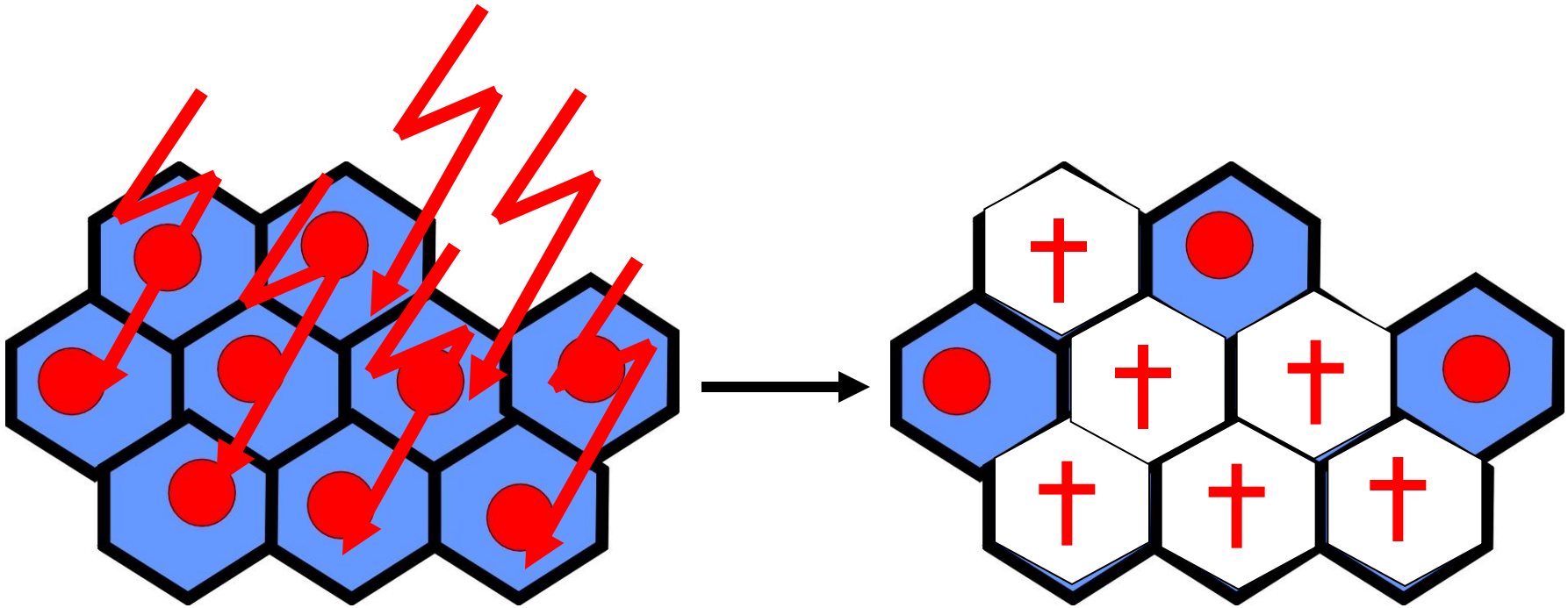
stochastic effect

(requires just one damaged (=**modified**) cell)

Problems with the terms deterministic and stochastic

- It is not clear whether the LNT (linear non-threshold) approach for stochastic effects is correct.
- For two radiation-induced types of health effects that came into focus recently, it is not at all clear whether they are deterministic or stochastic:
  - Cataracts
  - Cardiovascular diseases (CVDs)
- Both health effects will be dealt with in detail by Norman Kleiman (cataracts) and Richard Wakeford (CVDs).

