

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



Foto: Ian Thomas Ash, documentingian.com

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 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 accident.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 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.

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 background 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:

- » **Prof. Dr. rer. nat. Inge Schmitz-Feuerhake**, Professor emer. for Experimental Physics at the University of Bremen, Germany, member of the scientific council of IPPNW.de
- » **Dr. Hartmut Heinz**, MD specialising in occupational medicine, former Chief Medical Officer at Salzgitter AG (steel company), member of the nuclear energy working group of IPPNW.de
- » **Dr. Angelika Claußen**, MD specialising in psychotherapy, Bielefeld, Germany, member of the nuclear energy working group of IPPNW.de
- » **Dr. Winfrid Eisenberg**, MD, former Head of the Pediatric Clinic in Herford, Germany, member of the nuclear energy working group of IPPNW.de
- » **Dr. Claudio Knüsli**, MD, Medical Oncologist at St. Clara Hospital in Basel, Switzerland, member of the Board of Directors of IPPNW.ch
- » **Dr. Helmut Lohrer**, MD General Practitioner, Villingen, Germany, member of the IPPNW International Board of Directors, International Councillor of IPPNW.de
- » **Henrik Paulitz**, biologist, Seeheim, Germany, nuclear energy expert of IPPNW.de
- » **Dr. Alex Rosen**, MD, specialising in pediatrics, Berlin, member of the Board of Directors of IPPNW.de
- » **Dr. Jörg Schmid**, MD, specialising in psychotherapy from Stuttgart, Germany, member of the nuclear energy working group of IPPNW.de
- » **Reinhold Thiel**, MD, General Practitioner, Ulm, Germany, leader of the Ulmer Ärzteinitiative, member of the nuclear energy working group of IPPNW.de
- » **Prof. Dr. Wolfgang Hoffmann**, MD, MPH, Professor of Population-based Epidemiology and Community Health, Institute for Community Medicine, University Hospital of Greifswald, Germany
- » **Dr. rer. nat. Alfred Körblein**, physicist and independent scientist, Nuremberg, Germany, member of the scientific council of IPPNW.de
- » **Prof. Dr. Dr. h.c. Edmund Lengfelder**, MD, Professor emer. of the Institute for Radiobiology of the Medical University of Munich, Germany, Director of the Otto Hug Radiation Institute for Health and the Environment
- » **Dr. rer. nat. Hagen Scherb**, mathematician, Helmholtz Centre, German Research Centre for Health and the Environment in Munich, Germany

References:

