IPPNW

German Affiliate of International Physicians
for the Prevention of Nuclear War (IPPNW)

Gesellschaft für
Strahlenschutz e.V.

Health Effects of Chernobyl

25 years after the reactor catastrophe

Advance Copy
(embargoed till April 8)

April 2011

IPPNW
Körtestraße 10
10967 Berlin
Tel ++49-30-69 80 74-0
Fax ++49-30-693 81 66
E-Mail: ippnw@ippnw.de
Internet: www.tschernobyl-folgen.de

Gesellschaft für Strahlenschutz
Gormannstraße 17
10119 Berlin
Tel. ++49-30-4493736,
Fax ++49-30-44342834
Email: Pflugbeil.KvT@t-online.de
Internet: www.gfstrahlenschutz.de

Authors:
Dr. rer. nat. Sebastian Pflugbeil, Society for Radiation Protection
Henrik Paulitz, IPPNW
Dr. med. Angelika Claussen, IPPNW
Prof. Dr. Inge Schmitz-Feuerhake, Society for Radiation Protection

With the support of Strahlentelex information service

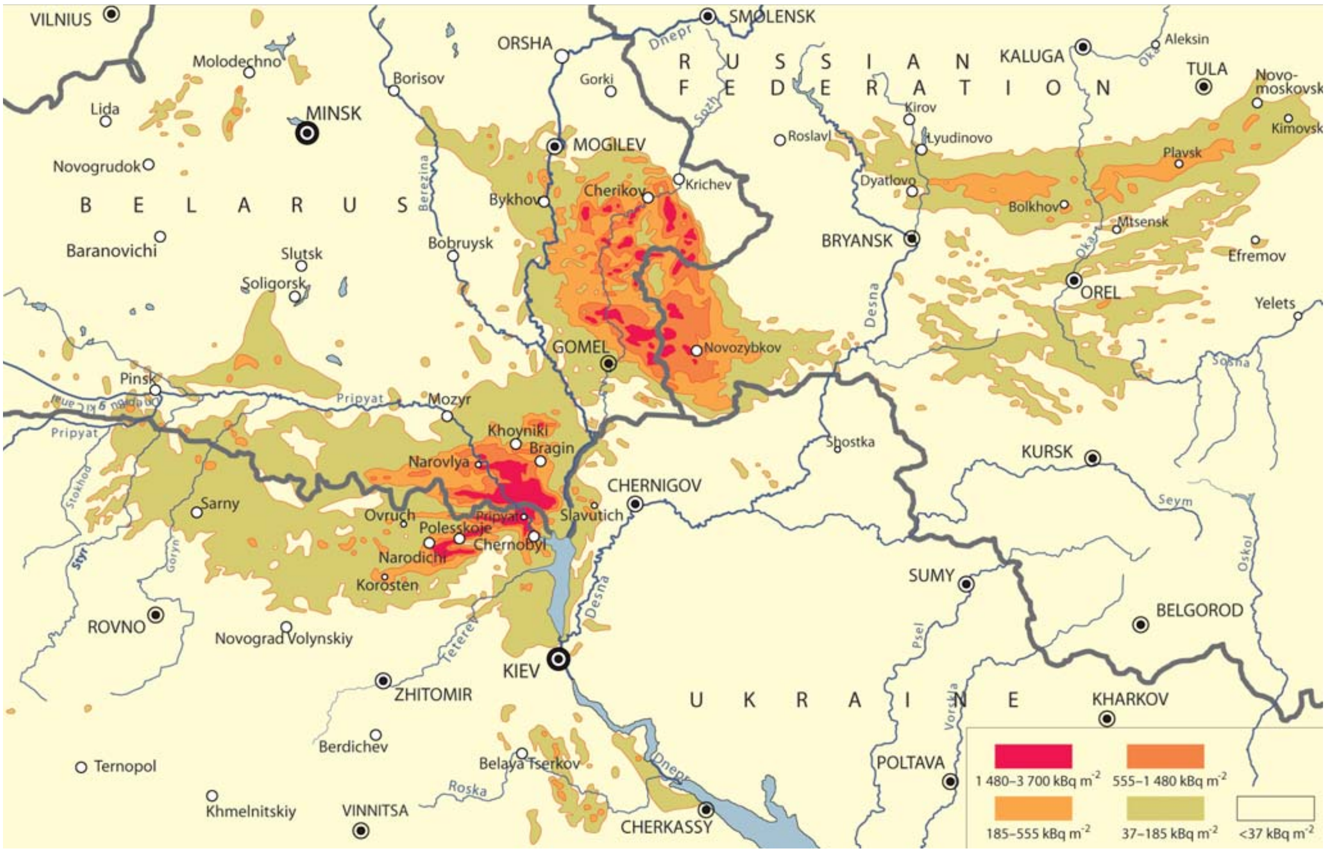
Contents

* see footnote on page 7

Abbreviations

Bq – Becquerel	describes the activity of radioactive material and gives the number of nucleii that decay per second.
ERR	the excess Relative Risk describes the risk of falling ill.
Gy – Gray	Gray measures the energy dose that ionising radiation emits. 1 Gy = 1 J/kg
IAEA	International Atomic Energy Agency.
ICRP	International Commission on Radiological Protection
man Sv	collective dose = number of people (man) x average dose (Sv).
RERF	Radiation Effects Research Foundation
Sv – Sievert	a sievert is the unit of measurement for the radiation dose. The limit officially considered in Germany to be safe is 0.001 Sv (1 mSv) per annum.
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation.
WHO	World Health Organisation.

Map of ^{137}Cs deposition levels in Belarus, the Russian Federation and Ukraine as of December 1989



SOURCE:
International Advisory Committee. The International Chernobyl Project.
Technical Report. IAEA, Vienna (1991)

Caesium-137 contaminated areas in Ukraine

SOURCE:
De Cort M, Dubois G, Fridman ShD, Germenchuk MG, Izrael YuA, Janssens A, Jones AR, Kelly GN, Kvasnikova EV, Matveenko II, Nazarov IM,.Pokumeiko YuM, Sitak VA, Stukin ED, Tabachny LYa. Tsaturov YuS and Avdyushin SI (1998) Atlas of Caesium Deposition on Europe after the Chernobyl Accident. EUR Report 16733. Office for Official Publications of the European Communities, Luxembourg

Executive Summary

"The atomic industry could take a catastrophe like Chernobyl every year."

Hans Blix, 1986 in his capacity as director of the IAEA

This paper evaluates studies that contain plausible indications of health damage caused by the Chernobyl catastrophe. The authors of this paper attach importance to the selection of methodically accurate and comprehensible analyses. Due to the already mentioned methodical difficulties, it is not our aim to present the "right" statistics in contrast to the obviously wrong ones given by the IAEA, since these can never be found. They can only supply us with indications as to the diversity and extent of the health effects we should be dealing with when we talk about the health effects of Chernobyl.

Populations which were particularly exposed to radiation by the Chernobyl catastrophe

a. Clean-up workers (liquidators):
   830,000 (Yablokov 2010)
b. Evacuees from the 30 km zone and other highly contaminated zones:
   350,400 (Yablokov, 2010)
c. The population of the heavily irradiated zones in Russia, Belarus and Ukraine:
   8,300,000 (Yablokov, 2010)
d. European population in zones with minor exposure to radiation:
   600.000.000 (Fairlie, 2007)

Disease/health damage is to be expected as a result of additional exposure to radiation because of Chernobyl

a. Cancer. Nevertheless, it should be noted that the latency period for many types of cancer is 25 – 30 years. At present we are only just seeing cases of thyroid cancers, breast cancers and brain tumours In the population. But liquidators have also developed cancer in numerous other organs: the prostate gland, stomach, cancer of the blood, thyroid cancer
b. Genetic changes: malformations, stillbirths, the lack of children
c. Non-cancerous diseases. Many organ systems could be affected; brain disorders; accelerated aging process; psychological disorders

Summary of findings

1. The effects of low–level radiation (0 – 500 mSv) were systematically monitored and investigated. In particular, the genetic effects were unclear prior to Chernobyl. This research has been augmented by research on cells, as well as on the molecular structures inside the cells. Despite this, the ICRP continues to give a dose limit of

100 mSv for teratogenic damage. This claim has been invalidated by numerous studies.

2. Non-targeted effects, such as genomic instability and the bystander effect have been found, i.e. change in the genomes of cells not directly affected by radiation.
3. The lower the radiation level, the longer the latency period before the outbreak of cancer (established as early as 2000 by Pierce and Preston in the context of the RERF studies)
4. The genomic instability is passed on in the genes and increases exponentially with each generation. Numerous research findings showing chromosome aberrations in the children of liquidators and mothers who were not exposed to radiation are available in the research centres of all three affected republics (Moscow, Minsk, Kiev). First signs of the cumulation effect could be cases of thyroid cancer among the children of irradiated parents. However, this is not yet certain.
5. It was found that the incidence of non-cancerous disease had increased; mainly cardiovascular and stomach diseases, and cases of neurological-psychiatric illness were found to be a somatic effect of low-level radiation. The latter was observed mainly during research on liquidators and their children.
6. According to figures given by the Russian authorities, more than 90% of the liquidators have become invalids; i.e. at least 740,000 severely ill liquidators. They are aging prematurely, and a higher than average number have developed various forms of cancer, leukaemia, somatic and neurological psychiatric illnesses. A very large number have cataracts. Due to long latency periods, a significant increase in cancers is to be expected in the coming years.
7. Independent studies estimate that 112,000 to 125,000 liquidators will have died by 2005.
8. Available studies estimated the number of fatalities amongst infants as a result of Chernobyl to be about 5000.
9. Genetic and teratogenic damage (malformations) have also risen significantly not only in the three directly affected countries but also in many European countries. In Bavaria alone, between 1000 and 3000 additional birth deformities have been found since Chernobyl. We fear that in Europe more than 10,000 severe abnormalities could have been radiation induced. The estimated figure of unreported cases is high, given that even the IAEA came to the conclusion that there were between 100,000 and 200,000 abortions in Western Europe because of the Chernobyl catastrophe.
10. According to UNSCEAR between 12,000 and 83,000 children were born with congenital deformations in the region of Chernobyl, and around 30,000 to 207,000 genetically damaged children worldwide. Only 10% of the overall expected damage can be seen in the first generation.
11. In the aftermath of Chernobyl not only was there an increase in the incidence of stillbirths and malformations in Europe, but there was also a shift in the ratio of male and female embryos. Significantly fewer girls were born after 1986.

    A paper by Kristina Voigt, Hagen Scherb also showed that after 1968, in the aftermath of Chernobyl, around 800,000 fewer children were born in Europe than one might have expected. Scherb estimated that, as the paper did not cover all countries, the overall number of “missing” children after Chernobyl could be about one million. Similar effects were also observed following above-ground nuclear weapons tests.

12. In Belarus alone, over 12,000 people have developed thyroid cancer since the catastrophe (Pavel Bespalchuk, 2007). According to a WHO prognosis, in the Belarus region of Gomel alone, more than 50,000 children will develop thyroid cancer during their lives. If one adds together all age groups then about 100,000 cases of thyroid cancer have to be reckoned with in the Gomel region.
13. On the basis of observed cases of thyroid cancer in Belarus and Ukraine, Malko (2007) calculated the number of future cases that might be expected, and then added the radiation factor. He arrived at the figure of 92,627 cases of thyroid cancer between 1986 and 2056. This calculation does not include cases of thyroid cancer among liquidators.
14. After Chernobyl, infant mortality rates in Sweden, Finland and Norway increased by a significant 15.8 percent compared to the trend for the period 1976 to 2006. Alfred Körblein calculated that for the period 1987 to 1992 an additional 1,209 (95 % confidence interval: 875 to 1,556) infants had died.
15. In Germany, scientists found a significant increase in trisomy 21 in newly-born children in the nine months following Chernobyl. This trend was especially marked in West Berlin and South Germany.
16. Orlov and Shaversky reported on a series of 188 brain tumours amongst children under three in Ukraine. Before Chernobyl (1981 to 1985) 9 cases were counted, not even two a year. In the period 1986-2002 the number rose to 179 children diagnosed with brain tumours – more than ten per year.
17. In the more contaminated areas of South Germany a significant cluster of a very rare type of tumour was found in children, so.called neuroblastoma.
18. A paper published by the Chernobyl Ministry in Ukraine registered a multiplication of the cases of disease of the endocrine system (25-fold from 1987 to 1992), the nervous system (6-fold), the circulatory system (44-fold), the digestive organs (60-fold), the cutaneous and subcutaneous tissue (50 times higher), the muscular-skeletal system and psychological dysfunctions (53-fold). The number of healthy people among evacuees sank from 1987 to 1996 from 59 % to 18%. Among the population of the contaminated areas from 52% to 21% and –particularly dramatic - among the children who were not directly affected themselves by Chernobyl fallout but their parents were exposed to high levels of radiation, the numbers of healthy children sank from 81% to 30% in 1996.
19. It has been reported for several years that type I diabetes (insulin-dependent diabetes mellitus) has risen sharply amongst children and adolescents.
20. Non-cancerous diseases greatly outnumber the more spectacular cases of leukaemia and cancer.

Up until today, there has unfortunately been no conclusive overview of the changes in the health condition of the whole of the affected population in the region of Chernobyl, not to mention the lack of an overview of the catastrophe for the people in the Northern hemisphere. The numbers referred to here may seem on the one hand to be terribly high, on the other hand rather low. But it has to be taken into account that nearly all of the collated studies dealt with relatively small sections of the population. Even supposedly slight changes in rates of sickness can signify serious health damage and a large extent of human suffering when they are extrapolated onto a larger population group.

Conclusion

Even though the lack of large-scale independent long-term studies does not permit a complete picture to be made of the current situation, a number of trends can be shown: a high mortality rate and an almost 100 % morbidity rate can be observed among people, such as liquidators, who were exposed to high radiation levels. 25 years after the reactor catastrophe cancer and other diseases have emerged on a scale that, owing to the long latency period, might have appeared inconceivable immediately following the catastrophe.

