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Risk of low dose radiation

30 years living with Chernobyl – 5 years living with Fukushima

Dr. Angelika Claussen, IPPNW Europe

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Low dose radiation-Fukushima

- 5 years living with Fukushima
- 30 years living with Chernobyl
- My talk will be about the dogm on low dose radiation that is suported by Japanese and international authorities namely UNSCEAR, WHO, ICRP, IAEO:
- **Find only thyroid cancer in children**
- **Under 100 mSv there is no problem for your health, just smile!**

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Low dose radiation, Fukushima

But after Chernobyl catastrophe studies show:

- Rise of cancer diseases, not only thyroid, but also leukemia, breast cancerand other cancer
- Rise of non-cancer diseases (exceeds the cancer cases) - blood system, stroke and heart attack, thyroid – endocrinological diseases, (Basedow, Hashimoto, iabetes), lens diseases
- Genetic effects: congenital malformations, rise in perinatal mortality, rise of stillbirth

Low dose radiation -Fukushima

Therefore our message is clear:

systematic health check-up to be made for:

- **All clean up workers**
- **All evacuees, adults and children**
- **All the population remaining in the most contaminated zones**
- **You can only find something if you look for it! Don‘t close your eyes!**

Chernobyl:

Comparing the number of cancer cases with non-cancers:

Yamashita and Shibata found 62 cases of thyroid cancer and 45.873 of non-cancer thyroid diseases in a cohort of 119.178 children from Ukraine, Belarus and Russia

Yamashita, S. & Shibata, Y. (Eds.) (1997). Chernobyl: A decade. In: Fifth Chernobyl Sasakava Medical Cooperation Symposium, October 14–15, 1996, Kiev (Elsevier, Amsterdam) (cited by UNSCEAR, 2000).

Low dose radiation Chernobyl

Tschernobyl related Cancer :

Clean-up workers: rise of **cancer** up to 20 %, Rise of acute and of chronic lymphatic leukemia (Zablotska et al, 2012)

Region Gomel, Belarus: rise of cancer rate to 55,9 %

Belarus overall: 40% (Okeanov et al. 2004)

Rise of breast cancer in the contaminated areas Gomel + Mogilov (Belarus) and Chernigov, Kiev, Zhytomir (Ukraine), (Pukkala et al. 2006)

Rise of Leukemia (children) in the contaminated areas of Ukraine: Significant if the contamination is higher than 10 mSv (Noshenko, 2010) and Belarus (A. Körblein 2013) for babies in the first year after Chernobyl

- **Rise of brain tumours** for children under 6 years (Ukraine) 5,8 fold (Orlov, Sharevsky, 2002)

Low level radiation Chernobyl

Chernobyl, non cancer diseases:

Prysyazhnyuk *et al*: in-utero radiated children:

Risk of cardiovasculer diseases rising compared to non –radiated children: (57.8% vs. 31.8%, $p < 0.05$)

Prysyazhnyuk, A. Ye. Et al (2002). Review of epidemiological finding in the study of medical consequences of the Chernobyl accident in Ukrainian population. In: Imanaka, T. (Ed.), Recent Research Activities on the Chernobyl NPP Accident in Belarus, Ukraine and Russia, KURRI-KR-79 (Kyoto University, Kyoto), pp. 188–287.

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Non-Cancer diseases: Chernobyl shows adverse effects on childrens‘ bloodcells

Study with 1.251 children from 1993 -1998 in the region of Narodichevsky/Shitomir - Ukraine

Data show a statistically significant reduction in red and white blood cell counts, platelet counts and hemoglobin with increasing residential 137Cs soil contamination

Stepanova et al Environmental Health 2008, ***7****:21*

Low level radiation Chernobyl

Chernobyl Non-Cancer diseases:

Radiation affects the human brain severely

Dose-related cognitive and neurophysiological abnormalities among prenatally exposed children after the Chernobyl accident .

Gestation ages of +8 weeks at >20 mSv on the fetus and >300 mSv on the thyroid in utero;

Gestation ages at 16–25 weeks, abnormalities at Doses >10 mSv and >200 mSv, respectively.