- 1 Kochupillai N, Verma IC, Grewal MS, Remalingaswami Y: Down's syndrome and related abnormalities in an area of high background radiation in coastal Kerala. *Nature* 1976, 262, 60-61
- 2 Lyman GH, Lyman CG, Johnson W: Association of leukemia with radium groundwater contamination. *JAMA* 1985, 254, 621-626
- 3 Flodin U, Fredriksson M, Persson B, Hardell L: Background radiation, electrical work and some other exposures associated with acute myeloid leukemia in a case-referent study. *Arch Environ Health* 1986, 41, 77-84
- 4 Knox EG, Stewart AM, Gilman EA, Kneale GW: Background radiation and childhood cancers. *J Radiol Prot* 1988, 8, 9-18
- 5 Henshaw DL, Eatough JP & Richardson RB: Radon as a causative factor in induction of myeloid leukaemia and other cancers. *Lancet* 1990, 28, 1008-1012
- 6 Darby S, Hill D, Auvinen A, Barros-Dios JM et al.: Radon in homes and risk of lung cancer: collaborative analysis of individual data from 13 European case-control studies. *BMJ* 2005, Jan. 29, 330 (7485) 223-228
- 7 WHO: Radon and cancer. Fact sheet N°291, September 2009
- 8 Körblein A: Zunahme von Krebs und Säuglingssterblichkeit mit der natürlichen Hintergrundstrahlung in Bayern. *Strahlentelex* 2003, 404/405 (17), 1-4
- 9 Kendall G, Murphy M: Natural environmental radiation and childhood cancer. *Environmental Radon Newsletter* 2007 (52), Childhood Cancer Research Group, University of Oxford
- 10 Kendall G, Little MP, Wakeford R: Numbers and proportion of leukemias in young people and adults induced by radiation of natural origin. *Leuk Res* 2011, 35, 1039-1045
- 11 Kendall G, Little MP, Wakeford R, Bunch KJ et al.: A record-based case-control study of natural background radiation and the incidence of childhood leukaemia and other cancers in Great Britain during 1980 – 2006. *Leukemia* 2013, 27, 3-9
- 12 Menzler S, Schaffrath-Rosario A, Wichmann HE, Kreienbrock L: Abschätzung des attributablen Lungenkrebsrisikos in Deutschland durch Radon in Wohnungen. *Ecomed* 2006
- 13 Gray A, Read S, McGale, P, Darby S.: Lung cancer deaths from indoor radon and the cost effectiveness and potential of policies to reduce them. *BMJ*, 2009, 338, a3110
- 14 Krewski D, Lubin JH, Zielinski JM, Alavanja M et al.: Residential Radon and Risk of Lung Cancer – a Combined Analysis of 7 North American Case-Control Studies. *Epidemiol* 2005, 16, 137-145
- 15 Huch R, Burkhard W: Kosmische Strahlenbelastung beim Fliegen, Risiko für die Schwangerschaft? *Perinat Med* 1992, 4, 67-69
- 16 Huch R: Fliegen während der Schwangerschaft. *Gynäkologe* 2001, 34, 401-407
- 17 Bundesamt für Strahlenschutz: Strahlenthemen – Höhenstrahlung und Fliegen, Salzgitter 2013 www.bfs.de
- 18 Berrington de Gonzalez A, Darby S: Risk of cancer from diagnostic X-rays: estimates for the UK and 14 other countries. *Lancet* 2004; 363(9406):345-351
- 19 Smith-Bindman R, Lipson J, Marcus R, Kim KP et al.: Radiation dose associated with common computed tomography examinations and the associated lifetime attributable risk of cancer. *Arch Intern Med* 2009, 169(22), 2078-2086
- 20 Berrington de Gonzales A, Mahesh M, Kim KP, Bhargavan M et al.: Projected cancer risks from computed tomographic scans performed in the United States in 2007. *Arch Intern Med* 2009, 169(22), 2071-2077
- 21 Doody MM, Lonstein JE, Stovall M, Hacker DG et al.: Breast cancer mortality after diagnostic radiography: findings from the U.S. Scoliosis Cohort Study. *Spine (Phila Pa 1976)* 2000, 25(16), 2052-2063
- 22 Pearce MS, Salotti JA, Little MP, McHugh K et al.: Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study. *Lancet* 2012, 380, 499-505
- 23 Heyes GJ, Mill AJ, Charles MW: Enhanced biological effectiveness of low energy X-rays and implications for the UK breast screening programme. *Br J Radiol* 2006, 79(939), 195-200
- 24 Memon A, Godward S, Williams D, Siddique I, Al-Saleh K: Dental x-rays and the risk of thyroid cancer: a case-control study. *Acta Oncol*, 2010, 49 (4), 447-453
- 25 Brenner DJ: Should we be concerned about the rapid increase in CT usage? *Rev Environ Health* 2010, 25 (1), 63-68
- 26 Brenner DJ, Hall EJ: Cancer risks from CT scans: Now we have data, what next? *Radiology* 2012, 265, 330-331
- 27 Schonfeld SJ, Lee C, Berrington de Gonzales A: Medical exposure to radiation and thyroid cancer. *Clin Oncol* 2011, 23 (4), 244-250

