The 100 Millisievert Threshold Lie: Accepted Knowledge about Radiation Effects after Chronical Low-Dose Exposure and Remaining Issues

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Abstract
Decades ago, the concept of the "stochastic" radiation effect was developed by the International Commission on Radiological Protection (ICRP) for cancer and hereditary diseases. Makers and users of radiation technologies and several professional associations have fought the ICRP´s no-threshold thesis since, and after the Fukushima disaster interested bodies have promoted the assertain that no detrimental effects have ever been observed below a dose of 100 mSv. In contrast to this view, the international committees ICRP, UNSCEAR[i] and BEIR[ii] have accepted meanwhile, that in fact stochastic effects must be expected following doses far below 100 mSv. This state of knowledge is derived from findings about radiation-induced cancer. Severe deficits in the official protection concepts must be seen in the neglect and underestimation of genetic and teratogenic effects.

Introduction

The most serious radiation effects by radioactivity – hereditary defects in the descendants of exposed parents – had been already detected in the twenties of the last century by the later nobel prize winner Herman Joseph Muller. He concluded from his investigations in drosophila that also low dose exposures, and thus also the natural background radiation, are mutagenous. In the thirties already, the idea arose that cancer is initiated by a single cell transformation, a "somatic" mutation. Therefore, Muller concluded that there is also no harmless dose range for cancer induction[iii].

After the second world war Muller warned of deteriorating the genetic pool of mankind by environmental radioactivity. He was therefore uninvited as a speaker at the Atomic Conference in Geneva in 1955 where the large-scale, so-called peaceful, use of nuclear energy was announced by U.S. president Eisenhower.

The anti-nuclear movement was initiated by scientists who experienced that the ruling opinions about the effects of radioactivity were wrong and dangerous, as e.g. was expressed by John Gofman and Arthur Tamplin in their book of 1971 "Poisoned Power. The Case against Nuclear Power Plants."[iv] They had been advisers of the U.S. Atomic Energy Commission AEC which was established for the promotion of nuclear energy application.

My personal change to become an opponent of the official strategies occured at the University of Bremen. We were contacted there by nuclear workers and learned that they had generally no chance to get any compensation for their illnesses.

The normative board for the evaluation of radiation risks und the proposal of dose limits is the International Commission on Radiological Protection ICRP. It followed a committee which had been founded in 1928 by radiological societies of several countries for the purpose of

[i] United Nations Scientific Committee on the Effects of Atomic Radiation
[ii] Biological Effects of Ionizing Radiations
[iii] Muller, H.J.: Über die Wirkung der Röntgenstrahlung auf die Erbmasse. Strahlentherapie 55, 1936, 207-224
[iv] Rodale Press inc., Emmaus, Pa. 18049

developing standards for radiation protection in the medical field. Therefore, it is traditionally obliged to the interests of the users. Since 1950, in the period of the Cold War and the development of nuclear energy consumption, it grew up to great importance. Although the commission derives only recommendations these are applied by all Western and Eastern industrial nations.

The ICRP, however, developed the concept of the "stochastic" radiation effect – quite in the sense of Muller. If a great collective is exposed by a small dose, one cannot predict which individual person will suffer from a radiation damage, only a propability is derivable. The amount of diseases increases with the accumulated dose, but after halving the dose there remains still an elevated effect. Therefore, no "threshold" exists i.e. a dose range without risk. The underlying idea is that a single quantum of radiation – one alpha- or beta particle or one electromagnetic wave of high energy is able to induce or promote a cell mutation.

There have been many efforts by makers and users of radiation technologies and several professional associations to deny this mechanism, and – as you know - after the Fukushima disaster interested bodies have promoted the assertain that no detrimental effects have ever been observed below a dose of 100 mSv.

For long decades it was, indeed, the official version and promoted by the members of the ICRP themselves, that low-dose effects are too rare to be detectable, and that the ICRP`s risk estimates are worst-case assumptions. The officials spoke of a "hypothetical" risk in the dose range of the legal limits for workers and the population, which might not exist in reality.

But things have changed in the meantime, not as radical as would be necessary, however in one essential basic point: the international committees ICRP and also that of the United Nations named UNSCEAR, as well as the radiation committee of the U.S. American Academy of Sciences BEIR have accepted now, that in fact stochastic effects must be expected following doses far below 100 mSv.