K. Loganovsky, Kiew, Ukraine:Do low doses of ionizing radiation affext the human brain?

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Low dose radiation Chernobyl

- **Brain effects on adults: Liquidators health**
- Radiation-associated cerebrovascular effects (stroke) were obtained at >150 -250 mSv.
- Dose-related neuropsychiatric,neurophysiological, neuropsychological, and neuroimaging abnormalities following exposure to >300 mSv
- neurophysiological and neuroimaging radiation markers at doses >1000 mSv were revealed

(source: K. Loganovsky 2009, 2015)

Low dose radiation Chernobyl

Non Cancer diseases: Liquidators health

Main deathcause : stroke , heart attack

second deathcause: cancer

Yablokov (2009) looking at the studies on liquidators from the health registries in Obninsk and in Kiew estimates that out of 830.000 liquidators

112.000 -125.000 died

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Low dose radiation Chrnobyl

Non-Cancer diseases: reproductive health

- Increase of stillbirth in Southern Bavaria
- Increase of stillbirth in Eastern European countries (Greece, Hungary, Poland , Sweden), effect not so clear in central Europe (Austria, Denmark, Germany, Italy, Norway, Switzerland)
- Sources: Scherb et al (1999) European stillbirth proportions before an dafter Chernobyl accident H. Scherb, E. Weigelt: Spatial-temporal logistic regression of the cesium contamination and the time trend in annual stillbirth proportions on a district level in Bavaria, 1980 to 1993

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Low dose radiation Chernobyl

- Rise of perinatal mortality in Germany and Poland according to the Cs- 137 contamination

- Rise of congenital malformations in Belarus, Ukraine, Bavaria according to Cs –137 soil contamination
- Sources: D. Lazjuk et al (1997), W. Wertelecki (2010, 2014) http://www.alfred-koerblein.de/chernobyl/english/index.htm

Low dose radiation Chernobyl

Genetic effects:

- Down –Syndrom in Berlin: (Sperling et al 1993, 2012)
- Chromosomal aberrations in children of liquidators (Yablokov 2009)
- Changes in the birth ratio of male/female Newborns (Hagen Scherb et al 2007 ff)

Low dose radiation

From new big epidemiological case - control studies on radiaton health effects we know:

Even doses beneath 10 mSv raise the risk to develop cancer, brain-vessels and heart vessels‘ damages and genetic changes was proven.Yamashita is wrong his estimations low dose is instead harmful