- 28 Pearce MS, Salotti JA, Little MP, Mc Hugh K et al.: Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumors: a retrospective cohort study. *Lancet* 2012, 380 (9840), 499-505
- 29 Miglioretti DL, Johnson E, Williams A, Greenlee RT et al.: The use of computed tomography in pediatrics and the associated radiation exposure and estimated cancer risk. *JAMA Pediatr* 2013, Jun 10:1-8.doi: 10.1001/jamapediatrics.2013.311 (Expub ahead of print)
- 30 Mathews JD, Forsythe AV, Brady Z, Butler MW et al.: Cancer risk in 680.000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians. *BMJ* 2013, 346:12360.doi: 10.1136/bmj.12360
- 31 Morin Doody M, Lonstein JE, Stovall M, Hacker DG et al.: Breast cancer mortality after diagnostic radiography: findings from the U.S. Scoliosis Cohort Study. *Spine* 2000, 25, 2052-2063
- 32 Nienhaus A, Hensel N, Roscher G, Hubracht M et al.: Hormonelle, medizinische und lebensstilbedingte Faktoren und Brustkrebsrisiko. *Geburtsh Frauenheilk* 2002, 62, 242-249
- 33 Kuni H, Schmitz-Feuerhake I, Dieckmann H: Mammographiescreening – Vernachlässigte Aspekte der Strahlenrisikobewertung. *Gesundheitswesen* 2003, 65, 443-446
- 34 Hill DA, Preston-Martin S, Ross RK, Bernstein L: Medical radiation, family history of cancer, and benign breast disease in relation to breast cancer risk in young women. *Cancer Causes Control* 2002, 13, 711-718
- 35 Infante-Rivard C: Diagnostic X-rays, DNA repair genes and childhood acute lymphoblastic leukemia. *Health Phys* 2003, 85, 60-64
- 36 Preston-Martin S, Thomas DC, Yu MC, Henderson BE: Diagnostic radiography as a risk factor for chronic myeloid and monocytic leukaemia (CML). *Brit J Cancer* 1989, 59, 639-644
- 37 Wingren G, Hallquist A, Hardell L: Diagnostic X-ray exposure and female papillary thyroid cancer: a pooled analysis of two Swedish studies. *Eur J Cancer Prev.* 1997, 6, 550-556
- 38 Preston-Martin S, White SC: Brain and salivary gland tumors related to prior dental radiography: implications for current practice. *J Am Dental Ass* 1990, 120, 151-158
- 39 Neuberger JS, Brownson RC, Morantz RA, Chin TD: Association of brain cancer with dental X-rays and occupation in Missouri. *Cancer Detect Prev* 1991, 15, 31-34
- 40 Stewart A, Webb J, Hewitt D: A survey of childhood malignancies. *BMJ* 1958, 5086, 1459-1508
- 41 Kuni H, Schmitz-Feuerhake I, Dieckmann H: Mammographiescreening – Vernachlässigte Aspekte der Strahlenrisikobewertung. *Gesundheitswesen* 2003, 65, 443-446
- 42 Smith-Bindman R, Lipson J, Marcus R, Kim KP et al.: Radiation dose associated with common computed tomography examinations and the associated lifetime attributable risk of cancer. *Arch Intern Med* 2009, 169(22), 2078-2086
- 43 Heyes GJ, Mill AJ, Charles MW: Enhanced biological effectiveness of low energy X-rays and implications for the UK breast screening programme. *Br J Radiol* 2006, 79(939), 195-200
- 44 Pijpe A, Andrieu N, Easton DF, Kesminiene A et al.: Exposure to diagnostic radiation and risk of breast cancer among carriers of BRCA1/2 mutations: retrospective cohort study (GENE-RAD-RISK). *BMJ* 2012, 345, e5660
- 45 Stewart A, Webb J, Hewitt D: A survey of childhood malignancies. *BMJ* 1958, 5086, 1459-1508
- 46 Mangano J, Sherman J: Elevated In Vivo Strontium-90 from Nuclear Weapons Test Fallout among Cancer Decedents. *Int J Health Serv* 2011, 41, 137-158
- 47 Knapp HA: Iodine-131 in Fresh Milk and Human Thyroids Following a Single Deposition of Nuclear Test Fall-Out. *Nature* 1964, 202, 534-537
- 48 National Cancer Institute: Estimated exposure and thyroid doses received by the American people from iodine-131 fallout following Nevada atmospheric nuclear bomb tests. www.cancer.gov/i131/fallout/
- 49 Institute of Medicine: Exposure of the American people to Iodine-131 from Nevada nuclear-bomb tests. National Academy Press. 1999
- 50 Kassenova T: The lasting toll of Semipalatinsk's nuclear testing. *Bulletin of the Atomic Scientists*, 2009
- 51 Cardis E, Krewski D, Boniol M, Drozdovitch V et al.: Estimates of the cancer burden in Europe from radioactive fallout from the Chernobyl accident. *Int J Cancer* 2006, 119, 1224–1235
- 52 Körblein A, Küchenhoff H: Perinatal mortality in Germany following the Chernobyl accident. *Radiat Environ Biophys* 1997, 36(1), 3-7
- 53 Körblein A: Perinatal mortality in West Germany following atmospheric nuclear weapons tests. *Arch Environ Health* 2004, Nov, 59 (11), 604-9.
- 54 Körblein A: Strontium fallout from Chernobyl and perinatal mortality in Ukraine and Belarus. *Radiats Biol Radioecol* 2003, 43(2),197-202