The number of non-cancerous diseases is far more dramatic than had ever before been imagined. “New” symptoms, such as the premature aging of liquidators, raise questions that research is still unable to answer.

By 2050 thousands more cases of illnesses will be diagnosed that will have been caused by the Chernobyl nuclear catastrophe. The delay between cause and noticeable physical reaction is insidious. Chernobyl is far from over.

Particularly tragic is the fate of the thousands of children who were born dead or died in infancy, who were born with malformations and hereditary diseases, or who are forced to live with diseases they would not have developed under normal circumstances.

The genetic defects caused by Chernobyl will continue to trouble the world for a long time to come – most of the effects will not become apparent until the second or third generation.

Even if the extent of the health effects is not yet clear, it can still be predicted that the suffering brought about by the nuclear disaster in Fukushima is, and will be, of a similar magnitude.

Note on the unreliability of official data published by WHO and IAEA

At the "Chernobyl Forum of the United Nations" organised in September 2005 by the International Atomic Energy Agency and the World Health Organisation, the presentation of the results of work on the effects of Chernobyl showed serious inconsistencies. For example: the press release of the WHO and IAEA stated that in the future, at most, 4000 surplus fatalities due to cancer and leukaemia amongst the most severely affected groups of people might be expected. In the WHO report on which this was based however, the actual number of deaths is given as 8,930. These deaths were not mentioned in any newspaper articles. When one examines the source quoted in the WHO report, one arrives at a number between 10,000 and 25,000 additional fatalities due to cancer and leukaemia.

Given this it can be rationally concluded that the official statements of the IAEA and the WHO have manipulated their own data. Their representation of the effects of Chernobyl has little to do with reality.

The Chernobyl Forum also does not take into account that even UNSCEAR has estimated that the collective dose (the usual measurement for radiation damage) for Europe outside the region of the former Soviet Union is higher than the corresponding data for the Chernobyl region. The collective dose from the catastrophe was distributed to 53% throughout Europe, 36% throughout the affected regions in the Soviet Union, 8% in Asia, 2 % in Africa and 0.3% in America.

S. Pflugbeil pointed out already in 2005 that there were discrepancies between press releases, the WHO report and the source quoted in it (Cardis et al.). Up until now neither the Chernobyl Forum, IAEA nor the WHO have deemed it necessary to let the public know that, on the basis of their own analysis, a two to five-fold higher number of deaths due to cancer and leukaemia are to be expected as the figures they have published.

Even in 2011 – some 5 years on - no official UN organisation has as yet corrected these figures. The latest UNSCEAR publication on the health effects of Chernobyl does not take into account any of the numerous results of research into the effects of Chernobyl from the three countries affected. Only one figure – that of 6,000 cases of thyroid cancer among children and juveniles, and leukaemia and cataracts in liquidators – was included in there recent information to the media. Thus, in 2011 the UNSCEAR committee declared: On the basis of studies carried out during the last 20 years, as well as of previous UNSCEAR reports, UNSCEAR has come to the conclusion that the large majority of the population has no reason to fear that serious health risks will arise from the Chernobyl accident. The only exception applies to those exposed to radioiodine during childhood or youth and to liquidators who were exposed to a high dose of radiation and therefore had to reckon with a higher radiation-induced risk.

What IPPNW and the Society for Radiation Protection are calling for

1. Western governments and the International Atomic Energy Agency IAEO are collating data in the Chernobyl region on the results of the accidents. Although they are using sick people to gain insight into the effects of radiation on health, they are hardly contributing any medical help to the victims of the *super-GAU*[*]. From a physician's point of view, this is unacceptable.

> **We therefore demand that the German Federal Government, the other European States and the United Nations help those people suffering from the effects of radiation in the Chernobyl region effectively and on a long-term basis.**

2. Essential data on the course of events of the Chernobyl catastrophe and the subsequent effects on health are not publicly available. They are classified in both East and West. This makes independent scientific analysis of the effects of Chernobyl extremely difficult. The United Nations pro-nuclear organs such as the IAEO are attempting – with the use of questionable scientific methods – to minimise the effects of the catastrophe by inaccurate use of Chernobyl data. From a scientific point of view, this is unacceptable.

> **We therefore demand that the German Federal Government, the other European States and the United Nations allow scientists, associations and interested citizens unrestricted access to data concerning the Chernobyl catastrophe.**
>
> **We therefore demand that the German Federal Government, the other European states and the United Nations conduct continuous comparative and extensive epidemiological studies into the development of the health effects of Chernobyl, similar to the Hiroshima studies. Such studies should pay special attention to those groups exposed to radiation in the uterus during the Chernobyl accident, as well as to the 0 -9 year-olds and the 10 – 19 year-olds.**

3. The Chernobyl catastrophe, the meltdown in the US nuclear power plant in Harrisburg, and especially the current nuclear catastrophe in Fukushima, as well as a number of other near-accidents in both the East and the West have shown that a sizeable nuclear accident can happen at any time and in any place.

Many of the countries that rely on nuclear energy are extremely densely populated, Japan for example, which is 15 times more densely populated than the Chernobyl region was. The actual effects on health of Fukushima depend on how the catastrophe develops. There will be no clear picture of the extent of these effects until the coming years and decades. If there were a *super-GAU* in the Biblis nuclear power station in Germany the health and economic effects would also be tenfold those of Chernobyl due to the higher density of population in the Rhein-Main area. This shows that the use of nuclear energy is generally irresponsible.

> **We therefore demand that the German Federal Government and other European governments immediately shut down all their nuclear power stations by the most rapid means possible.**

---

[*] The term “super-GAU cannot adequately be translated into English. The abbreviation GAU (größte anzunehmende Unfall) means “Maximum Credible Accident” (MCA). A „super-GAU” goes beyond the bounds of credibility as we know it and has consequences not yet imagined nor understood. One possible translation would be “disaster beyond all expectation”.

Moreover, since the main purpose of the International Atomic Energy Agency (IAEA), according to their statute, is to promote the use of nuclear energy. and in view of the latest nuclear catastrophe in Fukushima it is time for the agency to seriously reconsider their statutory objective.

With respect to the effects of ionising radiation the WHO should cancel the binding agreement with the IAEA (1959) immediately. People's health should be the primary objective of WHO.

"Who does not know the truth, is simply a fool...
Yet who knows the truth and calls it a lie,
is a criminal."

B.Brecht: Galileo Galilei

1. Introduction

“Keep the public confused
on nuclear fission and fusion.”

US-Präsident Eisenhower

The Chernobyl catastrophe changed the world. Millions of people were made victims overnight. Huge stretches of land were made uninhabitable. The radioactive cloud spread all over the world. An understanding of the dangers of the use of nuclear energy grew in countless numbers of minds. Although in Western Europe we cannot forget how we were forced to think about what we ate and the sand our children played in, it was not until 1989 and “The Children of Chernobyl“ that a vague awareness of the far greater problems faced by Ukraine, Belarus and Russia began to grow. That solidarity and a willingness to help the victims of a catastrophe have now lasted for over 16 years, is a historically unique phenomenon.

This paper evaluates scientific studies that contain plausible indications of causal relationships between radiation following the Chernobyl catastrophe and greatly differing diseases and fatalities.

The authors of this paper attach importance to methodically accurate and comprehensible analyses. We have tried not to lose sight of the immense uncertainty inherent in every estimation in this field. We have taken published papers into consideration, but believe a general rejection of papers that have not been published in peer-reviewed journals is unjustified – Galileo Galilei and Albert Einstein would have had no chance of having their papers accepted by a peer-reviewed journal.

The loss of the Chernobyl nuclear power station meant first and foremost a huge direct economic loss. Radiation from Chernobyl fallout rendered large areas of land agriculturally unusable. Large and small businesses were given up, towns and villages abandoned, some were flattened by bulldozers. Millions of people were affected by radiation and lost all they had; apartments, houses, homes and social security. Many lost their jobs and were unable to find new ones, families split up because they could not tolerate being irradiated or ostracized because of their proximity to Chernobyl.

The quarrel about the number of victims of Chernobyl is as stupid as it is cynical. It is a well-known fact that the frequently quoted death toll of 31 is long past being valid. Even the number of ‘less than 50’ quoted in Vienna in September 2005 cannot possibly be true. It is an unacceptable sophistry only to recognize those who died of acute radiation disease, cancer or leukaemia as Chernobyl deaths. Following Chernobyl there was an obvious if not drastic increase of illness rates, but - typically - experts judging from a distance, without ever having treated any of the victims, do not generally accept these rates as having resulted from Chernobyl.

We refuse to haggle over whether a liquidator (clean-up worker) who received a high radiation dose, who has been an invalid for years, whose wife has left him, whose daughter is unable to find a boyfriend because of her father’s history, who suffers from diverse illnesses, the treatment of which has been given up by doctors, and who commits suicide, counts as a Chernobyl death or not.

In this way, the search for reliable data on the dead of Chernobyl has become an impossible task - in any case there are many, far too many. There is no comprehensive picture of the consequences of Chernobyl, not yet. The following overview aims at reminding you of all you already knew, aims at getting you to study carefully and critically the simplified and minimised accounts given by the large organizations and to be attentive to their large uncertainties and blank spaces.

The analysis of the effects of Chernobyl is impeded by a large number of very varying levels of facts:

In the first years after the catastrophe the Ministry of Health in the USSR and the KGB issued a large number of prohibitions that resulted in vital information necessary to assess the situation being either withheld, kept secret or falsified. As a result of this, irreplaceable knowledge and information has been lost and cannot today be replaced by theoretical calculations, no matter how complicated they may be.

Official accounts of the catastrophe were mainly dominated by structures operating at the ‘red table’-level in Moscow, far away from Chernobyl. These accounts determine and falsify parts of the discussion up to the present day.

Leading scientists from both East and West in the fields of radio medicine/radiation protection and reactor safety/nuclear technology were quick with appeasements. They were later not, or only partially, prepared to correct their earlier assessments in spite of the pressure of compelling facts.

The authorities responsible were overstretched by having to investigate into exposure to radiation suffered by liquidators and the population. Suitable equipment, specialists and time were not available. Uncertainties were amplified by deliberate falsification of documents.

The effects on health were different than had been expected.

There was considerable migration from the heavily to the less contaminated areas that is difficult to reconstruct today. Comparisons between contaminated and uncontaminated areas thus become questionable.

There are numerous accounts of attempts at ‘compensatory justice’: contaminated food was distributed in clean areas and clean food was transported to contaminated areas, or clean and contaminated food was mixed – further shrouding the differences between clean and contaminated areas, and no longer retraceable, but certainly having a considerable effect upon the health of the population.

None of the governments in Russia, Belarus or Ukraine are interested in a comprehensive survey of the consequences of Chernobyl. They prefer to close the case, gradually re-cultivate and resettle lost territory and pay as little as possible to the victims. They are not interested in discussions about the mistakes that have been made. There is a tendency amongst the International Atomic Energy Agency (IAEA) and the United Nations Scientific Committee for the Effects of Atomic Radiation (UNSCEAR) to support this position. Independent scientific studies in this area are not being financed and are being obstructed or prevented.

Stochastic radiation damage is difficult to prove. Large epidemiological studies are expensive and reference to necessary data requires access that is only possible with state assistance.

Age patterns in the three mainly affected countries have changed drastically: a drop in birth rates, increases in death rates and reduction of male life expectancy by about 10 years. This is not an easy aspect to take into account when comparing cancer and disease statistics.

The Soviet system collapsed about the same time as Chernobyl. The entire health system deteriorated as a result. Medication supplies, hospital equipment and the entire social and economic structure collapsed. There are a very few very rich people and an increasing number of desperately poor people who can only feed themselves by growing their own food – regardless of whether the earth is contaminated or not. All this has a negative effect on the state of health. Definitively attributing specific health damage either to the change in the system or to Chernobyl is difficult, if not impossible.

A great many doctors are overworked and frustrated by their poorly functioning and badly equipped health service, under these conditions they have little energy or interest for scientific questions. They feel that experts on Western committees only perceive the Chernobyl region as an experimental laboratory, leaving the doctors alone to treat the patients. These doctors are accordingly hesitant about giving information to Western scientists.

The authorities responsible in European countries only carry out investigations into the consequences of Chernobyl reluctantly or not at all – they presume that nothing would come of them, in view of comparatively small amounts of Chernobyl radiation fallout. Were something to come of them, the entire academic world would be turned upside-down. History tells us that such scientific paradigm changes are often met with bitter resistance from those in office.

A considerable obstacle in the search for something approaching the real story of Chernobyl is the language barrier. There are a lot of serious analyses from scientists in Russia, Ukraine und Belarus, which have been published in Russian and discussed at congresses in Russian. They are almost completely ignored In the Western world because, in the West, Russian is not a commonly-understood language and good translations cannot be paid for.

In this overview we have compiled scientific studies, which clearly show that the radioactive gases and particles (isotopes) released from the destroyed reactor in Chernobyl gave, and still give, rise to numerous serious illnesses, causing many people to become sick and die. The papers evaluated here comply with scientific standards and most have been published in scientific journals.

The overview is unavoidably incomplete and inconclusive, we can only touch on the various issues – the overview would otherwise have become far too long and unreadable.