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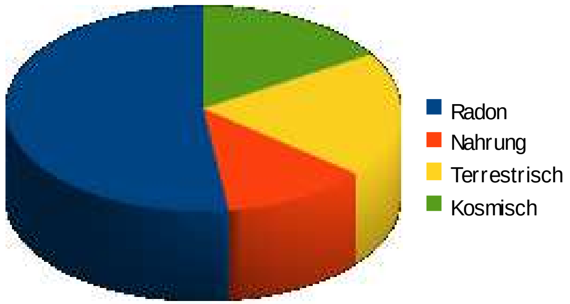
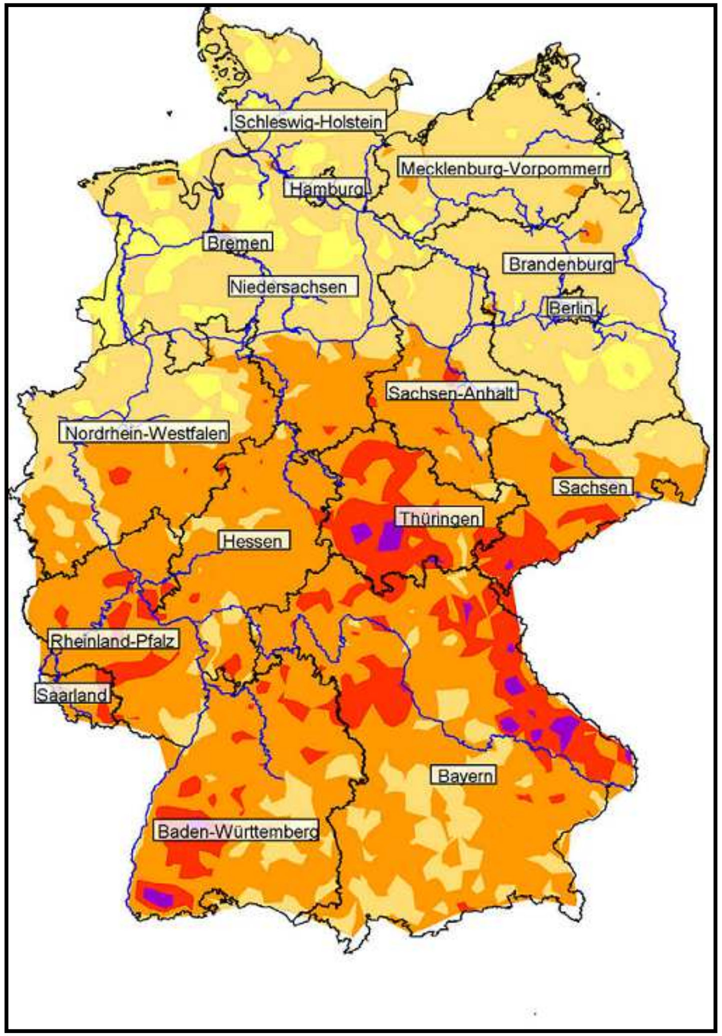
Low dose radiation

Even background radiation (0,5 -2,4 mSv /year) causes adverse health effects, cancer risk is rising





Low level radiation

Background radiation

16% elevated risk per 100 Bq/m^3
(95% CI 5 - 31%)

Smoking independent risk factor

No threshold

Radon causes 9% of all lung cancer cases 2% mortality cases through lung cancer

2005

BMJ Helping doctors make better decisions

Radon in homes and risk of lung cancer: collaborative analysis of individual data from 13 European case-control studies

S Darby, D Hill, A Auvinen, J M Barros-Dios, H Baysson, F Bochicchio, H Deo, R Falk, F Forastiere, M Hakama, I Heid, L Kreienbrock, M Kreuzer, F Lagarde, I Mäkeläinen, C Muirhead, W Oberaigner, G Pershagen, A Ruano-Ravina, E Ruosteenoja, A Schaffrath Rosario, M Tirmarche, L Tomášek, E Whitley, H E Wichmann, R Doll

Abstract

Objective To determine the risk of lung cancer associated with exposure at home to the radioactive disintegration products of naturally occurring radon gas.
Design Collaborative analysis of individual data from 13 case-control studies of residential radon and lung cancer.
Setting Nine European countries.
Subjects 7148 cases of lung cancer and 14 208 controls.
Main outcome measures Relative risks of lung cancer and radon gas concentrations in homes inhabited during the previous 5-34 years measured in becquerels (radon disintegrations per second) per cubic metre (Bq/m^3) of household air.
Results The mean measured radon concentration in homes of people in the control group was 97 Bq/m^3, with 11% measuring > 200 and 4% measuring > 400 Bq/m^3. For cases of lung cancer the mean concentration was 104 Bq/m^3. The risk of lung cancer

present throughout the earth's crust. It has a half life of four days, allowing it to diffuse through soil and into air before decaying by emission of an α particle into a series of short lived radioactive progeny. Two of these, polonium-218 and polonium-214, also decay by emitting α particles. If inhaled, radon itself is mostly exhaled immediately. Its short lived progeny, however, which are solid, tend to be deposited on the bronchial epithelium, exposing cells to α irradiation.