- 55 Kaatsch P, Spix C, Schmiedel S, Schulze-Rath R et al.: Epidemiologische Studie zu Kinderkrebs in der Umgebung von Kernkraftwerken (KiKK-Studie). Vorhaben 3602S04334, Deutsches Kinderkrebsregister, Mainz, Herausgegeben vom Bundesamt für Strahlenschutz (BfS), Salzgitter, 2007.
- 56 Spycher BD, Feller M, Zwahlen M, Rösli M et al.: Childhood cancer and nuclear power plants in Switzerland: a census-based cohort study. *Int J Epidemiol* 2011, doi: 10.1093/ije/dyr115
- 57 Committee on Medical Aspects of Radiation in the Environment (COMARE): FOURTEENTH REPORT. Further consideration of the incidence of childhood leukaemia around nuclear power plants in Great Britain. Chairman: Professor A Elliott, 2011, http://www.comare.org.uk/press_releases/documents/COMARE14report.pdf
- 58 Bithell JF, Keegan TJ, Kroll ME, Murphy MF et al.: Childhood Leukaemia near British nuclear Installations: Methodological issues and recent results. *Radiat Prot Dosimetry* 2008, 1-7
- 59 Koerblein A, Fairlie I.: French Geocap study confirms increased leukemia risks in young children near nuclear power plants. *Int J Cancer* 2012, 131(12), 2970-1
- 60 Cardis E, Vrijheid M, Blettner M, Gilbert E et al.: The 15-Country Collaborative Study of Cancer Risk among Radiation Workers in the Nuclear Industry: estimates of radiation-related cancer risks. *Radiat Res* 2007, 167, 396-416
- 61 Zielinski JM, Shilnikova N, Krewski D: Canadian National Dose Registry of Radiation Workers: overview of research from 1951 through 2007. *Int J Occup Med Environ Health* 2008, 21, 269-275
- 62 Wiesel A, Spix C, Mergenthaler A, Queißer-Luft A: Maternal occupational exposure to ionizing radiation and birth defects. *Radiat Environ Biophys* 2011, 50, 325-328
- 63 McKinney PA, Alexander FE, Cartwright RA, Parker L: Parental occupations of children with leukaemia in west Cumbria, north Humberside, and Gateshead. *BMJ* 1991, 302, 681-687
- 64 Dickinson HO, Parker L: Leukaemia and non-Hodgkin's lymphoma in children of male Sellafield radiation workers. *Int J Cancer* 2002, 99, 437-444
- 65 Richardson DB, Wing S, Schroeder J, Schmitz-Feuerhake I et al.: Ionizing radiation and chronic lymphocytic leukemia. *Environ Health Perspect* 2005, 113(1), 1-5
- 66 Möhner M, Lindtner M, Otten H, Gille H-G: Leukemia and Exposure to Ionizing Radiation Among German Uranium Miners. *Am J Ind Med* 2006, 49, 238-248
- 67 Hamblin TJ: Have we been wrong about ionizing radiation and chronic lymphocytic leukemia? *Leuk Res* 2008, 32(4), 523-525
- 68 Rericha V, Kulich M, Rericha R, Shore DL et al.: Incidence of leukemia, lymphoma, and multiple myeloma in Czech uranium miners: a case-cohort study. *Environ Health Perspect* 2006, 114(6), 818-822
- 69 Flodin U, Fredriksson M, Hardell L, Axelson O: Background radiation, electrical work and some other exposures associated with acute myeloid leukemias in a case-referent study. *Arch. Environ. Health* 1986, 41, 77-84
- 70 Knox EG, Stewart AM, Gilman EA, Kneale GW: Background radiation and childhood cancers. *J. Radiol. Prot.* 1988, 8, 9-18
- 71 Henshaw DL, Eatough JP & Richardson RB: Radon as a causative factor in induction of myeloid leukaemia and other cancers. *Lancet* 1990, 28, 1008-1012
- 72 Darby S, Hill D, Auvinen A, Barros-Dios JM et al.: Radon in homes and risk of lung cancer: collaborative analysis of individual data from 13 European case-control studies. *Brit. Med. J.* 2005, Jan.29, 330 (7485) 223-228 WHO Radon and cancer. Fact sheet N°291, September 2009
- 73 Kendall G, Murphy M: Natural environmental radiation and childhood cancer. *Environmental Radon Newsletter* 2007 (52), Childhood Cancer Research Group, University of Oxford
- 74 Kendall G, Little MP, Wakeford R: Numbers and proportion of leukemias in young people and adults induced by radiation of natural origin. *Leuk Res* 2011, 35, 1039-1045
- 75 Menzler S, Schaffrath-Rosario A, Wichmann HE, Kreienbrock L: Abschätzung des attributablen Lungenkrebsrisikos in Deutschland durch Radon in Wohnungen. *Ecomed* 2006
- 76 Huch R, Burkhard W: Kosmische Strahlenbelastung beim Fliegen, Risiko für die Schwangerschaft? *Perinat Med* 1992, 4, 67-69
- 77 Brenner DJ: Should we be concerned about the rapid increase in CT usage? *Rev Environ Health* 2010, 25 (1), 63-68
- 78 Pearce MS, Salotti JA, Little MP, Mc Hugh K et al.: Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumors: a retrospective cohort study. *The Lancet* 2012, 380 (9840), 499-505