What I want to report on here, is the evidence of effects from five fields of research which the committees refer to.

1) The late acceptance of the effects from in utero exposure by diagnostic X-rays

The English scientist Alice Stewart had started a research project in the 1950ties to find the causes of childhood cancer, the Oxford Survey of Childhood Cancers (OSCC). Her first publication appeared in 1957, in which was shown that diagnostic X-rays in pregnant women generates leukaemia in the children after birth (Fig.1).

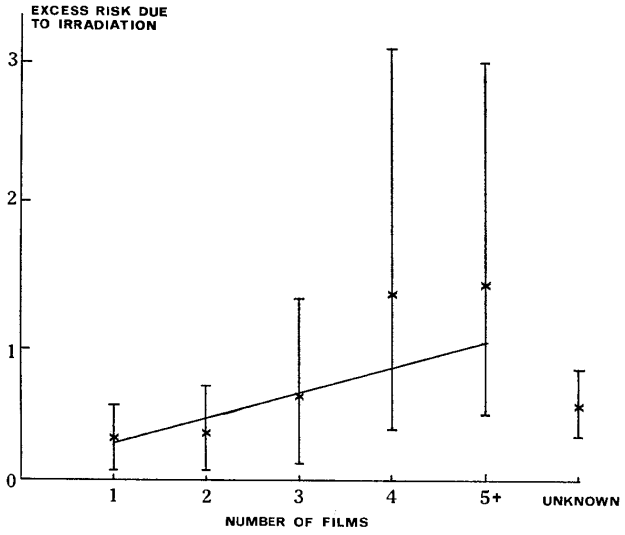
The investigations were continued and it was shown by Stewart, Kneale, and coworkers that a single X-ray film of contemporary dose – about 5 mSv – doubles the leukaemia risk, i.e. produces an increase of 100 %, and that also other childhood cancers are caused.

These results of have been critized for decades and were not respected by the international committees because these claimed that they do not correspond to the findings in the Japanese A-bomb survivors. But finally they were not only confirmed[1, 2] but also accepted.

The BEIR VII report of 2006 e.g., states[v]: "Studies of prenatal exposure to diagnostic X-rays have, despite long-standing controversy, provided important information on the existence of a significantly increased risk of leukaemia and childhood cancer following diagnostic doses of 10-20 mGy *in utero*."

[v] Chapter 7 (Medical Radiation Studies) page 173

Fig.1 Leukaemia risk in dependence of the number of X-ray films
OSCC (Bithell and Stewart Br. J. Cancer 1975)



2) Low-dose effects in the A-bomb survivors

It is a common claim in lectures on radiation protection, that effects in the low dose range cannot be measured but must be extrapolated from findings at high doses. The collective which they refer to are the Japanese A-bomb survivors. The investigators of the Radiation Effects Research Foundation RERF in Hiroshima protested against this interpretation, because most survivors are in the low dose cohorts (Table 1), and the mean dose of the whole sample is only about 200 mSv.

The RERF authors repeatedly stated that there is evidence about effects in the low dose cohorts, and that the best fit for the dose-response of solid cancers is the linear-non-threshold approach, called LNT, which means a proportionate relation between dose and effect.

This was confirmed in the last RERF study of 2012 about the mortality of solid cancer[3].

Pierce and Preston[4] studied the data for solid cancer in the dose range below 0.5 Sv in more detail and found:"There is a statistically significant effect in the range 0-0.1 Sv", that means below 100 mSv (= 0.1 Sv).

Table 1 Dose cohorts of the Life Span Study in Japanese A-bomb survivors
(Preston et al. in RERF Update Vol.18, 2007)

Dose Sv	<0,005	0.005-0,1	0,1-0,2	0,2-0,5	0,5-1	1-2	2 +	all
Number of persons	35545	27789	5527	5935	3173	1647	564	105,427

3) Radon in homes and lung cancer

Radon (Rn) is a volatile radioactive daughter of Radium which emits alpha particles with a half-life of 3.8 days. Because it is part of the atmosphere and enriches in European houses it is the main source of natural radiation exposure in Europe.

It was shown by analysis of 13 case-control studies in Europe[5] and 7 North American case-control studies[6] that there is a proportionate increase of lung cancer and the mean radon concentration for individuals in houses (Fig.1).