Air pollution by radon is ubiquitous. Concentrations are low outdoors but can build up indoors, especially in homes, where most exposure of the general population occurs. The highest concentrations to which workers have been routinely exposed occur underground, particularly in uranium mines. Studies of exposed miners have consistently found associations between radon and lung cancer.[1 2] Extrapolation from these studies is uncertain but suggests that residential radon, which involves lower exposure to many more people, could cause a substantial minority of all lung cancers. This is of practical relevance because radon concentrations in existing buildings can usually be reduced at moderate

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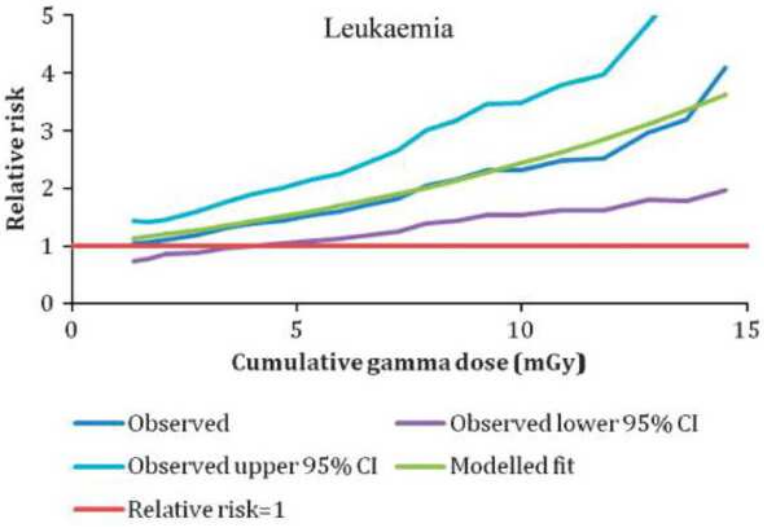
Low level radiation

Background radiation

Leukemia

12% elevated risk per mSv bone marrow dosis
(95% CI 3 – 22%)



Leukemia

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

G M Kendall, M P Little, R Wakeford, K J Bunch, J C H Miles, T J Vincent, J R Meara and M F G Murphy

We conducted a large record-based case–control study testing associations between childhood cancer and natural background radiation. Cases (27 447) born and diagnosed in Great Britain during 1980–2006 and matched cancer-free controls (36 793) were from the National Registry of Childhood Tumours. Radiation exposures were estimated for mother's residence at the child's birth from national databases, using the County District mean for gamma rays, and a predictive map based on domestic measurements grouped by geological boundaries for radon. There was 12% excess relative risk (ERR) (95% CI 3, 22; two-sided P=0.01) of childhood leukaemia per millisievert of cumulative red bone marrow dose from gamma radiation; the analogous association for radon was not significant, ERR 3% (95% CI −4, 11; P=0.35). Associations for other childhood cancers were not significant for either exposure. Excess risk was insensitive to adjustment for measures of socio-economic status. The statistically significant leukaemia risk reported in this reasonably powered study (power ~50%) is consistent with high-dose rate predictions. Substantial bias is unlikely, and we cannot identify mechanisms by which confounding might plausibly account for the association, which we regard as likely to be causal. The study supports the extrapolation of high-dose rate risk models to protracted exposures at natural background exposure levels.

P=0.01) of childhood leukaemia per millisievert of cumulative red bone marrow dose from gamma radiation; the analogous

2013

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Low level radiaton risk

Background radiation

Causes 15-20% of all cases of child leukemia

Journal of Radiological Protection

Official journal of the Society for Radiological Protection

Updated estimates of the proportion of childhood leukaemia incidence in Great Britain that may be caused by natural background ionising radiation

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Abstract
The aetiology of childhood leukaemia remains generally unknown, although exposure to moderate and high levels of ionising radiation, such as was experienced during the atomic bombings of Japan or from radiotherapy, is an established cause. Risk models based primarily upon studies of the Japanese A-bomb survivors imply that low-level exposure to ionising radiation, including to ubiquitous natural background radiation, also raises the risk of childhood leukaemia. In a recent paper (Wakeford *et al* 2009 *Leukaemia* **23** 770–6) we estimated the proportion of childhood leukaemia incidence in Great Britain attributable to natural background radiation to be about 20%. In this paper we employ the two sets of published leukaemia risk models used previously, but use recently published revised estimates of natural background radiation doses received by the red bone marrow of British children to update the previous results. Using the newer dosimetry we calculate that the best