- 79 Miglioretti DL, Johnson E, Williams A, Greenlee RT et al.: The use of computed tomography in pediatrics and the associated radiation exposure and estimated cancer risk. *JAMA Pediatr* 2013, Jun 10:1-8.doi: 10.1001/jamapediatrics.2013.311 (Expub ahead of print)
- 80 Morin Doody M, Lonstein JE, Stovall M, Hacker DG et. al.: Breast cancer mortality after diagnostic radiography: findings from the U.S. Scoliosis Cohort Study. *Spine* 2000, 25, 2052-2063
- 81 Nienhaus A, Hensel N, Roscher G, Hubracht M et. al.: Hormonelle, medizinische und lebensstilbedingte Faktoren und Brustkrebsrisiko. *Geburtsh. Frauenheilk.* 2002, 62, 242-249
- 82 Kuni H, Schmitz-Feuerhake I, Dieckmann H: Mammographiescreening – Vernachlässigte Aspekte der Strahlenrisikobewertung. *Gesundheitswesen* 2003, 65, 443-446
- 83 Infante-Rivard C: Diagnostic x rays, DNA repair genes and childhood acute lymphoblastic leukemia. *Health Phys.* 2003, 85, 60-64
- 84 Preston-Martin S, Thomas DC, Yu MC, Henderson BE: Diagnostic radiography as a risk factor for chronic myeloid and monocytic leukaemia (CML). *Brit. J. Cancer* 1989, 59, 639-644
- 85 Wingren G, Hallquist A, Hardell L: Diagnostic X-ray exposure and female papillary thyroid cancer: a pooled analysis of two Swedish studies. *Eur. J. Cancer Prev.* 1997, 6, 550-556
- 86 Preston-Martin S, White SC: Brain and salivary gland tumors related to prior dental radiography: implications for current practice. *J. Am. Dental. Ass.* 1990, 120, 151-158
- 87 Neuberger JS, Brownson RC, Morantz RA, Chin TD: Association of brain cancer with dental x-rays and occupation in Missouri. *Cancer Detect. Prev.* 1991, 15, 31-34
- 88 Cardis E, Vrijheid M, Blettner M, Gilbert E et. al.: The 15-Country Collaborative Study of Cancer Risk among Radiation Workers in the Nuclear Industry: estimates of radiation-related cancer risks. *Radiat. Res.* 2007, 167, 396-416
- 89 Zielinski JM, Shilnikova N, Krewski D: Canadian National Dose Registry of Radiation Workers: overview of research from 1951 through 2007. *Int. J. Occ. Med. Environ. Health* 2008, 21, 269-275
- 90 Wiesel A, Spix C, Mergenthaler A, Queißer-Luft A: Maternal occupational exposure to ionizing radiation and birth defects. *Radiat. Environ. Biophys.*, 2011, 50, 325-328
- 91 Hillis DM: Life in the hot zone around Chernobyl, *Nature* 1996, 380, 665-708
- 92 Im Kontext: Lyman GH, Lyman CG, Johnson W: Association of leukemia with radium groundwater contamination. *J. Am. Med. Ass.* 1985, 254, 621-626
- 93 Imaizumi M, Usa T, Tominaga T, Neriishi K et al.: Radiation dose-response relationships for thyroid nodules and autoimmune thyroid diseases in Hiroshima and Nagasaki atomic bomb survivors 55-58 years after radiation exposure. *JAMA* 2006, 295(9), 1011-1022
- 94 Völzke H, Werner A, Wallaschofski H, Friedrich N et al.: Occupational exposure to ionizing radiation is associated with autoimmune thyroid disease. *J Clin Endocrinol Metab* 2005, 90(8), 4587-4592
- 95 Cardis E, Howe G, Ron E, Bebeshko V et al.: Cancer consequences of the Chernobyl accident: 20 years on. *J Radiol Prot* 2006, 26(2), 127-140
- 96 Hamilton TE, van Belle G, LoGerfo JP: Thyroid neoplasia in Marshall islanders exposed to nuclear fallout. *JAMA* 1987, 258, 629-636
- 97 Hamilton PG, Chiacchierini RP, Kaczmarek RG: A follow-up study of persons who had Iodine-131 and other diagnostic procedures during childhood and adolescence. U.S. Dept. Health and Human Services, Public Health Service, Rockville, Maryland 20857, August 1989
- 98 Mürbeth S, Rousarova M, Scherb H, Lengfelder E: Thyroid cancer has increased in the adult populations of countries moderately affected by Chernobyl fallout. *Med Sci Monit* 2004, 10, 300-306
- 99 Cardis E., Kesminiene A, Ivanov V, Malakhova I et al.: Risk of thyroid cancer after exposure to 131-I in childhood. *J Natl Cancer Inst* 2005, 97, 724-732
- 100 Preston-Martin S, White SC: Brain and salivary gland tumors related to prior dental radiography: implications for current practice. *J Am Dental Ass* 1990, 120, 151-158
- 101 Longstreth WTJr, Phillips LE, Drangsholt M, Koepsell TD et al.: Dental X-rays and the risk of intracranial meningioma: a population-based case-control study. *Cancer* 2004, 100, 1026-1034
- 102 Claus EB, Calvocoressi L, Bondy ML et al. Dental x-rays and risk of meningioma. *Cancer* 2012; 118: 4530-4537
- 103 Rodvall Y, Ahlbom A, Pershagen G, Nylander M et al.: Dental radiography after age 25 years, amalgam fillings and tumours of the central nervous system. *Oral Oncol* 1998, 34, 265-269
- 104 Zielinski JM, Ashmore P, Band P, Jiang H et al.: Low dose ionizing radiation exposure and cardiovascular disease mortality: cohort study based on Canadian national dose registry for radiation workers. *Int J Occup Med Environ Health* 2009, 22, 27-33