Deterministic (tissue) effects



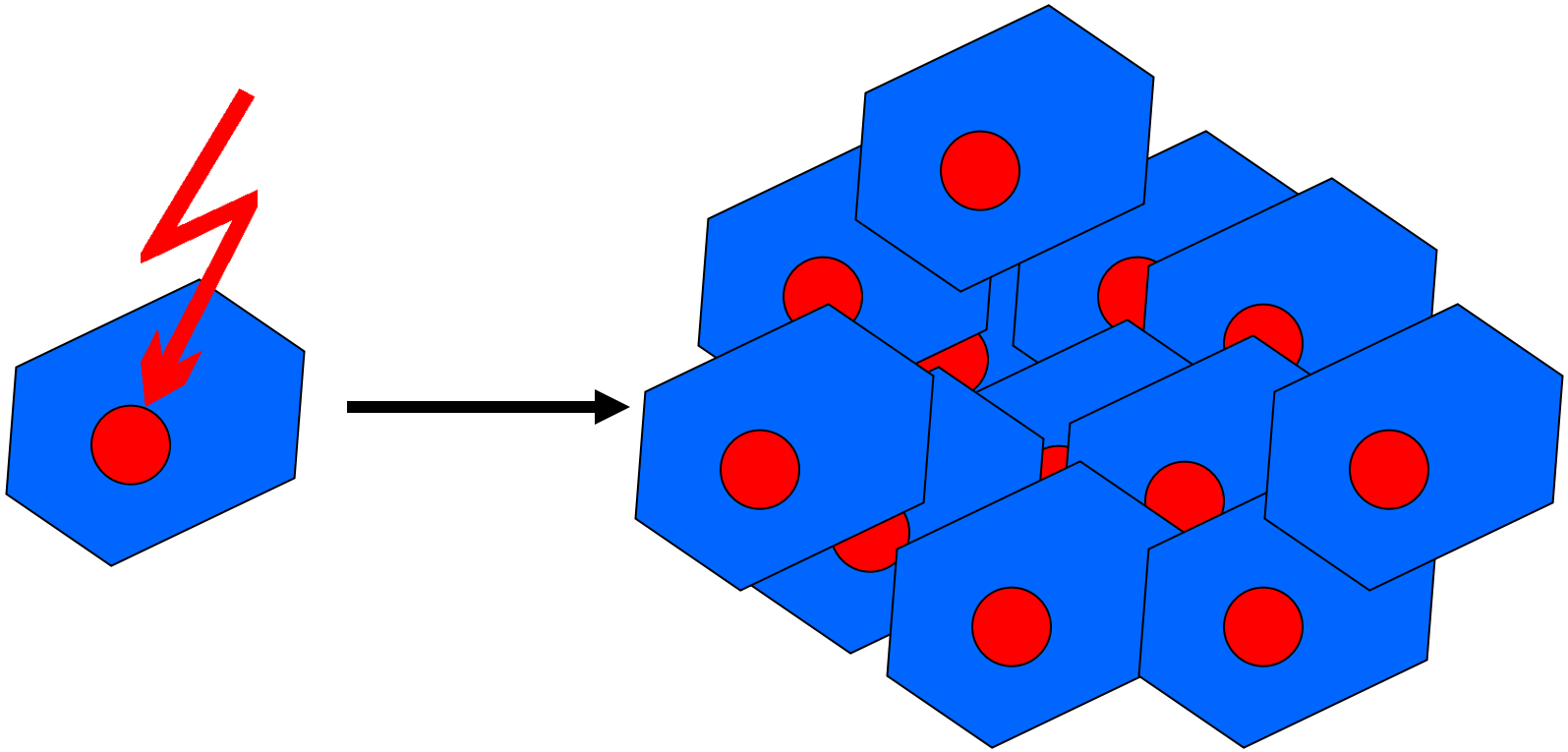
Skin burn after interventional cardiology procedure

- 69 year old patient with a long-standing heart-disease;
- a diagnostic nuclear medicine myocardial imaging study showed severe ischaemia in the distribution of the left anterior descending coronary artery;
- underwent a cardiac catheterization that included several attempts at coronary angioplasty (dilatation) and stenting.

Why attributing this health effect to ionizing radiation?