2009

Medical diagnostics

Medical diagnostics causes

Adverse health effects proven in epidmiological studies

Therefor be careful, use it only when it is necessary

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Gefahren ionisierender Stahlung

Medical diagnostics

More than 355.000 patients 1985-2002

One CT with ca. 50-60 mSv may raise the risk to develop leukemia or brain tumours threefold

No Confounder

THE LANCET

Articles

Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study

2012

Mark S Pearce, Jane A Salotti, Mark P Little, Kieran McHugh, Choonsik Lee, Kwang Pyo Kim, Nicola L Howe, Cecile M Ronckers, Preetha Rajaraman, Sir Alan W Craft, Louise Parker, Amy Berrington de González

Summary

Background Although CT scans are very useful clinically, potential cancer risks exist from associated ionising radiation, in particular for children who are more radiosensitive than adults. We aimed to assess the excess risk of leukaemia and brain tumours after CT scans in a cohort of children and young adults.

Methods In our retrospective cohort study, we included patients without previous cancer diagnoses who were first examined with CT in National Health Service (NHS) centres in England, Wales, or Scotland (Great Britain) between 1985 and 2002, when they were younger than 22 years of age. We obtained data for cancer incidence, mortality, and loss to follow-up from the NHS Central Registry from Jan 1, 1985, to Dec 31, 2008. We estimated absorbed brain and red bone marrow doses per CT scan in mGy and assessed excess incidence of leukaemia and brain tumours cancer with Poisson relative risk models. To avoid inclusion of CT scans related to cancer diagnosis, follow-up for leukaemia began 2 years after the first CT and for brain tumours 5 years after the first CT.

Findings During follow-up, 74 of 178 604 patients were diagnosed with leukaemia and 135 of 176 587 patients were diagnosed with brain tumours. We noted a positive association between radiation dose from CT scans and leukaemia (excess relative risk [ERR] per mGy 0·036, 95% CI 0·005–0·120; p=0·0097) and brain tumours (0·023, 0·010–0·049; p<0·0001). Compared with patients who received a dose of less than 5 mGy, the relative risk of leukaemia for patients who received a cumulative dose of at least 30 mGy (mean dose 51·13 mGy) was 3·18 (95% CI 1·46–6·94) and the relative risk of brain cancer for patients who received a cumulative dose of 50–74 mGy (mean dose 60·42 mGy) was 2·82 (1·33–6·03).

Interpretation Use of CT scans in children to deliver cumulative doses of about 50 mGy might almost triple the risk of leukaemia and doses of about 60 mGy might triple the risk of brain cancer. Because these cancers are relatively rare, the cumulative absolute risks are small: in the 10 years after the first scan for patients younger than 10 years, one excess case of leukaemia and one excess case of brain tumour per 10 000 head CT scans is estimated to occur. Nevertheless, although clinical benefits should outweigh the small absolute risks, radiation doses from CT scans ought to be kept as low as possible and alternative procedures, which do not involve ionising radiation, should be considered if appropriate.

Lancet 2012; 380: 499–505

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See Comment page 455

See Perspectives page 465

Institute of Health and Society (M S Pearce PhD, J A Salotti PhD, N L Howe MSc) and Northern Institute of Cancer Research (Sir A W Craft MD), Newcastle University, Sir James Spence Institute, Royal Victoria Infirmary, Newcastle upon Tyne, UK; Radiation Epidemiology Branch, Division of Cancer Epidemiology and Genetics, National Cancer Institute, Bethesda, MD, USA (M P Little PhD, C Lee PhD, C M Ronckers PhD, P Rajaraman PhD, A B de González DPhil); Great Ormond Street Hospital for Children NHS Trust, London, UK (K McHugh FRCR); Department of Nuclear Engineering, Kyung Hee University, Gyeongi-Do, South Korea (K P Kim PhD); Dutch Childhood Oncology Group—Longterm effects after