- 105 Little MP, Azizova TV, Bazyka D, Bouffler SD et al.: Systematic review and meta-analysis of circulatory disease from exposure to low-level ionizing radiation and estimates of potential population mortality risks. *Environ Health Perspect* 2012, 120, 1503-1511
- 106 Arizova TV, Muirhead CR, Druzhinina MB, Grigoryeva ES et al.: Cerebrovascular diseases in the cohort of workers first employed at Mayak PA in 1948-1958. *Radiat Res* 2010, 174, 851-864
- 107 McGeoghegan D, Binks K, Gilles M, Jones S et al.: The non-cancer mortality experience of male workers at British Nuclear Fuels plc, 1946-2005. *Int J Epidemiol* 2008, 37, 506-18
- 108 Lomat L, Galburt G, Quastel MR, Polyakov S et al.: Incidence of childhood disease in Belarus associated with the Chernobyl accident. *Environ. Health Persp* 1997, 105 (Suppl. 6), 1529-1532
- 109 Zalutskaya A, Mokhort T, Garmaev D, Bornstein SR: Did the Chernobyl incident cause an increase in Typ 1 diabetes mellitus incidence in children and adolescents? *Diabetologia* 2004, 47, 147-148
- 110 Loganovsky K, Havenaar JM, Tintle NL, Guey LT et al.: The mental health of clean-up workers 18 years after the Chernobyl accident. *Psychol Med* 2008, 38, 481-488
- 111 Bromet EJ, Havenaar JM, Guey LT: A 25 year retrospective review of the psychological consequences of the Chernobyl accident. *Clin Oncol (R. Coll. Radiol.)*, 2011, 23, 297-305
- 112 Schmitz-Feuerhake I, Pflugbeil S: Strahleninduzierte Katarakte (Grauer Star) als Folge berufsmäßiger Exposition und beobachtete Latenzzeiten. *Strahlentelex* 2006, 456-457, 1-7
- 113 Chodick G, Bekiroglu N, Hauptmann M, Alexander BH et al.: Risk of cataract after exposure to low doses of ionizing radiation: a 20-year prospective cohort study among US radiologic technologists. *Am J Epidemiol* 2008, 168(6), 620-631
- 114 Hall P, Adami H-O, Trichopoulos D, Pedersen NL et al.: Effect of low doses of ionising radiation in infancy on cognitive function in adulthood: Swedish population based cohort study. *BMJ* 2004, 328(7430), 19
- 115 Heiervang KS, Mednick S, Sundet K, Rund BR: Effect of low dose ionizing radiation exposure in utero on cognitive function in adolescence. *Scand J Psychology* 2010, 51(3), 210-215
- 116 Heiervang KS, Mednick S, Sundet K, Rund BR: The Chernobyl accident and cognitive functioning: a study of Norwegian adolescents exposed in utero. *Dev Neuropsychol* 2010, 35, 643-655
- 117 Körblein A, Küchenhoff H: Perinatal mortality in Germany following the Chernobyl accident. *Radiat Environ Biophys* 1997, 36(1), 3-7
- 118 Körblein A: Perinatal mortality in West Germany following atmospheric nuclear weapons tests. *Arch Environ Health* 2004, Nov, 59 (11), 604-9.
- 119 Körblein A: Strontium fallout from Chernobyl and perinatal mortality in Ukraine and Belarus. *Radiats Biol Radioecol* 2003, 43(2),197-202
- 120 Busby C, Lengfelder E, Pflugbeil S, Schmitz-Feuerhake I: The evidence of radiation effects in embryos and fetuses exposed to Chernobyl fallout and the question of dose response. *Medicine, Conflict and Survival* 2009, 25, 20-40
- 121 Møller AP, Bonisoli-Alquati A, Rudolfson G, Mousseau TA: Chernobyl birds have smaller brains. 2011 *PloS ONE* 6 (2): e16862.doi:10.1371/journal.pone.0016862
- 122 Møller AP, Mousseau TA: Efficiency of bio-indicators for low-level radiation under field conditions. *Ecol Indic* 2010, doi:10.1016/j.ecolind.2010.06.013
- 123 Bonisoli-Alquati A, Voris A, Mousseau TA, Møller AP et al.: DNA damage in barn swallows (*hirundo rustica*) from the Chernobyl region detected by use of the comet assay. *Comparative Biochemistry and Physiology* 2010, 151 (3), 271-277
- 124 Mousseau TA, Møller AP: Chernobyl and Fukushima: Differences and Similarities – a biological perspective. *Transactions of the American Nuclear Society* 2012, 107, 200
- 125 Sperling K, Pelz J, Wegner RD, Schulzke I et al.: Frequency of trisomy 21 in Germany before and after the Chernobyl accident. *Biomed Pharmacother* 1991, 45, 255-262
- 126 Hillis DM: Life in the hot zone around Chernobyl, *Nature* 1996, 380, 665-708
- 127 Liaginskaia AM, Tukov AR, Osipov VA, Prokhorova ON: Genetic effects in the liquidators of consequences of Chernobyl nuclear power accident. *Radiats Biol Radioecol* 2007, 47, 188-195 (in Russ.)
- 128 Schmitz-Feuerhake I: Genetisch strahleninduzierte Fehlbildungen. *Strahlentelex* 2013, 644-645(27), 1-5
- 129 Scherb H, Weigelt E, Brüske-Hohlfeld I: European stillbirth proportions before and after the Chernobyl accident. *Int J Epidemiol* 1999, 28(5), 932-40
- 130 Scherb H, Weigelt E: Congenital Malformation and Stillbirth in Germany and Europe Before and After the Chernobyl Nuclear Power Plant Accident. *Environ Sci & Pollut Res* 2003, Special Issue 1, 117–125