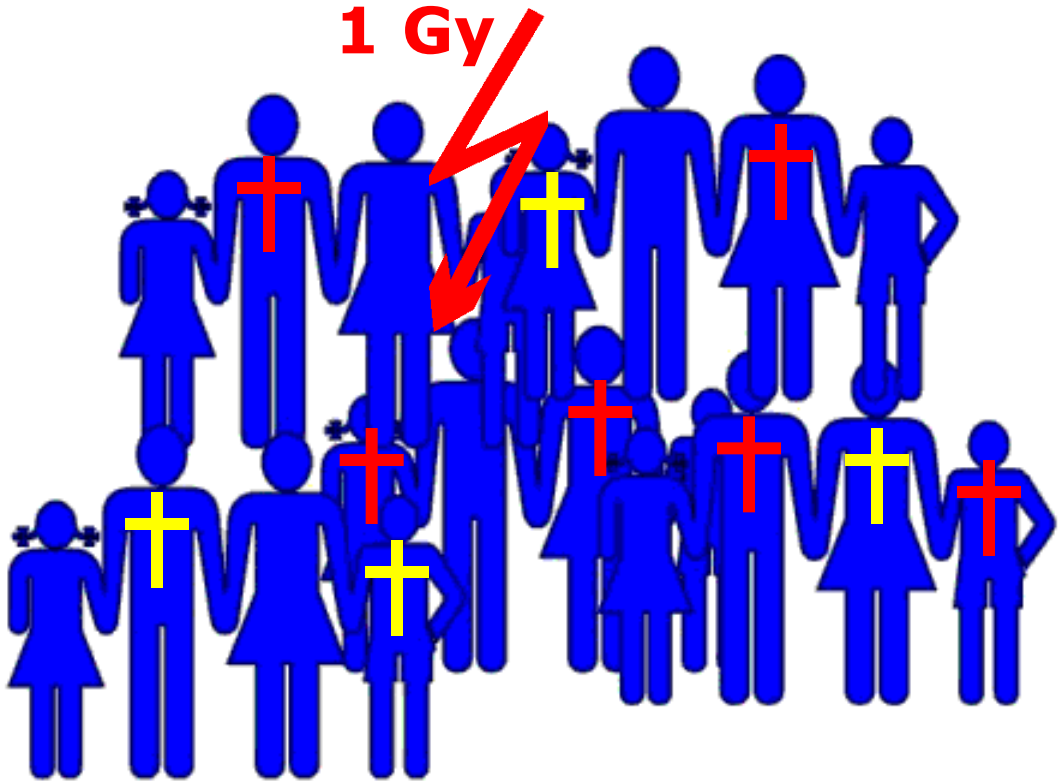
- The lesion appeared shortly after the intervention;
- the temporal sequence of the appearance of reddening, itching followed by skin breakdown within a few weeks and non-healing ulceration at about 6–12 months is characteristic of many radiation burns following high doses;
- the site of the lesion is consistent with a right anterior oblique projection that would be utilized for visualization of the left anterior descending coronary artery;
- a review of the actual images from the procedure showed an exact correlation with anatomical structures underlying this lesion;
- the size of the lesion was consistent with the diameter of the radiation beam used for this procedure.

Stochastic (cancer) effects



tumour

Problem: lack of a biomarker



?

20% spontaneous cancer deaths
10% additional cancer deaths due to 1 Gy

A problem in population studies: Dose

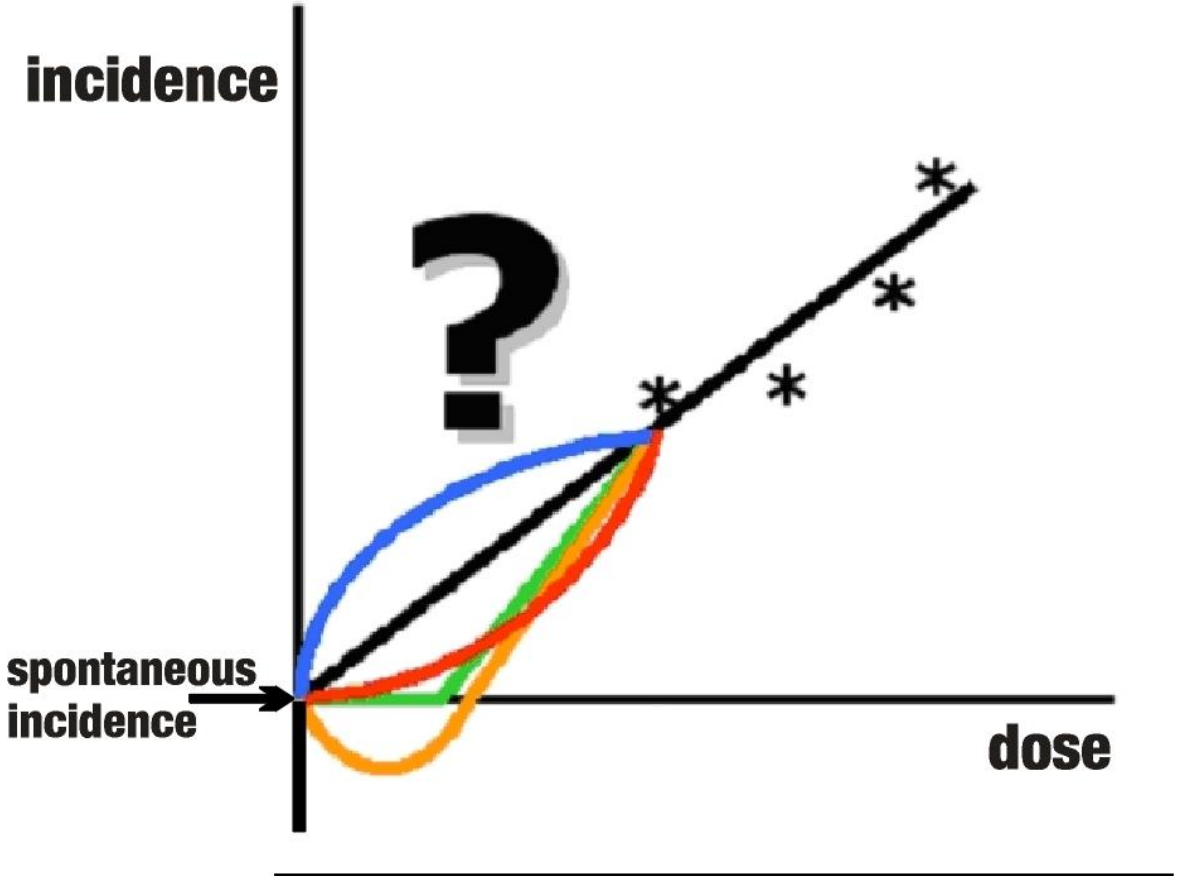
- A serious problem in population studies is to overcome the statistical fluctuations.
- With decreasing dose uncertainty increases (not linearly, but to the square!).
- Thus, it is not surprising that for the general public a statistically significant increase in radiation-induced cancer deaths is seen only from about 100 mSv upwards.