Darby et al.[5] state that the effect is also significant in the dose range below 200 Bq/m^3, which corresponds to an effective dose of 3.2 mSv per year and a lung dose of 26.7 mSv per year. This was adopted by the World Health Organisation (WHO) in 2009, Fact sheet No. 291. In 2011, a prospective study surveying 820,000 Canadians[7] found an 15 % increase of lung cancer mortality per 100 Bq/m^3 increase in radon (Darby 16 %; Krewski 11 %; WHO 16 %).

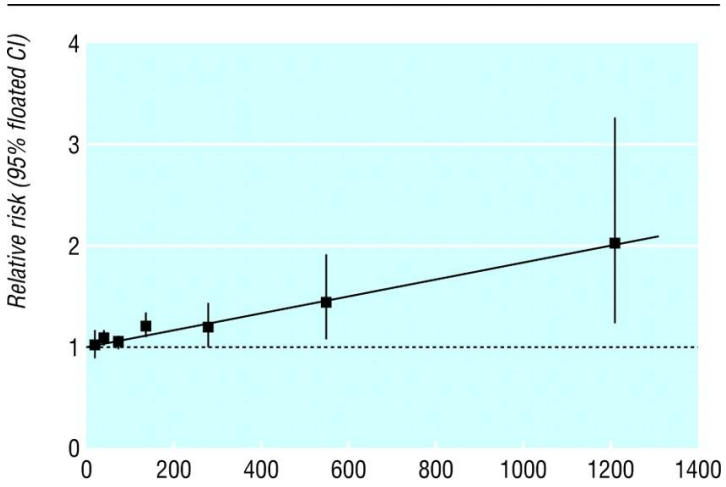


Fig.1 Dependence between lung cancer rate and measured mean concentration of Radon in homes in Bq/m^3 (Darby et al. 2005[5])

4) Low-dose effects after occupational exposures

Since the 1970ies, a great variety of studies on nuclear workers have been done. They showed a significant increase of cancer with dose even within the legal limits. This was confirmed in 2007 by the IARC (International Agency for Research on Cancer), a foundation of the WHO. IARC organized the 15-Country Collaborative Study of Cancer Risk among Radiation Workers in the Nuclear Industry[8]. The Canadian National Dose Registry published similar findings and states that the cancer risks are higher than in the studies on atomic bomb survivors[9]. In the third analysis of the British National Registry for Radiation Workers the authors find that it strengthens the evidence for elevated risk from these exposures[10]. The mean exposure taken from personal dosemeters was 24.9 mSv.

5) The contaminated population at Techa river, South Ural

The speaker of the 15-Country Study about workers Elisabeth Cardis came to the opinion that the effects of low dose-rate exposures are most reliably shown in that study and – besides Radon – in the Techa river population[11]. This region was contaminated between 1949 and 1956 by the effluents of a plutonium reprocessing facility (Mayak) for the Soviet nuclear weapons programme. The investigators found "strong evidence that such exposures lead to significant increases in risk that are rougly proportional to dose" (for solid cancer) and were not less effective than acute exposures[12]. The median stomach dose was estimated at 40 mGy (the dose unit Gy is similar to Sv in case of gamma, X-ray, and beta radiations, the main contribution to the population dose at Techa river is produced by the beta-emitter Strontium 90).

Further conclusions

The ICRP concept of the dose equivalent in Sv means that the findings 1) – 5) are transferable to all kinds of low-level exposure. The main purpose of my contribution was to show that things have changed in the meantime in the view of the international committees for radiological protection.

To insist on a "practical" threshold dose of 100 mSv in these days simply ignores the current state of knowledge. It is irresponsible and criminal with respect to the victims of environmental radioactive contaminations and other low dose exposures.

There are, however, numerous findings about low-level effects which are not yet adopted by the scientific community.

One important deficit in the official awareness are the findings after diagnostic exposures in children and adults which were gained in modern times with modern techniques. Examples are listed in the references:

Leukaemia after exposure of children and adults[13-18].
Breast cancer mortality in scoliosis patients of exposure age < 19 y., RR=1,63, mean breast dose 109 mGy[19].
Brain tumours by dental and other exposures, see Table 2.
Prostate cancer in the U.K.[25], the authors estimate that 20 % of cases in men < 60 y. are radiation-induced. The effect is confirmed by other low dose studies (nuclear workers, pilots, radon).
Others[20; 26-31].