- 131 Scherb H, Weigelt E: Spaltgeburtenrate in Bayern vor und nach dem Reaktorunfall in Tschernobyl. *Mund-, Kiefer- und Gesichtschirurgie* 2004, 8 106-110(5)
- 132 Scherb H, Voigt K: Trends in the human sex odds at birth in Europe and the Chernobyl Nuclear Power Plant accident, *Reproductive Toxicology* 2007, 23, 593-599
- 133 Kusmierz R, Voigt K, Scherb H: Is the human sex odds at birth distorted in the vicinity of nuclear facilities (NF)? A preliminary geo-spatial-temporal approach. Klaus Greve / Armin B. Cremers (Eds.): *EnviroInfo 2010 Integration of Environmental Information in Europe. Proceedings of the 24th International Conference on Informatics for Environmental Protection Cologne / Bonn, Germany, Shaker Verlag, Aachen 2010, 616-626*
- 134 Scherb H, Voigt K: The human sex odds at birth after the atmospheric atomic bomb tests, after Chernobyl, and in the vicinity of nuclear facilities. *Environ Sci Pollut Res Int* 2011, 18(5), 697-707
- 135 Scherb H, Sperling K: Heutige Lehren aus dem Reaktorunfall von Tschernobyl. *Naturwissenschaftliche Rundschau*, 2011, 64 (5), 229-239
- 136 Sperling K, Neitzel H, Scherb H: Evidence for an increase in trisomy 21 (Down syndrome) in Europe after the Chernobyl reactor accident. *Genet Epidemiol* 2012, 36(1), 48-55
- 137 Scherb H, Kusmierz R, Voigt K: The human sex odds at birth in France – a preliminary geo-spatial-temporal approach in the vicinity of three selected nuclear facilities (NF): Centre de Stockage (CdS) de l'Aube, Institute Laue-Langevin (ILL) de Grenoble, and Commissariat à l'Énergie Atomique (CEA) de Saclay/Paris. Wittmann J, Müller M: *Simulation in Umwelt- und Geowissenschaften – Workshop Leipzig. Shaker Verlag, Aachen 2013, 23-38*
- 138 Ziegłowski V, Hemprich A: Facial cleft birth rate in former East Germany before and after the reactor accident in Chernobyl. *Mund Kiefer Gesichtschir* 1999, 3 (4), 195–9
- 139 Sperling K, Pelz J, Wegner RD, Dorries A et al.: Significant increase in trisomy 21 in Berlin nine months after the Chernobyl reactor accident: temporal correlation or causal relation? *BMJ* 1994, 309,158–162.
- 140 Zatsepin P, Verger P, Robert-Gnansia E, Gagniere B et al.: Cluster of Down's syndrome cases registered in January 1987 in the Republic of Belarus as a possible effect of the Chernobyl accident. *Int J Rad Med* 2004 (Special Issue), 6, 57–71.
- 141 Liaginskaja AM, Tukov AR, Osipov VA, Prokhorova ON: Genetic effects in the liquidators of consequences of Chernobyl nuclear power accident. *Radiats Biol Radioecol* 2007, 47, 188-195 (in Russ.)
- 142 Wertelecki W: Malformations in a Chernobyl-impacted region. *Pediatrics* 2010, 125, 836-843
- 143 Schmitz-Feuerhake I: Genetisch strahleninduzierte Fehlbildungen. *Strahlentext* 2013, 644-645(27), 1-5
- 144 Dubrova YE: Monitoring of radiation-induced germline mutation in humans. *Swiss Med Wkly* 2003, 133, 474-478
- 145 Scherb H, Voigt K: Strahleninduzierte genetische Effekte nach Tschernobyl und in der Nähe von Nuklearanlagen. *Helmholtz Zentrum München, Neuherberg, Okt. 2013.*
- 146 Lazjuk G, Verger P, Gagnière B, Kravchuk Zh et al.: The congenital anomalies registry in Belarus: a tool for assessing the public health impact of the Chernobyl accident. *Reprod Toxicol* 2003, 17, 659-666
- 147 Pearce MS, Salotti JA, Little MP, Mc Hugh K et al.: Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumors: a retrospective cohort study. *Lancet* 2012, 380 (9840), 499-505
- 148 Mathews JD, Forsythe AV, Brady Z, Butler MW et al.: Cancer risk in 680.000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians. *BMJ* 2013, 346:12360.doi: 10.1136/bmj.12360
- 149 Bauer S, Gusev BI, Pivina LM, Apsalikov KN et al.: Radiation exposure due to local fallout from Soviet atmospheric nuclear weapons testing in Kazakhstan: solid cancer mortality in the Semipalatinsk historical cohort, 1960-1999. *Radiat Res.* 2005, 164(4 Pt 1), 409-419
- 150 Körblein A, Hoffmann W: Background radiation and cancer mortality in Bavaria: an ecological analysis. *Arch Environ Occup Health* 2006, 61(3),109-114
- 151 Cardis E, Vrijheid M, Blettner M, Gilbert E et al.: The 15-Country Collaborative Study of Cancer Risk among Radiation Workers in the Nuclear Industry: estimates of radiation-related cancer risks. *Radiat Res* 2007, 167, 396-416
- 152 World Health Organization (WHO): Health risk assessment from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami based on a preliminary dose estimation. 2013, 32
- 153 Bauer S, Gusev BI, Pivina LM, Apsalikov KN et al.: Radiation exposure due to local fallout from Soviet atmospheric nuclear weapons testing in Kazakhstan: solid cancer mortality in the Semipalatinsk historical cohort, 1960-1999. *Radiat Res.* 2005, 164(4 Pt 1), 409-419