The problem of limited knowledge

- We do not know the frequency of cancer cases well below 100 mSv in occupationally radiation-exposed populations.
- We cannot attribute with certainty a cancer in an individual to radiation.

- But decisions are required in some situations!

Various possibilities of extrapolation from the moderate into the low and very low dose range



Compensation Claims
Deterministic Effects

- The decisions are comparatively easy in the case of deterministic effects:
  - deterministic effects are possible only after severe accidents (high doses required!);
  - frequently, the circumstances of the accident are known;
  - the sequence of health effects is known.

Stochastic Effects

- As there is no biomarker available that unambiguously identifies a radiation-induced malignancy, frequently, the so-called „probability of causation“ is calculated.
- In a strict sense, it is not a „probability“. Therefore, quite often the term „assigned share“ is used.
- The details of the procedure will be outlined by Hajo Zeeb.

Problem

In many cases the major problem in compensation claims is not the calculation of the probability of causation (or assigned share), but the assessment of radiation dose.

Conclusions (1)

- An observed health effect in an individual could be unequivocally attributed to radiation exposure if the individual were to experience deterministic (tissue) effects, and differential pathological diagnosis were achievable that eliminated possible alternative causes.
- Other health effects in an individual that are known to be associated with radiation exposure — such as radiation-inducible malignancies (so-called “stochastic” effects) — cannot be unequivocally attributed to radiation exposure, because
  - radiation exposure is not the only possible cause and
  - there are at present no generally available biomarkers that are specific to radiation exposure.

Conclusions (2)

- An increased incidence of stochastic effects in a population could be attributed to radiation exposure through epidemiological analysis — provided that, inter alia,
  - the increased incidence of cases of the stochastic effect were sufficient to overcome the inherent statistical uncertainties.
- Although demonstrated in animal studies, an increase in the incidence of heritable effects in human populations cannot presently be attributed to radiation exposure; one reason for this is the large fluctuation in the spontaneous incidence of these effects.

Conclusions (3)

- In general, increases in the incidence of health effects in populations cannot be attributed reliably to chronic exposure to radiation at levels that are typical of the global average background levels of radiation.
- The reasons are:
  - the uncertainties associated with the assessment of risks at low doses,
  - the current absence of radiation-specific biomarkers for health effects and
  - the insufficient statistical power of epidemiological studies.
- Therefore, the Scientific Committee does not recommend multiplying very low doses by large numbers of individuals to estimate numbers of radiation-induced health effects within a population exposed to incremental doses at levels equivalent to or lower than natural background levels.

Conclusions (4)

- The Scientific Committee notes that public health bodies need to allocate resources appropriately, and that this may involve making projections of numbers of health effects for comparative purposes.
- This method, though based upon reasonable but untestable assumptions, could be useful for such purposes provided that
  - it were applied consistently,
  - the uncertainties in the assessments were taken fully into account, and
  - it were not inferred that the projected health effects were other than notional.