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Health effects of ionising radiation: Summary of expert meeting in Ulm, Germany, October 19th, 2013

Physicians and scientists have issued a warning about the possible health risks of ionising radiation. Even low doses of about 1 millisievert (mSv) increase the risk of developing radiation-induced diseases. There is no threshold below which radiation could be considered harmless.

On October 19th, 2013, the German and Swiss affiliates of the International Physicians for the Prevention of Nuclear War (IPPNW) invited physicians and scientists from the fields of radiobiology, epidemiology, statistics and physics to an expert meeting in the city of Ulm, the birthplace of Albert Einstein. The participants discussed current scientific evidence relating to the health effects of ionising radiation, especially in the area of low-dose radiation.

The group of experts concluded that a revision of existing radiation protection guidelines is essential in order to reflect the current level of scientific knowledge. Ionising radiation can cause discernible detrimental health effects, some of which can be predicted and quantified using models from epidemiological data. In the past, health risk assessment of ionising radiation has been based on studies performed on survivors of the nuclear bombings of Hiroshima and Nagasaki. However, this reference group can no longer be considered suitable in the light of new statistical evidence. Even very low doses of radiation can cause disease.

1. Even background radiation causes adverse health effects that are measurable

Even low doses of background radiation (from terrestrial and cosmic radiation, inhaled radon and ingested natural radioisotopes) lead to adverse health effects that can be measured in epidemiological studies. It is therefore misleading to claim that radiation exposure can be considered harmless as long as it falls within the dose range of "natural" background radiation.[1-17]

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The conclusions of the Ulm expert meeting are as follows:

1. Even background radiation causes adverse health effects that are measurable;
2. The use of radiation for medical diagnostics causes adverse health effects that are measurable;
3. The use of nuclear energy and the testing of nuclear weapons cause adverse health effects that are measurable;
4. On the basis of epidemiological studies that use the concept of collective dose, health risks of low-dose radiation can be reliably predicted and quantified;
5. The ICRP practice of using studies on Hiroshima and Nagasaki survivors as a basis for determining risk factors for low-dose radiation must be considered outdated;
6. An improved risk-based concept of radiation protection is needed, combined with stringent implementation of the imperative of radiation exposure minimisation

2. The use of radiation for medical diagnostics causes adverse health effects that are measurable

Both computer tomography (CT) and conventional x-ray examinations have been shown to cause increased rates of cancer (most notably breast cancer, leukaemia, thyroid cancer and brain tumours). Children and adolescents are at greater risk than adults, while the embryo is the most vulnerable of all.[18-40]

Reducing the use of diagnostic x-rays and nuclear medicine to the absolute necessitated minimum is urgently recommended. Strict indication guidelines should be adhered to and only low-radiation CT scanners used. Wherever possible, ultrasound or MRI should be preferred.

Certain population groups have an increased risk of developing cancer subsequent to radiation exposure, for example women with a genetic predisposition for breast cancer. Therefore it is recommended that women with such risk should not be included in screenings using x-rays. [41-45]

3. The use of nuclear energy and the testing of nuclear weapons cause adverse health effects that are measurable

Through the use of nuclear weapons (more than 2,000 tests) and severe nuclear accidents, vast quantities of radionuclides have been released and spread widely, exposing large numbers of the world population to increased radiation doses.

Epidemiological studies on the affected populations from around the nuclear weapon test sites in Nevada and Semipalatinsk and from the regions affected by the Chernobyl nuclear disaster show increased rates of morbidity and mortality.[46-54]

Even the normal routine operation of nuclear power plants leads to discernible adverse health effects in the surrounding population. Depending on the distance, higher incidence rates of leukaemia and other forms of cancers in children under five years of age have been found in the vicinity of nuclear power plants. (Currently, the strongest evidence can be found in Germany with consistent results in studies from Switzerland, France and the UK.)[55-59]

Workers occupationally exposed to ionising radiation show significantly higher rates of cancer than other groups, even when official dose limits are not exceeded.[60-64] The health of their children is more damaged than that of other children.[65-64] Employees in uranium mining companies and nuclear weapons' production plants show increased rates of chronic lymphatic leukaemia.[65-68]

Leukaemia and many other forms of cancer have been induced by low doses of ionising radiation, from nuclear weapon testing, nuclear accidents, in regions with increased background radiation or through diagnostic radiological procedures and occupational exposure.[69-92]

As a result of low-dose exposure to radioactive iodine, thyroid disease - including cancer – has been observed in children, adolescents and adults.[93-99] Furthermore, low-dose ionising radiation causes severe non-malignant diseases such as meningioma and other benign tumour entities, cardiovascular, cerebrovascular, respiratory, gastrointestinal and endocrinological disease and disorders, psychiatric conditions, as well as cataracts.[100-113]

Studies have also been able to show that in-utero and childhood exposure of the brain to ionising radiation leads to impaired cognitive development. Potential sources of radiation are, amongst others, diagnostic x-rays, radiation therapy and radiation exposure through nuclear accidents.[114-116]

Subsequent to nuclear accidents, teratogenic effects have been observed both in animals and humans, even those only exposed to low levels of radiation.[117-120] Some genetic effects can already be seen in the first generation of descendants, others only begin to appear in following generations. The latter may therefore be difficult to confirm. Numerous studies carried out in the "death zones" of Chernobyl and Fukushima on animals that have a high generational turnover show severe genetic defects that can be associated with the level of radiation exposure in their habitat. In humans, such defects have long been observed following low-dose radiation exposure. Transgenerational, i.e. genetically fixed radiation effects, have been frequently documented, for example in the children of Chernobyl 'liquidators'.[121-128] Numerous other studies also suggest genetic or epigenetic long-term damage caused by ionising radiation.[129-146]