We hope that in this way we are able to reactivate that which is already known, impart new knowledge and persuade others to carry on working independently and reflect upon how to help the victims of the catastrophe

Excursus: Key data from the Chernobyl Catastrophe[1]

Directly affected:
Belarus 2,500,000
Ukraine 3,500,000
Russia 3,000,000

135,000 were evacuated,
400,000 lost their homes and had to move away

3,000,000 people live in an area with > 185,000 Bq/m^2 (5 Ci/km^2)
270,000 people live in an area with > 555,000 Bq/m^2 (15 Ci/km^2)

Contaminated areas:
Belarus 30% 62,400 km^2
Ukraine 7% 42,000 km^2 und 40% of the forests
Russia, 1.6% (of the European part) 57,650 km^2

21,000 km^2 were contaminated with 185-555,000 Bq/m^2 (5-15 Ci/km^2) and
10,000 km^2 were contaminated with more than 555,000 Bq/m^2 (> 15 Ci/km^2)

Table: Population distribution in the radioactively contaminated areas of Ukraine, Belarus and Russia in 1995[2] (Residents)

Cs137 (kBq/qm)	Belarus	Russia	Ukraine	Total
37- 185	1,543,00	1,654,000	1,189,000	4,386,000
185- 555	239,000	234,000	107,000	580,000
555-1,480	98,000	95,000	300	193,300
Total	1,880,000	1,983,000	1,296,300	5,159,300

Areas in Europe that were contaminated with 37-185 kBq/m^2 Cs137:

Sweden 12,000 km^2
Finland 11,500 km^2
Austria 8,600 km^2
Norway 5,200 km^2
Bulgaria 4,800 km^2
Switzerland 1,300 km^2
Greece 1,200 km^2
Slovenia 300 km^2
Italy 300 km^2
Moldavia 60 km^2.

The Soviet Union established two guidelines for long-term measures:

- Inhabitants of areas with more than 1480 KBq/m^2 contamination had to be relocated.

1 UN-General Assembly A/50/418, 8.9.1995

2 UN Chernobyl Forum (EGE): Environmental Consequences of the Chernobyl Accident and Their Remediation: Twenty Years of Experience, Working Material, August 2005.

- Areas with more than 185 KBq/m^2 contamination were earmarked for dose-reduction measures, such as decontamination of the soil and substitution of the locally produced food with imported goods.

Number of liquidators:
800,000 (600,000 – 1,000,000) people
(compared with the size of the German army: approx. 275,000 persons)

We recommend the following background reading:

- "Strahlentelex" information service archive: www.strahlentelex.de
- Collection of Chernobyl Analyses, edited by T. Imanaka (Kyoto University, KURRI -KR-21 and KURRI-KR-79, English),
- Russian/English “International Journal of Radiation Medicine” published in Kiev (Ed. Prof. Angelina Nyagu, Kiev, ISSN 1562-1154) (complete collection available in the archives of the Society for Radiation Protection)
- Website «Physicians of Chernoby» www.physiciansofchernobyl.org.ua/eng/about.html
- Issues 5 (1992) and 24 (2003) from the reports of the “Otto Hug Strahleninstitut” - Bonn
- Edmund Lengfelder: “Strahlenwirkung Strahlenrisiko”, ecomed-V. 1990
- Roland Scholz: “Bedrohung des Lebens durch radioaktive Strahlung“, IPPNW-Studienreihe Band 4, 3rd edition, 1997
- The “Society for Radiation Protection” website: www.gfstrahlenschutz.de
- The IPPNW websites: www.ippnw.de and www.tschernobyl-folgen.de

2. Liquidators

Whether they did it voluntarily or under immense pressure, knowingly or in ignorance, the liquidators gave their lives and their health in order to limit the effects of the Chernobyl catastrophe. Through their commitment they were able to protect others from even worse harm. The liquidators have earned our respect. Unfortunately, not only did they fall victim to fire, toxins and radiation but also to an incompetent bureaucracy that has made it difficult, if not impossible, to establish the nature of their illnesses, to give them proper treatment and to support the liquidators either socially or financially.

Because of this, the exact levels of individual radiation exposure are not known (see also 10.4). What makes the situation even more difficult is the fact that the liquidators were brought from all over the Soviet Union, returning home at the end of their service. Today, the liquidators are spread throughout the whole of the former Soviet Union and the names and addresses of only about half of them are known. Only a small proportion of the liquidators were subject to regular examinations. Systematic use of confusing questions created deliberate misunderstandings, the question of whether certain diseases had been caused by exposure to radiation was interchanged with the question whether diseases had or could have appeared as a result of the Chernobyl catastrophe. In addition, use was made of the fact that links between non-cancerous illnesses and exposure to radiation, known for years to experts from the analysis of data from Hiroshima and Nagasaki, are hardly mentioned either in text and reference books or in reports from international bodies. An inadmissible chain of argument is often applied: non-cancerous – therefore not induced by radiation – therefore not a result of Chernobyl – end of debate.

Today a great number of liquidators are invalids and suffering from various illnesses simultaneously.[3] As early as September 1992, at the Second World Conference of Radiation Victims in Berlin, Prof. Georgiy F. Lepin from Minsk, Vice President of the Union of Chernobyl Liquidators, stated that 70.000 liquidators were invalids and 13.000 had died.[4]

The cancer researcher Ivanov found that in Russia the leukaemia risk among liquidators was twice as high if exposure had been between 150 and 300 mSv. This increased was observed in the period 1986 – 1996, but not between 1996 and 2003. He also found an increased incidence of cerebrovascular diseases, especially among those who had received the dose of 150 mSv in less than six months[5].

The Russian cancer researcher Ivanov established for Russian liquidators a relationship between the risk of dying and the radiation dose[6]. In a cohort of 47,820 he found a significantly increased mortality risk among those that had received a medium radiation dose of 128 mGy. The excess relative risk (ERR) in deaths caused by solid malignant neoplasms

3 Edmund Lengfelder, Christine Frenzel: 15 Jahre nach Tschernobyl, Folgen und Lehren der Reaktorkatastrophe [15 years after Chernobyl, effects of and lessons from the reactor catastrophe]. Otto Hug Strahleninstitut – MHM, Information, September 2001. (German)

4 Strahlentelex 138-139/1992, 8, CIS: Bereits 13.000 tote Liquidatoren [13,000 liquidators already dead]. (German)

5 Grosche, B (2007): BfS workshop on Chernobyl Health Consequences, 9 – 10 Nov, 2006 http://www.physiciansofchernobyl.org.ua/eng/Docs/Estimation%20of%20radiation%20rhsk,%20Munhen%202006.pdf

6 V.K. Ivanov et al. (2009): Mortality of the Chernobyl Emergency Workers: Analysis of Dose Response by Cohort Studies Covering Follow-Up Period of 1992–2006; in: Radiation Health Risk Sciences, 2009, Part 4, S. 95 -102

was 0.74/Gy, in deaths caused by cardiovascular disease it was 1.01 per GY, for all causes of death the ERR was 0.42/Gy.

In 2002, the Ukrainian Ministry of Health announced that the proportion of liquidators registered as sick had risen between 1987 and 2002 from 21.8 to 92.7 percent.[7]

On the 19th anniversary of the catastrophe, the Ukrainian embassy in Paris announced that 94 percent of the liquidators were sick.

In autumn 2005, doctors in Kiev reported that approximately 2,000 liquidators were invalids, today the number is 106,000. There is no comparable data for Russia and Belarus.

There are registers of liquidators (as far as they are known) in several of the former Soviet Republics. 10,000 liquidators are registered in Uzbekistan. Within 5 years following the catastrophe, 8.3 percent had become invalids. In the 10 years following the catastrophe, 73.8 percent of the liquidators had become invalids, more than 500 had died. 68.8 percent are suffering from 4-5 illnesses simultaneously. When the morbidity rates of 960 liquidators were compared with those of 200 people from the normal population they were found to have significantly higher rates of dyscirculatory encephalitis, neurocirculatory dystonia, chronic gastritis, chronic inflammation of rhe duodenal mucous membrane, chronic hepatitis, gastric and duodenal ulcers, chronic cholecystitis, arterial hypertension, ischemic heart disease, chronic bronchitis, chronic pyelonephritis, chronic inflammation of the prostate gland and degenerative diseases of the vertebral column.[8] Horishna (2005) examined mortality in Ukrainian male liquidators and found that between 1989 and 2005 there was a five-fold increase from 3.0 to 16.6/per 1,000 compared to the normal male population of working age of 4.1 60 6.0.[9]

In reaction to the Chernobyl Forum Meeting (of UN organisations) held in Vienna at the beginning of September 2005, Tetyana Amosova, Ukraine's Deputy Minister for Emergencies said that in Ukraine more than 17,000 families were receiving state benefits because the father had died following service as a liquidator.[10]

After considering information from different sources, Edmund Lengfelder estimates that 50,000 to 100,000 liquidators have died to date.[11]

On the basis of various studies A.Yablokov[12] estimated that 112,000 to 125,000 liquidators died by 2005. Both Russian and Ukrainian mortality studies identify non-malignant diseases and severe multimorbidity as the principal cause of liquidator death, together with death due to malignant disease. This type of multimorbidity is classified as radiation-induced premature senescence. How can premature aging following ionising radiation come about?

---

7 Nucleonics Week, May 2, 2002. Reproduced from Oda Becker, Helmut Hirsch 2004: 18 Jahren nach Tschernobyl, Sanierung des Sarkophags. Wettlauf mit der Zeit, [18 years after Chernobyl, restoration of the sarcophagus, and the race against time]. Published by Greenpeace e. V. Hamburg in April 2004.

8 Sh. A. Babadjanova and A.S. Babadjanov: Health of Liquidators in the Remote Period after the Chernobyl Accident; International Journal of Radiation Medicine 2001, 3(3-4): 71-76

9 Horishna, O.V. Chernobyl Catastrophe and Public Health. Results of Scientific Investigation, in: Yablokov, AV (2009): Mortality after the Chernobyl Accident, in: Ann N Y Acad Sci, 2009 Nov;1181:192-216.

10 Peter Finn: Chernobyl Report Reignites Debate; Washington Post 24.9.2005

11 E. Lengfelder et al.: 20 Jahre nach Tschernobyl: Erfahrungen und Lehren aus der Reaktorkatastrophe [20 years after Chernobyl: Experience and lessons from the reactor catastrophe] (German) Information from the Otto Hug Strahleninstitut – MHM, February 2006.

12 Yablokov, AV (2009): Mortality after the Chernobyl Accident, in: Ann N Y Acad Sci, 2009 Nov;1181:192-216.

2.1 Premature aging process as a result of radiation exposure

Numerous studies from Russia, Belarus and Ukraine show that ionising radiation accelerates the aging process. In an overview the Ukrainian scientists Bebeshko et. al show that accelerated senescence brought about by ionising radiation could provide a model for the normal process of aging[13].

"Ionising radiation influences both cell structure and cell function at molecular and genetic levels. The effects of ionising radiation on cells and cellular changes are the same or similar to biological mechanisms at work during the normal aging process: reactions of free radicals, the DNA repair process, changes in the functioning of the immune system, changed mechanisms in fat metabolism, systemic changes to the nerve system." (Bebeschko et al, 2006)

Prospective epidemiological studies on atomic bomb survivors showed that life expectancy following ionising radiation was significantly shortened because of non-cancerous diseases. [14]

Research work on liquidators from Russia, Belarus and Ukraine also found that illnesses among survivors occurred 10–15 years earlier than would normally be expected due to the normal aging process.[15] The following can be observed:

- Accelerated aging of the blood vessels – especially of the brain – and the coronary vessels[16]
- Senile cataracts, arteriosclerosis of the fundus oculi blood vessels and premature myopia.[17]
- Loss of the higher intellectual cognitive functions as a result of damage to the central nervous system[18]
- Loss of stability of the antioxidant system (which is responsible for repairing cell chromosome damage brought about by external damaging factors) [19]

P. Fedirko reported on special radiation-specific eye diseases such as radiation cataracts (that do not occur below a certain threshold level) and retinopathies. Taken together with the non-

13 Bebeshko, V., Bazyka, D., Loganovsky, K., Volovik, S., Kovalenko, A. et al.(2006) Does ionizing radiation accelerate the aging phenomena? International Conference. Twenty Years after Chernobyl Accident: Future Outlook. April 24 -26,2006, Kiev, Ukraine. Contributed Papers (HOLTEH, Kiev) 1:pp.13-18 (//www.tesec-int.org/pdf.)

14 Cologne, J.B., Preston D.L. (2000); Longevity of atomic-bomb survivors, Lancet 356 (9226): 303-307

15 Yablokov, A., Nesterenko, V., Nesterenko, A. (2009): Chernobyl – Consequences of the Catastrophe for People and Environment, Annals of the New York Academy of Sciences, Vol. 1181, Boston, Mass.

16 Ivanov, V., Tsyb, A. et al (2005); The radiation risks of cerebrovascular diseases among liquidators, Radiatsionnaia biologiia, radioecologiia / Rossiiskaia akademiia nauk; VOL: 45 (3); p. 261-70 /2005 May-Jun/

17 Fedirko, P. (2006); Augenerkrankungen bei Aufräumarbeitern, Schädigungen des Augenhintergrunds, der Makula, des Glaskörpers und der Linse, in: http://www.strahlentelex.de/20_Jahre%20_nach_Tschernobyl_Abstracts_GSS_Berlin-Charite_2006.pdf

18 Kholodova, N. (2006); Langzeitveränderungen des Nervensystems von Liquidatoren, die 1986/1987 im Einsatz waren, in:http://www.strahlentelex.de/20_Jahre%20_nach_Tschernobyl_Abstracts_GSS_Berlin-Charite_2006.pdf, Loganovsky, K., Yuriyev, K. (2001): EEG Patterns in Persons Exposed to Ionizing Radiation as a Result of the Chernobyl Accident, J Neuropsychiatry Clin Neurosci 13:441-458, November 2001 http://neuro.psychiatryonline.org/cgi/content/short/13/4/441

19 Burlakova, E. (2006): Naturwissenschaftliche Prinzipien von Schadwirkungen der Strahlung auf den Gesundheitszustand der Bevölkerung, in: http://www.strahlentelex.de/20_Jahre%20_nach_Tschernobyl_Abstracts_GSS_Berlin-Charite_2006.pdf

radiation-specific conditions (but which occur more frequently with radiation) a picture emerges of radiation-caused premature aging of the eye.