Gefahren ionisierender Stahlung

Medizinische Strahlung

10,9 Millionen Patienten 1985-2005

Krebsrisiko steigt um 24% durch 1 CT (4,5 mSv)

Jede weitere CT-Untersuchung erhöht das Risiko um etwa 16%

Je jünger, desto höher das Risiko:
- 1-4 Jahre: 35% höheres Krebsrisiko
- 5-9 Jahre: 25% höheres Krebsrisiko
- 10-14 Jahre: 14% höheres Krebsrisiko

BMJ Helping doctors make better decisions

2013

Cancer risk in 680 000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians

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Abstract

Objective To assess the cancer risk in children and adolescents following exposure to low dose ionising radiation from diagnostic computed tomography (CT) scans.

Design Population based, cohort, data linkage study in Australia.

Cohort members 10.9 million people identified from Australian Medicare records, aged 0-19 years on 1 January 1985 or born between 1 January 1985 and 31 December 2005; all exposures to CT scans funded by Medicare during 1985-2005 were identified for this cohort. Cancers diagnosed in cohort members up to 31 December 2007 were obtained through linkage to national cancer records.

Main outcome Cancer incidence rates in individuals exposed to a CT scan more than one year before any cancer diagnosis, compared with cancer incidence rates in unexposed individuals.

Results 60 674 cancers were recorded, including 3150 in 680 211 people exposed to a CT scan at least one year before any cancer diagnosis. The mean duration of follow-up after exposure was 9.5 years. Overall cancer incidence was 24% greater for exposed than for unexposed at younger ages ($P<0.001$ for trend). At 1-4, 5-9, 10-14, and 15 or more years since first exposure, IRRs were 1.35 (1.25 to 1.45), 1.25 (1.17 to 1.34), 1.14 (1.06 to 1.22), and 1.24 (1.14 to 1.34), respectively. The IRR increased significantly for many types of solid cancer (digestive organs, melanoma, soft tissue, female genital, urinary tract, brain, and thyroid); leukaemia, myelodysplasia, and some other lymphoid cancers. There was an excess of 608 cancers in people exposed to CT scans (147 brain, 356 other solid, 48 leukaemia or myelodysplasia, and 57 other lymphoid). The absolute excess incidence rate for all cancers combined was 9.38 per 100 000 person years at risk, as of 31 December 2007. The average effective radiation dose per scan was estimated as 4.5 mSv.

Conclusions The increased incidence of cancer after CT scan exposure in this cohort was mostly due to irradiation. Because the cancer excess was still continuing at the end of follow-up, the eventual lifetime risk from CT scans cannot yet be determined. Radiation doses from contemporary CT scans are likely to be lower than those in 1985-2005, but some increase in cancer risk is still likely from current scans. Future CT scans should be limited to situations where there is a definite clinical indication,

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Gefahren ionisierender Stahlung

Uranium mining

59.001 workers in East Germany
Causal relationship between the whole working time and cancer risk

21% elevated cancerrisk per WLM (95% CI 18 - 24)

BJC
British Journal of Cancer

Lung cancer risk among German male uranium miners: a cohort study, 1946–1998

B Grosche*[,1], M Kreuzer[1], M Kreisheimer[1], M Schnelzer[1] and A Tschense[1]
[1]*Federal Office for Radiation Protection, Department 'Radiation Protection and Health', Ingolstaedter Landstr. 1, 85764 Oberschleissheim, Germany*

