IPPNW-Information

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Health effects of ionising radiation

Summary of expert meeting in Ulm, Germany on October 19th, 2013

Physicians and scientists are warning the population about the health effects of ionising radiation. Even low doses of about 1 millisievert (mSv) can increase the risk of radiation-induced diseases such as cancer. No threshold exists below which radiation can be considered to be 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 a meeting in the city of Ulm, the birthplace of Albert Einstein. At that meeting, 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 health effects, some of which can be predicted and quantified using models from epidemiological data. In the past, health risk assessments of ionising radiation were 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 light of new statistical evidence. Even very low doses of radiation can cause disease.

The conclusions of the Ulm expert meeting are as follows:

1) Even background radiation causes measurable health effects

2) The use of radiation for medical diagnostics also causes measurable health effects

3) The use of nuclear energy and the testing of nuclear weapons also cause measurable health effects

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

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of basing risk factors for low-dose radiation on studies of Hiroshima and Nagasaki survivors must be considered outdated

6) An improved risk-based concept of radiation protection is needed, combined with stringent implementation of concepts to minimize radiation exposure

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1) Even background radiation causes measurable health effects

Even low doses of background radiation (from terrestrial and cosmic radiation, inhaled radon and ingested natural radioisotopes) lead to detrimental 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]

2) The use of radiation for medical diagnostics also causes measurable health effects

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 has the highest vulnerability.[18-40]

Reducing the use of diagnostic X-rays and nuclear medicine to the absolute minimum is urgently recommended. Strict indication guidelines should be adhered to and only low-dose CT equipment 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 factors should not be included in screenings using x-rays. [41-45]

3) The use of nuclear energy and the testing of nuclear weapons also cause measurable health effects

Through the more than 2,000 nuclear weapons tests and severe nuclear accidents, vast quantities of radionuclides have been distributed around the globe, exposing large populations to increased radiation doses.

Epidemiological studies on the affected populations 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 event-free routine operation of nuclear power plants leads to discernible health effects in the surrounding population. Childhood leukaemia and other forms of childhood cancers show higher incidence rates in populations living in the vicinity of nuclear power plants, with a clear correlation between cancer risk and the distance to the plant. The strongest evidence comes from a German study, 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] Their children show a higher incidence of birth defects, leukaemia and lymphoma than other children.[65-68]

Leukaemia and many other forms of cancer can be 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, can be 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, 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 who were only exposed to low levels of radiation.[117-120] Some genetic effects occur 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 and using 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 for quantitatively predicting stochastic radiation risk. Extensive new clinical studies confirm the linear-no-threshold model, which states that there is no lower threshold dose of radiation, below which no health effects can be expected.[147,148]

Using the collective dose concept and taking into consideration current scientific studies, the following risk factors (excess absolute risk, EAR)[*] should be used:

- 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 their 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's 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 disease, 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.

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[*] 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% to die of cancer – in addition to the base-line risk of 25%. An EAR of 0.2/Sv therefore corresponds to an excess relative risk (ERR) of 0.2/0.25=0.8/Sv.

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

Institutions such as ICRP have been using the survivors of the nuclear bombings of Hiroshima and Nagasaki as reference group for predicting health effects of radiation. Risk predictions on this basis are not transferrable to other populations exposed over a long 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 chronic internal alpha or beta irradiation following the incorporation of radionuclides. The same is true for chronic exposure to x-rays or gamma-rays from natural or artificial sources at dose levels comparable to normal background radiation.[158, 159]

- The ionising radiation released by the 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. Studies on occupationally exposed cohorts contradict this assumption and the WHO also no longer sees any justification for dividing the risk factor by half. [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 therefore 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 who survived were a select cohort of the especially resilient („survival of the fittest“) and 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 the offspring's chances of marriage and social integration. [164]

6) An improved risk-based concept of radiation protection is needed, combined with stringent implementation of concepts to minimize radiation exposure

In order to determine which amount of radiation associated health risks can be considered acceptable, a public debate is needed that includes the voices of those affected. To protect people, the risks of ionising radiation should be assessed as accurately as possible and presented in an understandable fashion. In the medical field, such criteria for radiation protection have been adopted in recent years.

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 minimization 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 take into consideration the increased vulnerability of the embryo and the young child.

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