Elena B. Burlakova et al. irradiated test animals with gamma rays from caesium-137 in low dose rates of 0.041 6, 0.004 16 and 0.000 416 milligray per minute (mGy/min) and total doses of 0.000 6 to 1.2 gray (Gy). They then examined various biophysical and biochemical parameters from the genetic and membrane apparatus of cells in organs taken from the irradiated animals. On the whole, an unusual dose dependency was shown. The dose/effect relationships were not uniform, they were non-linear and of differing character. Low-dose exposure generally increased the effect of damaging factors. The effects of irradiation were dependent upon the output parameters of the bio-object. Within certain dose intervals fractionated low-dose radiation is more effective than one single acute irradiation. The investigations by Burlakova et al. showed changes following irradiation, not only in animals but also in humans, in the structure and in the properties of the cell membranes, the activity of antioxidantives and regulating enzymes and in the concentrations of the antioxidants, thereby verifying the so-called Petkau effect[20] and going beyond it. Antioxidants such as tocopherol, vitamin A and ceruloplasmine decrease, free radicals and their by-products increase, membranes demonstrate more rigidity and the liquidity of the lipid and protein components change. All in all, according to Burlakova, ratios change following irradiation in the same way as they do in the aging process. “The liquidators”, said Burlakova, “have aged 10 to 15 years earlier than the rest of the population. The same effect can also be shown on animals and in their case one cannot speak of radiation angst or radiophobia.” As a possible therapy, Frau Burlakova recommends antioxidants. However, exact dosage is essential as too much could achieve exactly the opposite effect. In animal tests, they have at least succeeded in slowing down the progress of the disease in the initial stage of leucosis by 80 to 250 days.[21]

20 Abram Petkau, Canadian physician and biophysicist. In1972 he made an important observation regarding the behaviour of membranes exposed to radiation. His original work is difficult to obtain. Credit goes to Ralph Graeub (Switzerland), for drawing attention to Petkau’s work in a number of books, which have now been translated into a number of languages. Ralph Graeub: Der Petkau-Effekt und unsere strahlende Zukunft [The Petkau-Effect and our radiant future], Zytglogge-Verlag 1990.

21 Strahlentelex 454-455/2005, 1ff, Krebs, Leukämie und Geisteskrankheiten finden russische, weißrussische und ukrainische Forscher jetzt vermehrt bei ihren Mitbürgern [Cancer, leukaemia and mental illnesses are being found more frequently by Russian, Belarussian and Ukrainian researchers amongst their fellow citizens].(German).

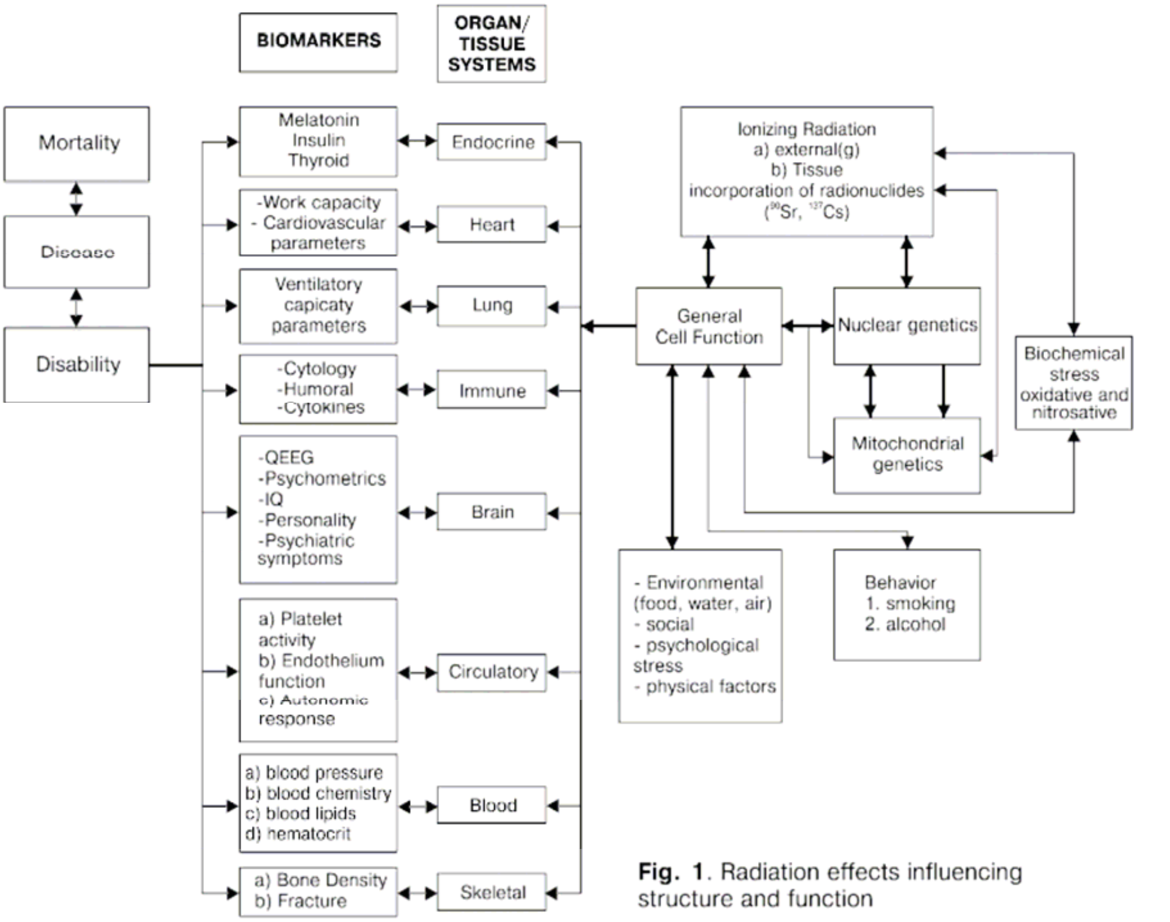


Fig. 1. Radiation effects influencing structure and function

The complex mechanisms of premature senescence acc. to Bebeshko and Loganovsky et. al[22]

2.2 Cancer and leukaemia

A statistically significant increase of leukaemia illnesses has been found amongst those Russian liquidators who were in service in Chernobyl in 1986 and 1987.[23]

According to Russian sources, a great number of liquidators are now invalids and suffering, amongst other things, from leukaemia, lung cancer and other tumours.[24]

22 Does Ionizing Radiation accelerate Aging phenomena? V. Bebeshko, D. Bazyka, K. Loganovsky, S. Volovik, A. Kovalenko, O. Korkushko, K. Manton

23 United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA): 3rd International Conference, Health Effects of the Chernobyl Accident, Results of 15-Year-Follow-Up Studies, Kiev, 4 to 8 June 2001, Conclusions.

24 Edmund Lengfelder, Christine Frenzel: 15 Jahre nach Tschernobyl, Folgen und Lehren der Reaktorkatastrophe [15 years after Chernobyl, effects of and lessons from the reactor catastrophe], (German) Otto Hug Strahleninstitut – MHM, Information, September 2001. (German)

According to Julia V. Malova the liquidators mainly suffer from cancer of the lung and the respiratory tract.[25]

Okeanov[26] et al. showed that there was a significant increase in cancer of the lung, colon, bladder, kidney and thyroid gland amongst Belarussian liquidators compared to a control population (Vitebsk area) ($p<0.05$).[27] The relative risk of liquidators in comparison to the control population (Vitebsk area) did not – with the exception of thyroid cancer – increase significantly until recent years (1997-2000), i.e. following a 12-15 years latency period. The average annual increase for all types of cancer amongst the liquidators was 5.5 percent, but only 1.5 percent ($p<0.05$) in the comparatively clean areas of Vitebsk in northern Belarus. Cancer of the colon increased by 9.4 percent amongst liquidators, but only by 3.2 percent ($p<0.05$) amongst adults in the Vitebsk area. Renal cancer increased by 8.0 percent and 6.5 percent ($p<0.05$) and cancer of the bladder by 6.5 percent and 3.8 percent $p<0.05$) respectively.

Liquidators who had been exposed to high doses of radiation over long periods of time developed cancer significantly more often. The cancer rate was significantly higher amongst liquidators living in the heavily contaminated areas of the Gomel region.

2.3 Damage to the nervous system

As early as autumn 1990, the Belarussian psychiatrist Kondrashenko (Minsk) warned of the effects of the catastrophe on the central nervous system. He reported on organic changes to the brain amongst people exposed to radiation.[28] Decade-old reports exist on damage to nerves and senses as well as on headaches suffered by villagers living in the vicinity of the nuclear weapons testing areas of Semipalatinsk (Kazakhstan). This information was not taken seriously in the West. Instead, in the aftermath of Chernobyl, the phenomenon of "radiophobia"[29] was invented, insinuating that many of the health problems that arose in the aftermath of Chernobyl were not due to radiation, but to an unfounded hysterical reaction in the population.[30]

Investigations carried out by Nadejda Gulaya, of the Pallaguin Institute for Biochemistry in Kiev, on nerve cells from both humans and animals in the Chernobyl region, show that the

---

25 Julia V. Malova, Russian Scientific Centre of Radiology, Psychological Rehabilitation, Moscow, 18. UICC International Cancer Congress Oslo 2002, Abstract No.O 183: Cancer patients - the participants of the liquidation of the consequences of the Chernobyl explosion: the aims and the recourses of the psychological rehabilitation. Strahlentelex 374-375/2002, 9, Verminderte Hirnfuktionen bei Katastrophenhelfern [Reduced brain function in disaster aid workers]. (German)

26 Professor A.E. Okeanov is now prorector for research at the International Sakharov Environmental University in Minsk. He co-founded the Belarussian cancer registry in 1973 and in the following years had access to the data banks of all twelve oncological clinics in Belarus as well as to the data from 95,000 liquidators.

27 A. E. Okeanov, E. Y. Sosnovskaya, O. P. Priatkina, A national cancer registry to assess trends after Chernobyl accident, Swiss Medical Weekly 2004, 134: 645-649.

28 Valentin Timofeevic Kondrashenko: die Besonderheiten neuro-psychischer Störungen im Grenzbereich zwischen gesund und krank bei Personen, die in den Gebieten mit erhöhter radioaktiver Verseuchung leben – Kinder von Tschernobyl [The characteristics of neuropsychological disorders in the borderland between health and sickness amongst people living in areas with increased radioactive contamination: children from Chernobyl] – Erstes Berliner Koordinierungstreffen, 27.-28.10.1990, Berlin; Enclosure 4, 1-5. (German)

29 Phobia is an excessively inadequate anxiety reaction, prompted by a particular situation und usually associated with an understanding of its unfoundedness. Definition in Pschyrembel: Clinical dictionary, 257th Edition, Berlin, New York, 1994 (German)

30 Sebastian Pflugbeil, Strahlentelex 374-375/2002, 9, Ergänzender Hinweis [Additional comment](German).

main cause of observed damage to the nervous system is much less due to the fear of radiation but actually caused by serious organic radiation damage.[31]

48 percent of the post-mortems carried out on liquidators who have since died show that death was due to a blood clot or problems with the blood circulation. Cancer, at a rate of 28 percent, takes only second place as cause of death. Barely 20,000 of the Red Army soldiers ordered into the clean-up areas are taking part in treatment or research programs. Most of them are seriously ill, both psychologically and physically. They are finding it difficult to deal with their traumatic experiences.[32]

Andreas Arnold from the ENT clinic at the Universitäts-Inselspitals in Bern came to the conclusion that symptoms of dizziness suffered by many liquidators were due to lesions in the central nervous system.[33]

A lot of drivers had to give up their jobs following deployment as liquidators because they kept going to sleep at the wheel.[34]

2.4 Psychological disorders

In their January 13, 1993 issue, the Moscow Times quoted a study showing that 80 percent of 1,600 liquidators examined in a clinic in St. Petersburg were suffering from serious psychological problems.[35] 40 percent of victims seeking medical help were found to be suffering from neural disorders such as loss of memory.

Tens of thousands of liquidators suffer from dysphasia, depression, memory dysfunction and concentration problems. [36] Julia V. Malova, psychiatrist at the Moscow Centre for radiation diseases where she is especially concerned with liquidators' health, explained: "Our theory is that, in some way, the flow of blood to the brain has been, and possibly still is, reduced." These types of illnesses occur significantly more often amongst liquidators than the rest of the population.

Another complex of symptoms found particularly often amongst liquidators is the Chronic Fatigue Syndrome (CFS). According to Loganovsky (2000, 2003) the diagnostic criteria for CFS apply to 26% of people that received a radiation exposure of less than 0.3 sievert. The frequency of CFS has decreased from 65.5% of liquidators in 1990-1995 to 10.5% in 1995-

31 Strahlentelex 136-137/1992, 8, Tschernobyl, Nervenschäden nach radioaktiver Strahlung [Chernobyl, nerve damage following nuclear radiation]. Detailed information below.

32 Julia V. Malova, Russian Scientific Centre of Radiology, Psychological Rehabilitation, Moscow, 18. UICC International Cancer Congress Oslo 2002, Abstract No. O 183: Cancer patients - the participants of the liquidation of the consequences of the Chernobyl explosion: the aims and the recourses of the psychological rehabilitation. Strahlentelex 374-375/2002, p. 9, Verminderte Hirnfunktionen bei Katastrophenhelfern. [Reduced brain function in disaster aid workers] Die tageszeitung (taz) of 16. July 2002.

33 A. Arnold, R. Häuser: Vestibular syndromes, +/- associated with Cochlear Damage, in Liquidators; PSR/IPPNW-Switzerland, Congress "Gesundheit der Liquidatoren" [Liquidator Health] in Bern, 12.11.2005.

34 S. Pflugbeil, Reisegespräche [Conversations whilst travelling].

35 Strahlentelex 146-147.1993, 4f., Moskau: Nervenkrank durch Tschernobyl. [Moscow: psychological illness due to Chernobyl]. Based on a report in the Frankfurter Rundschau. (German)

36 Julia V. Malova, Russian Scientific Centre of Radiology, Psychological Rehabilitation, Moscow, 18. UICC International Cancer Congress Oslo 2002, Abstract No. O 183: Cancer patients - the participants of the liquidation of the consequences of the Chernobyl explosion: the aims and the recourses of the psychological rehabilitation. Strahlentelex 374-375/2002, 9, Verminderte Hirnfuktionen bei Katastrophenhelfern [Reduced brain function in disaster aid workers] (German). Die tageszeitung (taz) July 16, 2002.