Table 1. Brain tumours after diagnostic X-ray exposure.

Investigation (Case-control studies)		Study about	Results (relative risk)
Dental exposures	Los Angeles[20] 1972-1979 ≥ 4 x Panorama	Meningiomas	2.5 P=0.04
	Missouri Cluster[21] 1973-1982	Malign tumours	10.7 (1.4-81)
	Uppsala[22] 1987-1990 ≥ 1 x annually	Meningiomas Gliomas All tumours	2.1 (1.0-4.3) not elevated not sign.elevated
	U.S.A.[23a] 1995-2003 ≥ 6 x Panorama	Meningiomas	2.0 (1.0-4.2)
	U.S.A. regions 2006-2011[23b] Single tooth and Panorama	Meningiomas	1.4 – 4.9
X-ray Neck/Head	2 Swedish regions[24] 1994-1996	Meningiomas All tumours	5.0 (1.6-15.8) 1.6 (1.0-2.6)

The risks of occupational exposures have been shown also in air crews because of cosmic radiation and in radiologists and other medical persons related to X-rays or radionuclides. Late effects were further found in regions contaminated by nuclear tests of the United States, United Kingdom and France, which is denied, however, by the local main stream experts. The results of studies in the Soviet test area in Semipalatinsk may find acceptance soon[32].

It is a great scandal, that the health effects registered after the Chernobyl catastrophe are denied by ICRP and the other international committees, except of thyroid cancer in children and detriments in a small group of so-called liquidators, i.e. persons who were ordered for tasks at the destroyed reactor.

The UNSCEAR committee which derived the official dose estimates from Chernobyl uses a special method which was applied already in other unagreeable situations: they calculate theoretically with simplified assumptions a very tiny dose and draw then the conclusion that such a small exposure is not able to generate statistically observable effects, and that possible observations about health effects must have other causes than irradiation.

This procedure was already applied in the case of the nuclear accident of the U.S. plant Three Mile Island in 1979, and also for the British reprocessing plant of nuclear fuels Sellafield (leukaemia in children and young adults). And this is the method in Germany, too, evaluating the registered increase of childhood cancer in the vicinity of German nuclear power plants.

The underestimation of doses is proven by numerous investigations using "biological" dosimetry, which were done by studying certain chromosome anomalies in the blood of persons affected by Chernobyl fallout. The measured effects which are generated immediately with irradiation show that the exposures must have been much higher, indeed to some orders of magnitude[33,34].

Sequels from low-level exposures are expected by the ICRP only for cancer and hereditary damages. For the third "classic" radiation effect – the teratogenic one, following exposure in utero - they have, indeed, claimed a threshold dose of 100 mSv in their publication 90 of 2003[37]. This is neither in concordance with early scientific findings, nor necessarily to derive from the Japanese survivor data, nor in any kind compatible with numerous observations after the Chernobyl event[34-36, 38].

It must be noticed that other illnesses than cancers are also inducible by radiation. While the A-bomb survivors show low but significant excesses for non-neoplastic diseases of the circulatory, respiratory and disgestive systems[3], such effects and neurological distortions are found also in the populations affected by Chernobyl fallout[34].

A very serious problem for the protection of future generations is further the ignorance about genetic effects by the ICRP. In their recommendations of 2007, they lowered the risk figure for hereditary diseases nearly beyond recognition[39]. They claim that there is no evidence for such effects and refer again to the Japanese A-bomb survivors. They ignore that it is not known up to now which spectrum of parameters has to be studied in order to detect the full impact of genetic deteriorations.

A well-known genetic effect is, however, cancer in the descendants of exposed parents. After the investigations of the British epidemiologist Martin Gardner who found a dependency between leukaemia in children and juveniles and the exposure of their fathers in the British reprocessing plant Sellafield[40], this relation was confirmed in several other studies[41]. But these results were declared to be not plausible in view of the knowledge about the Japanese data.

Japanese researchers have reported that the results for descendants of A-bomb survivors must be questioned because these people feared discrimination of their children[42]. In order not to endanger their chance to get married they kept silence about their origin and health problems. Studies in children of parents which were exposed by Chernobyl radioactivity have shown that not only cancers are genetically induced in the next generation by low level exposure but also malformations, metabolic diseases, mental disorders, and Down´s syndrome[34].

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