From 1946 to 1990 extensive uranium mining was conducted in the southern parts of the former German Democratic Republic. The overall workforce included several 100 000 individuals. A cohort of 59 001 former male employees of the Wismut Company was established, forming a large retrospective uranium miners' cohort for the time period 1946–1998. Mean duration of follow-up was 30.5 years with a total of 1 801 630 person-years. Loss to follow-up was low at 5.3%. Of the workers, 16 598 (28.1%) died during the study period. Based on 2388 lung cancer deaths, the radon-related lung cancer risk is evaluated. The excess relative risk (ERR) per working level month (WLM) was estimated as 0.21% (95% CI: 0.18–0.24). It was dependent on time since exposure and on attained age. The highest ERR/WLM was observed 15–24 years after exposure and in the youngest age group (<55 years of age). While a strong inverse exposure-rate effect was detected for high exposures, no significant association was detected at exposures below 100 WLM. Excess relative risk /WLM was not modified by duration of exposure. The results would indicate the need to re-estimate the effects of risk modifying factors in current risk models as duration of exposure did not modify the ERR/WLM and there was only a modest decline of ERR/WLM with increasing time since exposure.
British Journal of Cancer (2006) **95,** 1280–1287. doi:10.1038/sj.bjc.6603403 www.bjcancer.com
Published online 17 October 2006

Keywords: epidemiology; cohort study; uranium miners; lung cancer; radon

From 1946 to 1990 there was extensive uranium mining in the southern parts of the former German Democratic Republic (GDR). It was conducted by the Soviet-German Incorporated Company Wismut. Some 231 000 metric tons of uranium ore were produced (Wismut, 1999) and incorporated into the former Soviet Union's nuclear programme. About 400 000 persons may have worked with the company, most of them underground or in uranium ore processing facilities (Otten and Schulz, 1998). Approximately 130 000 of the workers are known. Up to 1999, 7695 workers with radiation-induced lung cancers had been compensated (Schröder *et al*, 2002). In 2000, the annual number of newly compensated cases was still almost 200 although with a decreasing trend (Koppisch *et al*, 2004).

et al, 2004; Kreisheimer, 2006), yet further follow-up was only conducted for the Czech (Tomášek, 2002; Tomášek and Zarska, 2004) and the French cohort (Rogel *et al*, 2002; Laurier *et al*, 2004). Although the evidence of a radon-related lung cancer risk among miners is large, it is based upon various heterogeneous cohorts for which the cohort-specific risk estimates vary by more than an order of magnitude. The new German cohort is as big as all the 11 cohorts put together, but less heterogeneous in various aspects: same societal and geographical background, same way of follow-up, and one system for exposure estimation.

The aim of the present analysis was to evaluate the lung cancer risk associated with radon and its progeny due to cumulative radon exposure, exposure rate, duration of exposure, time since exposure, and attained age.

2006

Uranium Mining

Rössing, Namibia
Zaire et al. „Unexpected Rates of Chromosomal Instabilities and Alterations of Hormone Levels in Namibian Uranium Miners“. Rad Res 1997 May;147(5):579-84.

Saskatchewan, Kanada
Rachel et al. „Mortality (1950–1999) and Cancer Incidence (1969–1999) in the Cohort of Eldorado Uranium Workers“. Radiation Research, December 2010, Vol. 174, No. 6a

Jadugoda, Indien
Koide H. „Radioactive contamination around Jadugoda uranium mine in India“. Research Reactor Institute, Kyoto University, 08.07.02.

Uranium Mining

Radium Hill, Australien
Woodward et al. „Radon daughter exposures at the Radium Hill uranium mine and lung cancer rates among former workers, 1952-87". Cancer Causes and Control 2:91

Shiprock, USA
Gilliland et al. „Uranium Mining and Lung Cancer Among Navajo Men in New Mexico and Arizona". J Occup Environ Med 42(3):278-283, March 2000.

Elliot Lake, Kanada
Kusiak et al. „Mortality from lung cancer in Ontario uranium miners". Br J Ind Med 1993;50:920-928.