2001, while the so-called Metabolic Syndrome X (MSX) has simultaneously increased from 15 to 48.2%. CFS and MSX are regarded as being symptomatic of the development of other neuro-psychiatric and physical illnesses. CFS is also regarded as being synonymous with environmentally influenced vulnerability to, and an indication of the onset of neuro-degeneration, of cognitive impairment and neuro-psychiatric disturbances. The left side of the brain appears to be more vulnerable than the right side.

P. Flor-Henry reported that the observed depressive status-displays and clinical syndromes such as schizophrenia and CFS, that prevail amongst a high percentage of the liquidators, are accompanied by organic changes in the brain, mainly in the left cerebrum (by right-handers) and can be objectified with the aid of the electroencephalogram (EEG). They believe this indicates that various neurological and psychiatric illnesses can be caused by exposure to radiation levels between 0.15 and 0.5 Sievert.

Symptoms are also expressed in the form of the premature aging phenomenon. These neurological clinical pictures appear earlier, and more severely, the younger the victim was at the time of exposure to radiation.

Flor-Henry also reported that similar clinical syndromes, which are accompanied by EEG changes in the left cerebrum, have also been observed amongst liquidators suffering from acute radiation syndrome. It surprises him that neither these psychiatric illnesses nor EEG-changes have appeared amongst the Russian veterans of the lost war in Afghanistan. These soldiers had, after all, been subject to enormous levels of traumatic stress but, unlike the Chernobyl liquidator, had not been treated as heroes in their homeland. However, with the aid of magnetic resonance imaging (MRI), EEG and positron emissions tomography (PET) it is possible to prove that cerebral changes in Chernobyl liquidators and veterans of the first Gulf War, as well as the war in Bosnia, are very similar. Flor-Henry attributes this to the use of projectiles containing uranium (depleted Uranium, DU), in both the Gulf and Bosnian wars, which released uranium-238-oxide dust into the air upon impact, allowing it to be inhaled. He has found that those victims who were exposed to uranium-238 developed similar neuropsychiatric syndromes as the atom bomb survivors of Japan in 1945.

A neurological study by L.A. Zhavoronkova from the Institute of Neurophysiology of the Russian Academy of Sciences, and N.B. Kholodova from the Institute of Radiology, Ministry of Public Health[37], found liquidators' higher cognitive and psychological functions to be impaired: sluggishness of thought, increased fatigue, reduced visual and verbal memory functions, and diminished higher motor functions. The findings are similar to those for premature aging.

Another study within the framework of the French-German Chernobyl Initiative, using standardised structured psychiatric interviews (Romanenko et al. 2004), put the extent of mental disturbance amongst liquidators at 36% and at 20.5% for the entire Ukrainian population. The increased frequency of depressions turned out to be really dramatic: 24.5% amongst liquidators and 9.1% for the general population in Ukraine (Demyttenaere et al. 2004)

A progressive increase in neuro-psychiatric disturbances has also been noticed amongst liquidators who worked in the restricted zone around Chernobyl from 1986 until 1987, and in

---

37 ISSN 0362_1197, Human Physiology, 2010, Vol. 36, No. 4, pp. 388–398. © Pleiades Publishing, Inc., 2010.

Original Russian Text © L.A. Zhavoronkova, A.P. Belostocky, M.A. Koulikov, S.V. Kuptsova, N.B. Kholodova, L.B. Oknina, 2010, published in Fiziologiya Cheloveka, 2010, Vol. 36, No. 4, pp. 22–33.

particular amongst those who spent 3 to 5 years there. The increased frequency of neuro-psychiatric disturbances amongst the workforce who had been there since 1986/1987 and received radiation doses of more than 250 millisievert (mSv), was put at 80.5% and for radiation doses under 250 mSv at 21.4% ($p<0{,}001$) (Nyagu et al. 2004). Loganovsky reported that since 1990, there has been an increase of schizophrenic disease: 5.4 per 10,000 amongst the workforce as compared to 1.1 per 10,000 in the general population. The schizophrenia incident rate amongst the people living and working in the Chernobyl zone rose 2.4-fold in the period 1986-1997 and 3.4-fold in the period 1990-1997 (Loganovsky & Loganovskaya, 2000) as compared to the rest of the Ukrainian population.

2.5 Heart and circulatory diseases

A study by the World Health Organisation (WHO) found a significant increase of heart and circulatory diseases amongst liquidators in the Russian Federation.[38]

According to Russian information, a large proportion of liquidators are now invalids and suffer, amongst other things, from heart and circulatory problems. [39] Ivanov (1999) found a 40% increased risk of cardiovascular disease for Russian liquidators.[40]

D. Lazyuk examined cardiovascular diseases amongst liquidators from Belarus.[41] His study showed that, in the observation period 1992 to 1997, there was a huge increase in cases of fatal cardiovascular disease amongst liquidators (22.1 percent) compared with the general population (2.5 percent). It is under debate as to whether this is caused by radioactive damage to the blood vessels.

3.4 Other illnesses

A study carried out by the World Health Organisation (WHO) of liquidators in the Russian Federation, found a statistically significant increase in blood and endocrinal diseases, as well as a significant increase in gastro-enteritis, infections and parasite-related disease.[42]

According to Russian information, many invalided liquidators suffer from inflammatory gastro-enteritis.[43]

---

38 The Radiological Consequences of the Chernobyl Accident, European Commission and Belarus, Russian and Ukrainian Ministries on Chernobyl Affairs, Emergency Situation and Health, Report EUR 16544 EN, 1996.

39 Edmund Lengfelder, Christine Frenzel: 15 Jahre nach Tschernobyl, Folgen und Lehren der Reaktorkatastrophe [15 Years after Chernobyl, effects of and lessons from the reactor catastrophe]. Otto Hug Strahleninstitut – MHM, Information, September 2001. (German)

40 Ivanov.V. K. et al.Radiation-epidemiological analysis of the incidence of non-cancer diseases among Chernobyl liquidators, in: “Radiation & Risk”, 1999, Issue 11

41 Dimitri Lazyuk: Cardiovascular Diseases among Liquidators and Populations; PSR/IPPNW-Swiss Congress "Health of Liquidators" in Bern, November 12, 2005.

42 The Radiological Consequences of the Chernobyl Accident, European Commission and Belarus, Russian and Ukrainian Ministries on Chernobyl Affairs, Emergency Situation and Health, Report EUR 16544 EN, 1996.

43 Edmund Lengfelder, Christine Frenzel: 15 Jahre nach Tschrnobyl, Folgen und Lehren der Reaktorkatastrophe [15 Years after Chernobyl, effects of and lessons from the reactor catastrophe], Otto Hug Strahleninstitut – MHM, Information, September 2001.

Pavel Fedirko from the Research Centre for Radio Medicine at the Academy of Medical Sciences in Ukraine reported that, of the 5,200 liquidators he examined, 95% suffer from eye disease – amongst other things, cataracts, macula degeneration and chronic conjunctivitis.[44]

For many years now Elena Burlakova has been looking into the effects of low dose radiation at cell level.[45] [46] [47] In a costly study involving liquidators and sections of the population, the biochemist found that low dose radiation destroyed the protective anti-oxidants-system, particularly of children and young adults under 30. "People age faster", said Burlakova.[48]

In the following overview, Yarilin shows how the incidence rates of 12 groups of illnesses amongst liquidators had changed. It is worth looking at how these values have multiplied over a period of just seven years:[49]

Table: Incidence of 12 morbidity groups amongst liquidators (from 100,000 persons)[50]

Illness/organ group	1986	1987	1988	1989	1990	1991	1992	1993
Infections and parasites	36	96	197	276	325	360	388	414
Tumours	20	76	180	297	393	499	564	621
Malignant growths	13	24	40	62	85	119	159	184
Endocrinal sytem	96	335	764	1.340	2,020	2,850	3,740	4,300
Blood & blood-producing organs	15	44	96	140	191	220	226	218
Psychological changes	621	9,487	1,580	2.550	3,380	3,930	4,540	4,930
Nervous system & sense organs	232	790	1,810	2.880	4,100	5,850	8,110	9,890
Circulation	183	537	1,150	1.910	2,450	3,090	3,770	4,250
Respiratory System	645	1,770	3,730	5.630	6,390	6,950	7,010	7,110
Digestive Organs	82	487	1,270	2.350	3,210	4,200	5,290	6,100
Urogenital System	34	112	253	424	646	903	1,180	1,410
Skin and subcutaneous tissue	46	160	365	556	686	747	756	726

2.7 Children of liquidators

An unusually high number of mutations have been found in the genetic material of the children of liquidators. Scientists from Haifa University have found changes in these children

44 Pavel Fedirko: Eye Diseases among Liquidators: Lesions of Fundus and Macula, Vitreous and Lens; PSR/IPPNW-congress "Gesundheit der Liquidatoren" in Bern, 12.11.2005.

45 Elena B. Burlakova, V.I. Naidich (ed.): The Effects of Low Dose Radiation; VSP Utrecht, Boston, 2004.

46 Elena B. Burlakova (ed.): Low Doses of Radiation, Are They Dangerous?; NOVA Sc.Publ. Huntington, N.Y., 2000.

47 . Б. Бурлакова: Последствие Чернобыльской датастрофы: Здоровье человека; Москва, 1996.

48 Elena Burlakova: Ionizing Radiation and Premature Aging; PSR/IPPNW-congress "Gesundheit der Liquidatoren" in Bern, 12.11.2005.

49 A.A. Yarilin: Immunological Disturbances; in: Chernobyl Catastrophe Consequences: Human Health, Moscow, 1996, 68-96, Russ. In: Burlakova et al.: Peculiarities of Biological Action of Low Irradiation Doses and their Probable Relation to the Health Status of Participants of Chernobyl Accident Liquidation; in: Imanaka (ed.): KURRI-KR-21, 1998, 223-234.

50 A.A. Yarilin: Immunological Disturbances …

that were seven times greater than the number found in the genomes of siblings, who were conceived prior to service in Chernobyl. These mutations do not occur in connection with serious illnesses. Their increased frequency, however, indicates that they will be passed on to future generations. An increase in the number of mutations was found, particularly in children who were conceived immediately following the accident. The numbers decrease in relation to the length of time following the accident. The fathers of the children had received radiation doses of between 50 and 200 milliSievert. That is approximately the amount that nuclear power station workers receive during a10-year period.[51]

Professor Sheban and his colleague Prilebslaya looked into the development of thyroid cancer in the children of liquidators. A cohort of 700 persons was examined in the study. It was shown that the incidence of thyroid diseases was significantly greater for children of liquidators than for children of unexposed parents.[52] This phenomenon raises questions for which there are no satisfactory answers.

Tsyb reported a significant rise in the frequency of all types of illnesses amongst the children of liquidators compared to Russian children from Obninsk (1994-2002). More frequent amongst liquidator's children were, in particular, cancer and leukaemia, congenital deformations, endocrinal and metabolic illnesses as well as mental disturbances and behavioural problems. Within a number of years there was also a significant increase in cases of disease of the urogenital, the neural system and the sense organs. The rate of illness was particularly high in 1999.[53]

---

51 Weinberg HS, Korol AB, Kirzhner VM, Avivi A, Fahima T, Nevo E et al. Very high mutation rate in offspring of Chernobyl accident liquidators. Proc Biol Sci 2001; 268 (1471):1001-5, Proceedings the Royal Society of London (Bd. 268, 1001).

52 Angelika Claußen: Die Katastrophe von Tschernobyl. Eine Annäherung bei einem Besuch in der verbotenen Zone [The Chernobyl catastrophe. Encounters made during a visit in the forbidden zone], IPPNW-Forum 96/2005, 6f. (German)

53 A.F. Tsyb et al.: General characterization of health in first-generation offspring born to liquidators of the Chernobyl NPP accident consequences; Int. J. Rad. Med. 2004, 6(1-4): 116-121.

3. Infant mortality

During the last century, infant mortality had gradually decreased. This was due to a number of factors – the most important being improved medical care, vaccinations and improved living conditions. Every country pays particular attention to the development of infant mortality rates and proudly presents any drop in death rates as proof of an efficient health service. Therefore, many countries have several decades worth of reliable data on infant mortality.

From the period of atmospheric nuclear weapons testing it is known that the infant mortality parameter is sensitive to radioactivity. It therefore comes as no surprise that there are now numerous studies showing that infant mortality is not only higher in the vicinity of Chernobyl, but also further away - in Europe. In the textbooks there is nothing to be found on this yet, but it is to be found in a number of different journals.

3.1 The Chernobyl region

In1987 - the year following the reactor accident - there was an increase in the number of stillbirths and perinatal deaths in the Ukrainian and Belarussian areas around Chernobyl. Alfred Körblein comes to the conclusion that this is connected to caesium exposure. There has been a second increase in perinatal mortality in Belarus and in Ukraine since 1989. In the case of this second increase, a link to exposure to strontium of pregnant women has beeen established.[54]

In Ukraine, the "strontium effect" is more dominant than the "caesium effect". It has become clear from the difference between the expected and the actual rate of perinatal mortality that in three Ukrainian regions - Zhytomyr, rural Kiev and Kiev city - alone, 151 children died in 1987 mainly due to the caesium effect, whereas between 1988 and 1991 712 children died as a result of the strontium effect. This means that following Chernobyl there was a total of 863 perinatal deaths in the area as a result of caesium and strontium exposure.[55]

Another study registered increased perinatal mortality and other unfavourable pregnancy outcomes in two heavily contaminated areas of Ukraine close to the Chernobyl reactor.[56]

In 1987 in Belarus there was a greater increase (not significant) in perinatal mortality in the highly contaminated region of Gomel than in other areas of Belarus.[57] However, what is decisive for A. Körblein is the fact that, in the first half of the 1990s, perinatal mortality in the area of Gomel was about 30 percent higher than in the rest of the rural areas of Belarus. This is possibly a delayed effect following increased absorption of strontium during puberty. The analysis showed that between 1987 and 1998 than were 431 more children died in the Gomel area than could have been expected from the data of comparable areas.[58]

---

54 A. Körblein: Strontium fallout from Chernobyl and perinatal mortality in Ukraine and Belarus. Radiats Biol Radioecol. 2003 Mar-Apr;43(2):197-202. Strahlentelex, 398-399/2003, 5.