4. On the basis of epidemiological studies that use the concept of collective dose, health risks of low-dose radiation can be reliably predicted and quantified

The concept of collective dose is the current evidence-based school of scientific thought used for quantitatively predicting stochastic radiation risk. Extensive new clinical studies confirm the linear-no-threshold model, which states that there is no lowest dose threshold of radiation, below which no health effects can be expected.[147,148]

When using the collective dose concept, while taking current scientific studies into consideration, the following risk factors (excess absolute risk, EAR)* should be applied:

A risk factor of 0.2/Sv should be applied for predicting mortality from cancer and 0.4/Sv for incidence of cancer.[149-151] The UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the International Commission on Radiological Protection (ICRP) still adhere to low risk factors of 0.05/Sv for cancer mortality and 0.1/Sv for cancer incidence. The World Health Organization (WHO), meanwhile, has recognized in their 2013 Fukushima Health Risk Assessment that ICRP recommended risk factors should be doubled.[152]

The risk factors mentioned above pertain to an exposed population with normal age distribution. However, according to ICRP, the sensitivity to ionising radiation in young children (< 10 years of age) and foetuses is higher than in adults by a factor of 3.[153-155]

The risk factors for predicting incidence and mortality of non-malignant physical disorders (non-cancerous disease), in particular cardiovascular diseases, are of the same order as for malignant diseases.[156,157]

It is recommended that WHO and national radiation protection institutions adopt the above-mentioned risk factors as a basis for health risk assessments following nuclear accidents.

5. The ICRP practice of basing risk factors for low-dose radiation on studies on Hiroshima and Nagasaki survivors must be considered outdated

Institutions such as the ICRP have been using the survivors of the nuclear bombings of Hiroshima and Nagasaki as a reference for predicting health effects of radiation in their research. Prediction of risk on this basis is not transferable to other populations exposed over a long period of time to increased radiation levels for the following reasons:

The Japanese survivors were exposed briefly to penetrating, high-energy gamma radiation. Radiobiological research has shown that such exposure is less damaging to tissue than internal alpha or beta irradiation following the incorporation of radionuclides. The same is true for long-term exposure to x-rays or gamma-rays through natural or artificial sources at dose levels comparable to normal back-ground radiation.[158,159]

The ionising radiation released by nuclear bombs had an extremely high dose rate. Earlier, it was assumed that the mutagenicity would therefore be higher than that of lower dose rates. ICRP currently claims that this assertion still holds and divides the risk for developing cancer by a factor of 2 in their figures. Studies on occupationally exposed cohorts contradict this assumption and the WHO also no longer sees any justification for halving the risk factor.[160,161]

The radiation dose acquired through radioactive fallout and neutron activation was not taken into consideration by the Radiation Effects Research Foundation (RERF), despite the fact that these caused significant effects in the survivors of Hiroshima and Nagasaki. The actual radiation-induced effects were subsequently underestimated.[162]

Because the RERF first began its work in 1950, important data from the first five years after the nuclear bombings are missing. It should therefore be assumed that the assessment of teratogenic and genetic effects, as well as cancers with short latency periods, is incomplete.

Due to the catastrophic situation after the nuclear bombings of Hiroshima and Nagasaki, it has to be assumed that those that survived were a select cohort of the especially resilient („survival of the fittest“). Therefore those studied were not representative of a normal population. This selection bias has led to an underestimation of the radiation risk by approximately 30%.[163]

The survivors of the nuclear bombings were ostracised by Japanese society. It is very likely that information regarding family origin or morbidity of descendants was withheld or falsified in order not to endanger, for example, the offspring's chances of marriage and social integration.[164]

*Note by the editors: The risk factors used in the concept of collective dose describe the probability that due to radiation-induced carcinogenesis, the cancer incidence or cancer mortality rate increases above the base-line rate in a given population. Usually this excess absolute risk (EAR) is presented in the unit 1/Sv.

A risk factor (EAR) of 0.2/Sv for cancer mortality means that an irradiation of 1 Sv would cause an excess risk of 20% of death from cancer – in addition to the base-line risk of 25%. An EAR of 0.2/Sv corresponds to an excess relative risk (ERR) of 0.2/0.25=0.8/Sv .

6. An improved risk-based concept of radiation protection is needed, combined with stringent implementation of the imperative of radiation exposure minimisation

Determining how much radiation-induced health risk can be considered acceptable and reasonable can only be decided on a societal level, including the voice of those affected. To protect people, the risks of ionising radiation should be assessed as accurately as possible, and presented in an understandable fashion. Such criteria for radiation protection are being adopted increasingly in the medical field.

A risk-based concept for assessing the dangers of ionising radiation can help to reduce harmful effects, also at low dose rates. Together with the legal minimisation requirements, a concrete set of measures in the framework of such a concept could serve to further lower radiation-associated risks. The existing German Risk Acceptance Concept for Carcinogenic Hazardous Substances can serve as a good example in this regard.[165-169]

The protection of unborn life and the genetic integrity of future generations should be given highest priority. Radiation protection must therefore supplement adult-based models and realign them to the particular vulnerability of the embryo and the child.

Speakers and participants of the expert meeting in Ulm, October 19th, 2013:

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