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Low dose radiation

Nuclear workers

154 Factories in 15 countries
598.000 Arbeiter
> 90% < 50 mSv

Solid Tumors: 97% elevated risk per Sv (95% CI 14 - 197)

Leukämie: 193% elevated risk per Sv (95% CI 0 - 847)

1-2% of overall mortality among nuclear workers caused by radiation

BMJ Helping doctors make better decisions

2005

Risk of cancer after low doses of ionising radiation: retrospective cohort study in 15 countries

E Cardis, M Vrijheid, M Blettner, E Gilbert, M Hakama, C Hill, G Howe, J Kaldor, C R Muirhead, M Schubauer-Berigan, T Yoshimura, F Bermann, G Cowper, J Fix, C Hacker, B Heinmiller, M Marshall, I Thierry-Chef, D Utterback, Y-O Ahn, E Amoros, P Ashmore, A Auvinen, J-M Bae, J Bernar Solano, A Biau, E Combalot, P Deboodt, A Diez Sacristan, M Eklof, H Engels, G Engholm, G Gulis, R Habib, K Holan, H Hyvonen, A Kerekes, J Kurtinaitis, H Malker, M Martuzzi, A Mastauskas, A Monnet, M Moser, M S Pearce, D B Richardson, F Rodriguez-Artalejo, A Rogel, H Tardy, M Telle-Lamberton, I Turai, M Usel, K Veress

Abstract

Objectives To provide direct estimates of risk of cancer after protracted low doses of ionising radiation and to strengthen the scientific basis of radiation protection standards for environmental, occupational, and medical diagnostic exposures.
Design Multinational retrospective cohort study of cancer mortality.
Setting Cohorts of workers in the nuclear industry in 15 countries.
Participants 407 391 workers individually monitored for external radiation with a total follow-up of 5.2 million person years.
Main outcome measurements Estimates of excess relative risks per sievert (Sv) of radiation dose for mortality from cancers other than leukaemia and from leukaemia excluding chronic lymphocytic leukaemia, the main causes of death considered by radiation protection authorities.
Results The excess relative risk for cancers other than leukaemia was 0.97 per Sv, 95% confidence interval 0.14 to 1.97. Analyses of causes of death related or unrelated to smoking indicate that, although confounding by smoking may be present, it is unlikely to explain all of this increased risk. The excess relative risk for leukaemia excluding chronic lymphocytic leukaemia was 1.93 per Sv (< 0 to 8.47). On the basis of these estimates, 1-2% of deaths from cancer among workers in this cohort may be attributable to radiation.
Conclusions These estimates, from the largest study of nuclear workers ever conducted, are higher than, but statistically compatible with, the risk estimates used for current radiation protection standards. The results suggest that there is a small excess risk of cancer, even at the low doses and dose rates typically received by nuclear workers in this study.

by the public in the general environment, by patients through repeated diagnostic procedures,[4] and by radiation workers.

The effects of low dose chronic exposure to external radiation have been directly estimated in several cohorts of workers in the nuclear industry,[5] but the sample size has limited the precision of these estimates. Analyses of combined cohorts have improved precision.[6-8] Estimates from these analyses, however, are compatible with a range of possibilities, from a reduction of risk at low doses to risks higher than those underlying current radiation protection recommendations.

The 15 country study, an international collaborative study of cancer risk among radiation workers in the nuclear industry, was carried out to further improve the precision of direct estimates of risk after protracted low dose exposures and to strengthen the scientific basis of radiation protection.[1] We present risk estimates for mortality from all cancers, excluding leukaemia, and from leukaemia excluding chronic lymphocytic leukaemia and compare them with estimates derived from data on survivors of the A bomb. We have used the term nuclear industry to refer to facilities engaged in production of nuclear power, manufacture of nuclear weapons, enrichment and processing of nuclear fuel, production of radioisotopes, or reactor or weapons research. Uranium mining is not included.

Methods

This multinational retrospective cohort study used a common protocol in 15 countries and collected information on nearly 600 000 workers. Study cohorts were defined from employment or dosimetric records of participating facilities or, where available, from centralised national dose registries. The a priori eligibility criteria for inclusion of cohorts[9] were essentially complete and non-selective follow-up for mortality;

Low dose radiation

Non cancer effects of radiation: Rising risk of

- strokes,
- heart diseases,
- Digestive diseases
- cataracts
- central nervous systems damages

Different radiation dosis up to 600 mGy, in different cohorts of radiation workers, Overview of studies

Mark P. Little: Radiat Environ Biophys. 2014

Thank you for your attention