55 Alfred Körblein 2005: Studies of pregnancy outcome following the Chernobyl accident. Unpublished.

56 V.I. Kulakov, T.N. Sokur, A.I. Volobuev, I.S. Tzibulskaya, V.A. Malisheva, B.I. Zikin, L.C. Ezova, L.A. Belyaeva, P.D. Bonartzev, N.V. Speranskaya, et.al.: Female reproductive function in areas affected by radiation after the Chernobyl power station accident, Environ Health Perspect. 1993 Jul;101 Suppl 2:117-123. reproduced by: Alfred Körblein 2005: Studies of pregnancy outcome following the Chernobyl accident. Unpublished.

57 Alfred Körblein: Säuglingssterblichkeit nach Tschernobyl [Infant mortality since Chernobyl]. Report no. 24/2003 Otto Hug Strahleninstituts, 6-34. (German)

58 Alfred Körblein 2005: Studies of pregnancy outcome following the Chernobyl accident. Unpublished.

Whilst the effect of radioactive caesium was essentially limited to 1987, the strontium effect continued until the end of the investigation period in 1998. The number of additional deaths of newborns since1988 outweighs the effect of 1987 ten times over. Dose estimates from Belarus assume that strontium makes up only about 5 percent of the caesium dose. Körbleins calculations deviate from current dose estimates by at least 2 orders. One possible explanation for this discrepancy is that the currently accepted dose factor massively underestimates the effect of strontium.

Körblein's results are consistent with changes in perinatal mortality in Germany following the atmospheric atom bomb tests in the 1950s and 1960s.

3.2 Germany

In1986 in Berlin, an unusual increase of infant mortality was observed. Compared to 1985, infant mortality in Berlin rose in 1986 from 10.6 to12.5 per 1,000 live births in the first year of life. The mortality rate of non-German infants increased over-proportionally from 9.6 auf 14.3 per thousand. The mortality rate even increased between the end of the first week and the end of the first year of life by 26 percent. There had previously been a decrease in infant mortality.[59]

For the years 1975 to 1987, M. Schmidt, H. Ziggel and G. Lüning, working with the physicist Prof. Dr. Jens Scheer in Bremen, had looked into infant mortality within the first seven days of life.[60] Whereas early infant mortality in the entire republic had been on the decrease up to spring 1986, a change began to take place in the months following Chernobyl. In the southern areas of the Federal Republic, particularly in Bavaria and Baden-Württemberg, where the highest amounts of radiation had been detected, considerably more deaths were registered amongst newborns than in those (northern) areas, where there had been less radioactive fallout. The extrapolation had, however, omitted to take sufficient account of previous changes in infant mortality brought about by fallout from atmospheric nuclear weapons tests.

A paper, published in 1997 by Alfred Körblein[61] and Helmut Küchenhoff, came to the conclusion that there was a significant increase in perinatal mortality in the whole of Germany following Chernobyl. Analysis of monthly death rates showed an increase in perinatal mortality seven months after the exposure of pregnant women to radioactive caesium was calculated to have been at its highest.[62] The author put this increase down to the fact that, during the winter of 1986/1987, agricultural products from animals that had been given contaminated feed came onto the market.

Hagen Scherb und Eveline Weigelt, of the GSF-research centre for environment and health in Neuherberg, found a significant increase of about 5 percent of perinatal mortality in Germany

59 Strahlentelex 7/1987, 2. Strahlentelex 8/1987, 3.

60 G. Lüning, J. Scheer, M. Schmidt, H. Ziggel: Early infant mortality in West Germany before and after Chernobyl. Lancet. 1989 Nov 4;2(8671): 1081-1083.

61 Dr. Alfred Körblein (Munich Institute for the Environment) had already drawn the wrath of the establishment upon himself by disrespectfully and carefully reading the renowned studies from the Cancer Registry in Mainz (Director: Prof. Dr. Jörg Michaelis) on cancer incidence in the vicinity of German nuclear power plants and coming to very different results than Michaelis and the Minister for the Environment at the time, Angela Merkel. The resoluteness of Körblein and the coherence of his arguments have played a great part in prompting a new analysis of cancer incidence in the vicinity of German nuclear power plants.

62 A. Körblein, H. Küchenhoff: Perinatal Mortality in Germany following the Chernobyl accident. Radiat Environ Biophys 1997; 36(1): 3-7.

in 1987 as compared to the trend in other years.[63] This is the equivalent of about 300 additional cases. On the basis of stillbirth statistics from other European countries, Scherb and Weigelt even consider it possible that this figure underestimates the effect (see below).

Since Chernobyl there has also been an increase in perinatal mortality in southern Germany. In 1991, Munich's Institute for the Environment published a study on the effects of the Chernobyl reactor accident of April 1986 on perinatal mortality in areas of the Federal Republic of Germany that had been weakly or heavily contaminated with radioactivity. This showed that, in the more heavily contaminated southern part of Germany, there were two increases in the incidence rate of early neonatal mortality, once in early summer 1986 and once in winter 1986/87.[64]

Körblein also examined birth rate developments in order to record any increase in spontaneous abortions as a result of Chernobyl.[65] It was found that birth rates in southern and northern Bavaria differed. In southern Bavaria, more badly hit by Chernobyl fallout than northern Bavaria, the birth rate in February 1987 showed an 11 percent significant ($p=0.0043$) decrease against the expected value. The birth deficit is 615. In northern Bavaria there was only a 4% insignificant ($p=0.184$) reduction.

3.3 Other countries

By studying the monthly data, Körblein found that there had been a significant increase of perinatal mortality at the beginning of 1987 in the Ukrainian region of Zhytomyr, as well as in Poland.[66]

Scherb and Weigelt also examined stillbirth rates in several countries and regions outside the Chernobyl region that had also been relatively heavily contaminated by Chernobyl fallout.[67] According to their analysis, the perinatal mortality rate in the combined countries/regions of Bavaria, East Germany, West-Berlin, Denmark, Iceland, Latvia, Norway, Poland, Sweden and Hungary increased in 1986 by 4.6% ($p=0.0022$) and from 1987-1992 by a highly significant 8.8% ($p=0.33E-6$) compared to the trends based on the periods 1981-1985 and 1987-1992. According to this model, it follows that, for the years 1986 to 1992, there were about 3,200 stillbirths ($\pm 1{,}300=2\sigma$) more than had been expected. This is an average of about 460 additional stillbirths per annum in this period of time and group of countries.[68 69 70 71 72]

63 Hagen Scherb, Eveline Weigelt: Zunahme der Perinatalsterblichkeit, Totgeburten und Fehlbildungen in Deutschland, Europa und in hoch belasteten Gebieten deutschen und europäischen Regionen nach dem Reaktorunfall von Tschernobyl im April 1986 [Increase in perinatal mortality, stillbirths and malformations in Germany, Europe and in heavily contaminated areas of German and European regions following the reactor accident in Chernobyl in April 1986]. Report no. 24/2003 from the Otto Hug Strahleninstituts, 35-75. (German)

64 Strahlentelex 108-109/1991, p. 4, Die Säuglingssterblichkeit war in Süddeutschland erhöht [Increase in perinatal mortality in southern Germany]. (German)

65 Alfred Körblein: Säuglingssterblichkeit nach Tschernobyl [Perinatal mortality since Chernobyl]. Report no. 24/2003 Otto Hug Strahleninstituts, 6-34. (German)

66 Ibid.

67 Hagen Scherb, Eveline Weigelt: Zunahme der Perinatalsterblichkeit, Totgeburten und Fehlbildungen in Deutschland, Europa und in hoch belasteten Gebieten deutschen und europäischen Regionen nach dem Reaktorunfall von Tschernobyl im April 1986 [Increase in perinatal mortality, stillbirths and malformations in Germany, Europe and in heavily contaminated areas of German and European regions following the reactor accident in Chernobyl in April 1986]. Report no. 24/2003 from the Otto Hug Strahleninstituts, 35-75. (German)

68 Ibid.

Finland is the Scandinavian country most heavily polluted by Chernobyl. A Finnish study showed a distinctive increase in premature births of children who had been conceived in the first four months after Chernobyl in the areas with the highest dose rates and ground contamination with caesium-137.[73]

Scherb und Weigelt examined the development of stillbirths in Finland.[74] The scientists criticized the fact that in1987, of all years, Finland changed their definition of stillbirth. But Scherb and Weigelt still believe, albeit for different reasons, that the stillbirth statistics published in February 2001 by Auvinen and colleagues provide them with consistent and usable data for the years 1977 to 1992. Backed by this data, Scherb and Weigelt analysed the trend in stillbirths in Finland from 1977 to 1994. They found a highly significant change-point in 1987. The effect was approximately twice as strong as in Sweden and about two thirds of the effect in Hungary.

After Chernobyl, infant mortality rates in Sweden, Finland and Norway increased by a significant 15.8 percent compared to the trend for the period 1976 to 2006. Alfred Körblein calculated that for the period 1987 to 1992 an additional 1,209 (95 % confidence interval: 875 to 1,556)[75] infants had died.

69 H. Scherb, E. Weigelt, I. Brüske-Hohlfeld: European stillbirth proportions before and after the Chernobyl accident; International Journal of Epidemiology 1999; 28:932-940.

70 H. Scherb, E. Weigelt: Spatial-temporal change-point regression models for European perinatal data; European Radiation Research 2000, 30th Annual Meeting of the European Society for Radiation Biology, Warzawa, August 27-31, 2000.

71 H. Scherb, E. Weigelt, I. Brüske-Hohlfeld: Regression Analysis of Time Trends in Perinatal Mortality in Germany 1980-1993; Environmental Health Perspectives Vol. 108, No. 2, February 2000.

72 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; in: Friedl, H. et al. (eds): Proceedings of the 14th International Workshop on Statistical Modelling, Technical University Graz, 647-650.

73 T. Harjulehto, T. Aro, H. Rita, T. Rytömaa, L. Saxén: The accident at Chernobyl and outcome of pregnancy in Finland. Br Med J. 1989; 298: 995-997. Strahlentelex 178-189/1994, 7, Neugeborenensterblichkeit nach Tschernobyl.

74 Hagen Scherb, Eveline Weigelt: Zunahme der Perinatalsterblichkeit, Totgeburten und Fehlbildungen in Deutschland, Europa und in hoch belasteten Gebieten deutschen und europäischen Regionen nach dem Reaktorunfall von Tschernobyl im April 1986 [Increase in perinatal mortality, stillbirths and malformations in Germany, Europe and in heavily contaminated areas in German and European regions following the reactor accident in Chernobyl in April 1986]. Report no. 24/2003 from the Otto Hug Strahleninstituts, 35-75. (German)

75 Körblein, A.: Säuglingssterblichkeit nach Tschernobyl in skandinavischen Ländern, Strahlentelex 510 -511, 2008

Excursus: Miscarriages and pregnancy terminations

Usually miscarriages and pregnancy terminations since Chernobyl have been silently ignored. There are, however, a number of unsettling indications:

- in Poland there were considerably less live births in 1986 compared to previous years.[76 77]
- in1987 Trichopoulos reported on pregnancy terminations following Chernobyl. He came to the conclusion that in May 1986, 23 percent of early pregnancies in Greece were terminated. Altogether about 2,500 wanted pregnancies were terminated because of Chernobyl.[78]
- Ketchum's information, that there were 100,000 to 200,000 additional terminations in Western Europe because of the Chernobyl catastrophe, refers to data from the IAEA.[79]
- there have been numerous indications from doctors, and women in the Chernobyl region, that in the days and weeks following Chernobyl abortions were systematically carried out. No one wants to talk about this and we have no knowledge of accurate data on these abortions.

Dr. Mole, longstanding member of the ICRP and the NRPB, already addressed this issue prior to Chernobyl as follows: "The most important consideration is the generally accepted value judgement that early abortions of embryos have little personal and social importance."[80]

We do not share Dr. Mole's evaluation. For us, these appallingly high numbers of aborted embryos count as victims of Chernobyl.

Ever since discovering the mutagenicity of ionising radiation in animal experiments, damaging radiation genetic effects in humans have also been repeatedly considered and examined. The ICRP, however, is of the opinion that teratogenic damage (stillbirths, infant mortality, severe malformation) does not occur below a dose of 100 mSV. Since the mean dose for Germany in 1986-7 was only 0.2 mSV, according to ICRP opinion there can't have been an increase in teratogenic damage. On the other hand, there are numerous studies from Germany, Europe and the three countries in the Chernobyl region that show that there was indeed an increase in teratogenic damage, contrary to expectations on the part of these scientists.

Körblein (2011) established a significant dose-effect relationship between Caesium contamination, and also Strontium later on, in the food chain and also in the soil, and an increase in perinatal mortality.[81]

Moreover, recent studies by Scherb et al (2010) show just such damaging genetic effects after the Chernobyl accident. They studied gender odds, in other words the relation of girls to boys born, and „missing" births due to the reactor catastrophe at Chernobyl. They found that

76 J. Gould, Lecture on 18/19.11.1987 in Hamburg.

77 J.M. Gould: Mortality Consequences of Chernobyl Radiation in the US, First Global Radiation Victims Congress, New York, 29.9.1987.

78 D. Tricholoulos: The Victims of Chernobyl in Greece: induced abortions after the accident. Brit. Med. J. 295(1987) 1100.

79 L.E. Ketchum: Lessons of Chernobyl: SNM Members Try to Decontaminate World Threatened by Fallout; The Journal of Nuclear Medicine 28(1987) 6, 933ff.