- 154 Körblein A, Hoffmann W: Background radiation and cancer mortality in Bavaria: an ecological analysis. Arch Environ Occup Health 2006, 61(3), 109-114
- 155 ICRP: Radiation and your patient: A Guide for medical practitioners. A web module produced by Committee 3 of the International Commission on Radiological Protection (ICRP).
http://www.icrp.org/docs/rad_for_gp_for_web.pdf
- 156 Little MP, Azizova TV, Bazyka D, Bouffler SD et al.: Systematic review and meta-analysis of circulatory disease from exposure to low-level ionizing radiation and estimates of potential population mortality risks. Environ Health Perspect 2012, 120, 1503-1511
- 157 Shimizu Y, Kodama K, Nishi N, Kasagi F et al.: Radiation exposure and circulatory disease risk: Hiroshima and Nagasaki atomic bomb survivor data, 1950-2003. BMJ 2010, 340, b5349
- 158 Straume T: High-energy gamma rays in Hiroshima and Nagasaki: implications for risk and WR. Health Physics 1995, 69, 954-956
- 159 Frankenberg D, Kelnhofer K, Bär K, Frankenberg-Schwager M: Enhanced neoplastic transformation by mammography X rays relative to 200 kVp X rays: indication for a strong dependence on photon energy of the RBEM for various end points. Radiat Res 2002, 157, 99-105
- 160 Jacob P, Ruhm W, Walsh L, Blettner M et al.: Is cancer risk of radiation workers larger than expected? Occup Environ Med 2009, 66(12), 789-796
- 161 World Health Organization (WHO): Health risk assessment from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami based on a preliminary dose estimation. 2013, 32
- 162 Watanabe T, Miyao M, Honda R, Yamada Y: Hiroshima survivors exposed to very low doses of A-bomb primary radiation showed a high risk for cancers. Environ Health Prev Med 2008, 13, 264-270
- 163 Stewart AM, Kneale GW: A-bomb survivors: factors that may lead to a reassessment of the radiation hazard. Int J Epidemiol 2000, 29, 708-14
- 164 Yamasaki JN, Schull WJ: Perinatal loss and neurological abnormalities among children of the Atomic bomb. Nagasaki and Hiroshima revisited, 1949 to 1989. JAMA 1990, 264, 605-609
- 165 Gefahrstoffverordnung (GefStoffV) in der Fassung vom 15.07.2013 www.baua.de/de/Themen-von-A-Z/Gefahrstoffe/Rechtstexte/pdf/Gefahrstoffverordnung.pdf?blob=publicationFile&v=12
- 166 Bekanntmachung zu Gefahrstoffen 910 (BekGS 910) <http://www.baua.de/de/Themen-von-A-Z/Gefahrstoffe/TRGS/pdf/Bekanntmachung-910.pdf?blob=publicationFile&v=10>
- 167 Kalberlah F, Bloser M, Wachholz C: Toleranz- und Akzeptanzschwelle für Gesundheitsrisiken am Arbeitsplatz. Dortmund: Bundesanstalt für Arbeitsschutz und Arbeitsmedizin 2005. 174 Seiten, Projektnummer: F 2010
- 168 Leitfaden zur Quantifizierung von Krebsrisikozahlen bei Exposition gegenüber krebserzeugenden Gefahrstoffen für die Grenzwertsetzung am Arbeitsplatz 2008, Fachbeitrag <http://www.baua.de/de/Publikationen/Fachbeitraege/Gd34.pdf?blob=publicationFile&v=7>
- 169 Weitere Literatur zu Risiko-Akzeptanz: [http://www.dguv.de/dguv/ifa/Fachinfos/Exposition-Risiko-Beziehung-\(ERB\)/Grundlagen-des-Risikokonzeptes/index.jsp](http://www.dguv.de/dguv/ifa/Fachinfos/Exposition-Risiko-Beziehung-(ERB)/Grundlagen-des-Risikokonzeptes/index.jsp)



IPPNW – German Affiliate of the International Physicians for the Prevention of Nuclear War
Körtestr. 10 · 10967 Berlin
Phone: +49/ (0) 30 - 68 80 74 - 0
Fax: +49/ (0) 30 - 683 81 66
ippnw@ippnw.de · www.ippnw.de

Online available: www.ippnw.de/strahlung

© IPPNW e.V., Januar 15th, 2014
All rights reserved.
Authors: Reinhold Thiel, Dr. Winfrid Eisenberg, Henrik Paulitz
Contact: paulitz@ippnw.de

Account for Donations:

IPPNW. IBAN DE39100205000002222210, BIC (SWIFT-Code) BFSWDE33BER, Bank für Sozialwirtschaft,
Reason for Payment: „IPPNW-Information“