80 Mole, Brit.J.Radiol. 52(1979)614,84-101.

81 Körblein, Alfred: Erhöhte Sterblichkeit von Neugeborenen nach Tschernobyl, in: Strahlentelex 580-581/03.03.2011

about 800,000 fewer children had been born as would have been expected. A similar trend could be identified in the vicinity of 31 nuclear installations in Switzerland and Germany where about 15,000 fewer children had been born in a forty year period, mostly girls.[82]

82 Scherb, H., Verlorene Kinder. Die Geschlechtschance des Menschen bei der Geburt in Europa und in den USA nach den oberirdischen Atomwaffentests und nach Tschernobyl. In: Strahlentelex 558-559,2010

4. Genetic and teratogenic damage (malformations)

One of the main difficulties of monitoring genetic damage is the fact that the overwhelming majority of changes does not become visible for several generations. For this reason, fundamental knowledge at the beginning of genetic science came from the study of flies, of which several generations could be examined in a laboratory in a short space of time because of their short life span. Our observations of genetic damage to humans following the Chernobyl catastrophe are therefore still in the early stages.

The following assessments on genetic damage in the aftermath of the Chernobyl catastrophe came from the Vavilov Institute of General Genetics of the Russian Academy of Sciences [83]: With reference to the UNSCEAR-Report from1988,[84] the collective doses for all the affected countries in the Northern hemisphere amounts to 600,000 man Sv. 40% of this, i.e. 240,000 man Sv, fell on the territories of the former USSR. People of childbearing age constitute about 40% of the population. Therefore about 40% of the collective doses affects future generations. That would be 240,000 man Sv for all affected countries and 96,000 man Sv for the affected states of the Chernobyl region (former USSR). Based on this key data, it is possible to estimate the extent of genetic damage resulting from the Chernobyl catastrophe. If the risk evaluation takes multifactor hereditary diseases into consideration, then 1,200 to 8,300 cases of genetic damage in the first generation can be expected in the affected countries within the territory of the former USSR. About 10% of the expected genetic damage occurs in the first generation – this means that that we have to reckon with a total of 12,000 – 83,000 genetically damaged people in the affected countries of the Chernobyl region. That would be a total of 3,300 – 23,000 in the first generation and 30,000 – 207,500 people affected in the Northern hemisphere by the Chernobyl catastrophe in the long-term.

It is surprising that in this UNSCEAR estimate the collective dose for Europe is greater than the collective dose for the Chernobyl region, from which it necessarily follows that the estimates concerning the number of victims and the extent of genetic damage in Europe are going to be even higher than those for the Chernobyl region. This is due mainly to the much higher population density in the European countries

UNSCEAR states that there was a collective dose of 318,000 man Sv for Europe from which it follows that under the conditions named above, there will be 1,800 – 12,200 genetically damaged people in Europe in the first generation following Chernobyl. Altogether, we have to consider a total of 18,000 – 122,000 genetically damaged people in Europe as a result of the Chernobyl catastrophe.[85]

---

83 V.A. Shevchenko: Assessment of Genetic Risk from Exposure of Human Populations to Radiation; in: E.B. Burlakova: Consequences of the Chernobyl Catastrophe: Human Health; Moscow, 1996, 46-61.

84 United Nations: Sources, Effects and Risk of Ionizing Radiation; UNSCEAR, New York, 1988, Report to the General Assembly, United Nations, New York, 1988. N° 1.35-44.

85 These thoughts essentially adhere to data given by V.A. Shevchenko: Assessment of Genetic Risk from Exposure of Human Populations to Radiation; in: E.B. Burlakova: Consequences of the Chernobyl Catastrophe: Human Health; Moscow, 1996, S. 46-61, but elaborate on those for Europe. Figures were very much rounded-down, because at this point in time only a rough estimation is possible.

Table: Estimated size of the genetic risk for the northern hemisphere, the Chernobyl region and for Europe following Chernobyl (from Shevchenko[86] und UNSCEAR 88)

Area	Collective doses [man Sv]	Collective doses for the childbearing age group [man Sv]	Genetic damage in the 1st generation (10%)	Genetic damage altogether (100%)
Northern hemisphere	600,000	240,000	3,300-23,000	33,000-230,000
Chernobyl region	216,000	86,400	1,200-8,300	12,000-83,000
Europe	318,000	127,200	1,800-12,200	18,000-122,000

4.1 The Chernobyl region

Approximately one week after the Chernobyl reactor catastrophe, a number of German citizens returned to the Federal Republic of Germany from their various locations in Ukraine. Analyses of their chromosomes showed a surprisingly clear increase in chromosome anomalies (genetic malformations): Acentric chromosome anomalies were about twice as frequent as dicentric. Centric chromosome rings were also found. Most of those examined were visiting Ukraine on behalf of a company and had been located up to about 400 kilometres away from Chernobyl. Whole-blood cultures were examined from these people. The blood samples were taken in May 1986[87].

A paper, by Lazjuk and colleagues in Belarus, diagnosed an increased number of deformities in 5-12 week old foetuses.[88] Lazjuk published data on the rate of congenital malformations over the period from 1985 to 1994. There were12.5 birth defects per 1,000 live births in 1985 in Belarus. In 1994, the figures were 17.7/1,000. Lazjuk points out that since 1991, ultrasonic examinations have been introduced in order to recognise malformations at an early stage. If those pregnancies that were terminated following ultrasonic examination are taken into account (1,551 cases), the rate for 1994 would have been 22.4 birth defects per 1,000 live births or pregnancies, i.e. the rate of birth defects has almost doubled in 10 years. There were particularly high rates of anencephaly (missing brain), spina bifida (open spine), cleft lip/ palate, polydactylia (supernumery digit) and muscular atrophy of limbs. [89]

86 V.A. Shevchenko: Assessment of Genetic Risk from Exposure of Human Populations to Radiation; in: E.B. Burlakova: Consequences of the Chernobyl Catastrophe: Human Health; Moscow, 1996, 46-61.

87 G. Stephan, U. Oestreicher: An increased frequency of structural chromosome aberrations in persons present in the vicinity of Chernobyl during and after the reactor accident. Is this effect caused by radiation exposure? Mutation Research, 223(1989) 7-12.

88 G.I. Lazjuk, I.A. Kirillova, I.u.E. Dubrova, I.V. Novikova: Incidence of developmental defects in human embryos in the territory of Byelarus after the accident at the Chernobyl nuclear power station, Genetika, 1994 Sep; 30(9): 1268-1273 (Russian). Reproduced from: Alfred Körblein 2005: Studies of pregnancy outcome following the Chernobyl accident. Unpublished.

89 Hoffmann, W.: Fallout from the Chernobyl nuclear disaster and congenital malformations in Europe. Archives of Environmental Health 56 (2001) 478-484. Strahlentelex, 374-375/2002, 9 f. Inge Schmitz-Feuerhake, Malformations in Europe and Turkey. (German)

In Belarus, Petrova and colleagues also observed an increase in the rate of children suffering from anaemia or congenital malformations.[90]

In January 1987 - nine months after Chernobyl – cases of trisomy 21 (Down's syndrome) in newborns became more frequent in Belarus. Zatsepin et al. had carried out examinations in the period from 1981 to 2001. The authors deduce that because of the time correlation to the Chernobyl accident the increase in Down's syndrome in January 1987 is due to Chernobyl fallout. Other possible influencing factors, such as prenatal diagnostic or altered maternal age distribution, can be excluded as causes.[91]

Scientists from the Universities of Moscow and Leicester examined blood samples from 79 families, the parents of which had been living within a 300-kilometre radius of the reactor. The scientists were surprised by the fact that in those children born between February and September 1994 cases of mutations had doubled. The genetic scientists reasoned, that as the examined children were only two years old this was due to genetic changes in the parental germ cells. Professor David Hillis from the University of Texas in Austin drew attention to the correlation with measurement results from field mice that had lived off highly contaminated food in the area around the Chernobyl sarcophagus: "The rate of mutation amongst the field mice is one hundred thousand times higher than normal".[92]

Godlevsky reported on morbidity amongst newborns up to 7-days old as well as on the dynamics of congenital development anomalies amongst newborns in the Ukrainian district of Lugyny. Morbidity rose from 80 cases per 1,000 births in 1985 to about 4-fold in 1995 (shown in the figure). The absolute number of development anomalies rose from 4 in 1985 with varying high values to 17 in 1989 and 33 in 1992, in 1996 the value then falls to 11.[93]

Vladimir Wertelecki (University of South Alabama) examined the incidence and distribution of congenital malformations in the area of Rovno. The northern part of this area was exposed to distinctly more radiation than the southern part. At 22 per 10,000 live births, the rate of neural tube defects is among the highest in Europe (comp.: the average rate of neural tube defects in Europe is 9.43. Wertelecki found a significantly higher rate of neural tube defects in the northern part of Rovno, where radiation exposure was greater, than in the southern part: 27.0 compared to 18.3 per 10,000 live births (odds ration 1.46, confidence interval 95 % CI = 1.13. – 1.93)[94]

Table: Teratogene effects observed following the Chernobyl accident.

Country	Effects	References
Belarus National Genetic Monitoring Registry	Anencephaly, open spine, cleft lip/palette, polydactylia, muscular atrophy of limbs, Down's syndrome	Lazjuk et al. 1997

90 A. Petrova, T. Gnedko, I. Maistrova, M. Zafranskaya, N. Dainiak: Morbidity in a large cohort study of children born to mothers exposed to radiation from Chernobyl, Stem Cells, 1997; 15 Supp 2:141-150. Reproduced by: Alfred Körblein 2005: Studies of pregnancy outcome following the Chernobyl accident. Unpublished.

91 Zatsepin 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.

92 GID 112/113, June 1996. Deutschland-Radio Newsletter, 27.04.1996. Strahlentelex, 228-229/1996, 9, Erbgutveränderungen bei Kindern verdoppelt [Changes in genetic material amongst children doubles]. (German)

93 Ivan Godlevsky, O. Nasvit: Dynamics of Health Status of Residents in the Lugyny District after the Accident at the ChNPP; In T. Imanaka: KURRI-KR-21, Kyoto, 1998, 149-156.

94 Wertelecki, Wladimir: Malformations in a Chornobyl-Impacted Region. Pediatrics 2010;125; e836-e843, http://www.pediatrics. org/cgi/content/full/125/4/e836, in Strahlentelex 564-565,2010

Belarus High contamination area Gomel District Chechersky in the Gomel region Region of Mogilev Region of Brest	congenital malformations congenital malformations congenital malformations congenital malformations	Bogdanovich 1997; Savchenko 1995 Kulakov et al. 1993 Petrova et al. 1997 Shidlovskii 1992
Ukraine District of Polessky in the Kiev area Region of Lygyny	congenital malformations	Kulakov et al. 1993 Godlevsky, Nasvit 1998
Turkey	Anencephaly, open spine	Akar et al.1988/89; Caglayan et al. 1990; Güvenc et al. 1993; Mocan et al. 1990
Bulgaria, Pleven region	Malformations of heart and central nervous system, multiple malformations	Moumdjiev et al. 1992
Croatia	Malformations upon autopsy of stillborns and cases of early death	Kruslin et al. 1998
Germany German Democratic Republic, Central registry Bavaria Annual Health Report of West Berlin 1987 City of Jena (Registry of congenital malformations)	Cleft lip and/or palate Cleft lip and/or palate Congenital malformations Malformations in stillborns Isolated malformations	Zieglowski, Hemprich 1999 Scherb, Weigelt 2004 Körblein 2003, 2004; Scherb, Weigelt 2003 Strahlentelex 1989 Lotz et al. 1996

Literature:

Akar, N., Cavdar, A.O., and Arcasoy, A., 1988, High incidence of Neural Tube defects in Bursa, Turkey, Paediatric and Perinatal Epidemiol. 2:89-92.

Akar, N., Ata, Y., and Aytekin, A.F., 1989, Neural Tube defects and Chernobyl? Paediatric and Perinatal Epidemiol. 3:102-103.

Bogdanovich, I.P., 1997, Comparative analysis of the death rate of children, aged 0-5, in 1994 in radiocontaminated and conventionally clean areas of Belarus, in: Medicobiological effects and the ways of overcoming the Chernobyl accident consequence, Collected book of scientific papers dedicated to the 10th anniversary of the Chernobyl accident, Minsk-Vitebsk, p. 4.

Caglayan, S. Kayhan, B., Mentesoglu, S., and Aksit, S., 1990, Changing incidence of neural tube defects in Aegean Turkey, Paediatric and Perinatal Epidemiol. 4:264-268.

Godlevsky, I., and Nasvit, O., 1998, Dynamics of health status of residents in the Lugnyny district after the accident of the ChNPS, in: Research activities about the radiological consequences of the Chernobyl NPS accident and social activities to assist the sufferers by the accident, T. Imanaka, ed., Research Reactor Institute, Kyoto University, KURRI-KR-21, pp.149-156.

Güvenc, H., Uslu, M.A., Güvenc, M., Ozkici, U., Kocabay, K., and Bektas, S., 1993, Changing trend of neural tube defects in Eastern Turkey, J. Epidemiol. Community Health 47:40-41.

Körblein, A., Säuglingssterblichkeit nach Tschernobyl, 2003, Berichte Otto Hug Strahleninstitut 24:6-34.

Kulakov, V.I., Sokur, T.N., Volobuev, A.I., Tzibulskaya, I.S., Malisheva,V.A., Zikin, B.I., Ezova, L.C., Belyaeva, L.A., Bonartzev, P.D., Speranskaya, N.V., Tchesnokova, J.M., Matveeva, N.K., Kaliznuk, E.S., Miturova, L.B., and Orlova, N.S., 1993, Female reproduction function in areas affected by radiation after the Chernobyl power station accident, Environ Health Persp. 101, Suppl. 2:117-123.

Kruslin, B., Jukic, S., Kos, M., Simic, G., and Cviko, A., 1998, Congenital anomalies of the central nervous system at autopsy in Croatia in the period before and after Chernobyl, Acta Med. Croatica 52:103-107.

Lazjuk, G.I., Nikolaev, D.L., and Novikova, I.V., 1997, Changes in registered congenital anomalies in the Republic of Belarus after the Chernobyl accident, Stem Cells 15, Suppl. 2:255-260.

Lotz, B., Haerting, J., and Schulze, E., 1996, Veränderungen im fetalen und kindlichen Sektionsgut im Raum Jena nach dem Reaktorunfall von Tschernobyl [Changes in fetal and child dissection material in the Jena area since the Chernobyl reactor accident], Oral presentation at the International Conference of the Society for Medical Documentation, Statistics, and Epidemiology, Bonn, Germany.

Mocan, H., Bozkaya, H., Mocan, Z.M., Furtun, E.M., 1990, Changing incidence of anencephaly in the eastern Black Sea region of Turkey and Chernobyl, Paediatric and Perinatal Epidemiol. 4:264-268.

Moumdjiev, N., Nedkova, V., Christova, V., Kostova, Sv., 1992, Influence of the Chernobyl reactor accident on the child health in the region of Pleven, Bulgaria, in: 20th Int. Congr. Pediatrics Sept. 6-10, 1992 in Brasil, p.57. Cited by Akar, N., Further notes on neural tube defects and Chernobyl (Letter), Paediatric and Perinatal Epidemiol. 8, 1994, 456-457.

Petrova, A., Gnedko, T., Maistrova, I., Zafranskaya, M., Dainiak, N., 1997, Morbidity in a large cohort study of children born to mothers exposed to radiation from Chernobyl. Stem Cells 16, Suppl. 2: 141-150

Scherb, H., and Weigelt, E., 2003, Congenital malformation and stillbirth in Germany and Europe before and after the Chernobyl nuclear power plant accident, Environ. Sci.& Pollut.Res. 10 Special (1):117-125.

Scherb, H., Weigelt E., Spaltgeburtenrate in Bayern vor und nach dem Reaktorunfall in Tschernobyl [Cleft lip and cleft palate birth rate in Bavaria before and after the Chernobyl nuclear power plant accident], Mund Kiefer Gesichtschirurgie 2004 Mar;8(2):106-10. (German)

Savchenko, V.K., 1995, The Ecology of the Chernobyl Catastrophe. Scientific outlines of an international programme of colloborative research. Man and the Biosphere Series Vol. 17, UNESCO Paris, p.83.

Shidlovskii, P.R., 1992, General morbidity of the population in districts of the Brest region. Zdravoohranenie Belorussii (Minsk) 1:8-11 (Russ.).

Strahlentelex 55, 1989, Säuglinge starben vermehrt oder wurden tot geboren [More perinatal deaths or stillbirths], Berlin, Germany, p. 6.

Zieglowski, V., and Hemprich, A., 1999, Facial cleft birth rate in former East Germany before and after the reactor accident in Chernobyl, Mund Kiefer Gesichtschir. 3:195-199 (in German).

4.2 Germany

In January 1987 - nine months after Chernobyl - in a laboratory for genetic diagnostic in Munich (Dr. Klaus Waldenmeyer), it was found that the frequency of trisomy 21 (Down's syndrome) was three times the normal figure.[95] Even with the necessary prudence that, according to Dr. Waldenmeyer, is mandatory in judging such observations, an increase in the occurrence of genetic changes exactly nine months after the catastrophe is extremely conspicuous[96]. In Munich, six cases of trisomy 21 became known[97].

K. Sperling also observed a sharp rise in cases of trisomy 21 (Down's syndrome) in Berlin nine months after Chernobyl. In January 1987, 12 children were born with Down's syndrome in

95 People with Down's syndrome have a chromosome set, in which chromosome 21 occurs three times instead of twice. They therefore have a total of 47 instead of 46 chromosomes, the carriers of genetic information. These genetic changes occur as a result of a disruption in the meiosis of the sexual cell, usually of the mother, prior to fertilization. The results are a typical physical appearance of the children, low intelligence quota, reduced defence against infection and malformations of internal organs for example, cardiac defects

96 Strahlentelex, 3/1987, Feb. 19,1987, 1f, Mongolismus nach Tschernobyl zwei- bis dreimal häufiger [Down's syndrome since Chernobyl two to three times more frequent] (German)

97 Strahlentelex, 5/1987, March 19, 1987, 1f. , "Mongolismus" 9 Monate nach Tschernobyl [Down's syndrome nine months after Chernobyl]

West Berlin, whereas normally only two or three cases would be expected. This figure qualifies as "highly significant", thereby excluding a coincidental fluctuation.[98] In eight of these cases, the probable date of conception coincided with the time of the highest measured increase of radioactivity in Berlin[99]. K. Sperling et al. confirmed the observed increase of the rate of Down's syndrome in 1987 in an extensive data analysis published in the British Medical Journal. Sperling was able to support his analysis with unusually accurate figures. Due to the earlier 'island-status' of the city and his institute's responsibility for the supervision of all children with Down's syndrome in West Berlin, Sperling's figures were practically perfect compared to the figures from the other Federal States. Sperling was able to eliminate other causes than radioactive fallout during that spring for the cluster of chromosome disorders, in particular the mother's age. Five couples had conceived their child between April 29 and Mai 8, 1986 when radiation was at its highest in Berlin. For a further five couples, the date of conception was also either during this period or shortly after. By means of genetic cell examination Sperling and Mikkensen were able to establish that in six out of seven cases the extra chromosome was on the maternal side. According to Sperling, in eight of the total of 12 cases, a link between increased radioactivity and the chromosome anomaly was probable and, in any case, could not be excluded. Sperling assumed that the cause could have been radioactive Iodine 131, due to its half-life of about 8 days and its heavy concentration in the environment, in the air and in food, in the spring of 1986. Still being debated is whether there is an interaction between the ovaries and the thyroid gland, as well as direct storage in the ovaries. In earlier medical studies of mothers and children with trisomy 21, an increased frequency of thyroid diseases such as hyperthyroidism (Clark 1929) and autoimmune reactions (Fialkow 1964) had been observed.[100]

Following his observations in Berlin, Professor Sperling initiated a national survey of 40 human genetic institutes and places of research in the Federal Republic of Germany. Evaluation of the 28,737 prenatal chromosome analyses from 1986 showed 393 occurrences of deviation from the normal number of chromosome at the time, 237 of these were cases of trisomy 21. The greatest number of deviations was amongst embryos that had been conceived in the days following the Chernobyl disaster. The increased frequency was greater in the more heavily radioactively contaminated southern part of Germany.[101]

Professor Sperling's Trisomie-21-study for Berlin was later confirmed in a re-analysis. Pierre Verger from the Institute for Nuclear Safety and Radiation Protection in Fontenay-aux Roses Cedex (France) examined the available papers for a possible connection between ionising radiation and the emergence of the chromosome anomaly responsible for Down's syndrome, taking the ages of the mothers as well as possible prenatal radiation into consideration. [102]

In Hamburg in the Chernobyl year of 1986, there was the second highest rise in 30 years of the number of immature and premature infants under 2,500gm birth weight. These figures include immature as well as prematurely born infants. The Hamburg senate provided this information in answer to a question put by Ursula Caberta y Diaz, member of the senate

98 Ibid.

99 Strahlentelex, 166-167/1993, 4, Chernobyl effects also measurable in Germany. (German)

100 Karl Sperling, Jörg Pelz, Rolf-Dieter Wegner, Andrea Dörries, Annette Grüters, Margareta Mikkelsen, Significant increase in trisomy 21 in Berlin nine months after the Chernobyl reactor accident, temporal correlation or causal relation? British Medical Journal 1994, 309: 158-62, 16 July 1994. Karl Sperling, Jörg Pelz, Rolf-Dieter Wegner, I. Schulzke, E. Struck, Frequency of trisomy 21 in Germany before and after the Chernobyl accident, Biomed & Pharmacother, 1991, 45, 255-262.

101 Ibid.

102 Pierre Verger, Down Syndrom und Ionizing Radiation, Health Physics, December 1997, Vol 73:6, 882-893. Strahlentelex, 268-269/1998, 1-4. In a re-analysis, the Trisomie-21 study of the Berlin human geneticist Sperling was confirmed.

(SPD). Whereas from 1981 to 1985, an average of 60 per 1,000 infants were born with a low birth weight (in 1982 the figure was 65), in the year of Chernobyl there were 67 underweight infants.[103]

Following Chernobyl there was also an increase of radiation-typical congenital malformations in the GDR where it was a legal regulation that an autopsy for all miscarriages and all deaths of children under 16 years of age had to be carried out. The registry of congenital malformations in Jena showed a 4-fold increase in isolated malformations in 1986-87, as compared to 1985, which then subsided in subsequent years. The increase mainly affected the central nervous system and the abdominal wall.[104] An analysis of the GDR central registry of congenital malformations showed an increase in cases of cleft lip and palette of about 9.4% in 1987 (compared to the mean values for 1980 and 1986), which was more pronounced in the 3 northern areas, which had been most affected by fallout. [105]

According to the 1987 annual health report for Berlin, in West Berlin the incidence of malformations of stillborn infants doubled. The hands and feet were most commonly affected, then the heart and urethra, and the incidence of facial clefts also increased.[106]

In the southern part of Bavaria, where the contamination by radioactive fallout had been comparatively high, the rate of congenital malformations at the end of 1987 - seven months after the highest contamination of pregnant women with caesium - was almost twice as high as in northern Bavaria. In November and December 1987, the rate of congenital malformations in Bavarian districts showed a highly significant correlation to ground contamination levels of caesium. A. Körblein and H. Küchenhoff showed that there was a temporal correlation between the rate of congenital malformations in southern and northern Bavaria and the seven-month delayed effect of exposure to caesium of pregnant women. In November and December 1987, the rate of congenital malformations in the 24 Bavarian districts most heavily contaminated was almost three times that of the 24 Bavarian districts with the lowest contamination. In the ten most heavily contaminated districts, the rate of congenital malformations was in fact almost eight times higher than in the ten least contaminated (odds ratio = 7.8 $p<0.001$). The results are also compatible with an increased stillbirth rate. Bavaria is the only German state that has data on congenital malformations from before and after Chernobyl. They were retrospectively collated for 1984 to 1991 by order of the Bavarian Ministry of State for Development and Environmental Issues.[107]

H. Scherb et al. found a correlation between the rise in the rate of congenital malformations following Chernobyl and ground contamination levels of caesium in the Bavarian districts. For

103 Strahlentelex, 47/1988, S. 6, Hamburg, Im Tschernobyl-Jahr 1986 vermehrt untergewichtige Säuglinge geboren [More underweight babies born in 1986, the year of Chernobyl]. (German)

104 Lotz, B. et al.: Veränderungen im fetalen und kindlichen Sektionsgut im Raum Jena nach dem Reaktorunfall von Tschernobyl [Changes in fetal and child dissection material in the area of Jena following the Chernobyl reactor accident], Bonn, Lecture: Society for Medical Documentation, Statistics and Epidemiology, 1996. In Hoffmann, W.: Fallout …(German)

105 Zieglowski, V., A. Hemprich: Facial cleft birth rate in former East Germany before and after the reactor accident in Chernobyl. Mund Kiefer Gesichtschirurgie 1999; 3:195-199; In Hoffmann, W.: Fallout from the Chernobyl nuclear disaster and congenital malformations in Europe. Archives of Environmental Health 56 (2001) 478-484.

106 Hoffmann, W.: Fallout from the Chernobyl nuclear disaster and congenital malformations in Europe. Archives of Environmental Health 56 (2001) 478-484.

107 Alfred Körblein: Folgen von Tschernobyl: Fehlbildungen bei Neugeborenen in Bayern. [Effects of Chernobyl: Malformations of newborns in Bavaria]. Umweltnachrichten 94/2001, Umweltinstitut München e.V. December 2001, 11-16. H. Scherb, E. Weigelt, Spaltgeburtenrate in Bayern vor und nach dem Reaktorunfall in Tschernobyl [Cleft lip and cleft palate birth rate in Bavaria before and after the Chernobyl nuclear power plant accident], Mund Kiefer Gesichtschirurgie 2004 Mar;8(2):106-10. (German)

the group of orofacial cleft anomalies, they found an increase in the increased frequency of malformations in the years following Chernobyl (1987-1991) compared to previous years (1984-1986).[108]

The second main focus of Scherb and Weigelt's work comprised the analysis of the data on malformations that had been ascertained in Bavaria by order of the Bavarian Ministry of the Environment. They allow the estimate of 1,000 to 3,000 excess congenital malformations in Bavaria following Chernobyl, between October 1986 and December 1991.[109] The authors arrive at a risk estimation that ranges in size similar to that of the stillbirth risk of 0.5%-2.0%/(1 kBq/m^2). Even when using cautious interpretation, this means that there is a relative risk coefficient of 1.6/(1mSv/a), if only the external dose of the caesium isotopes Cs134 and 137 is taken into consideration. This contradicts the opinion that there is a (relatively high) threshold value with regard to reproduction disorders.[110] [111] [112]

Radiation exposure in the uterus following Chernobyl also had the effect of reducing intelligence levels. A recent study showed diminished cognitive ability among adolescents from those areas in Norway that had been most heavily subjected to fallout from Chernobyl.

Adolescents who were at the developmental stage of the 8th to 15th week of pregnancy during the Chernobyl reactor catastrophe, and whose mothers lived in those areas of Norway most heavily affected by the fallout, demonstrate significantly lower IQs. The psychologist Sverdvik Heiervang from the University of Oslo and colleagues reported this in a recent paper on the effects of low dose radiation exposure in the uterus on cognitive functions during adolescence, which was published in the Scandinavian Psychological Society's publication Scandinavian Journal of Psychology. The paper thereby substantiates earlier findings from Sweden (Almond et al. 2007), Ukraine (Nyagu et al. 1998) and Belarus (Belarus; Loganovsky et. al 2008).[113]

---

108 H. Scherb, E. Weigelt, Spaltgeburtenrate in Bayern vor und nach dem Reaktorunfall in Tschernobyl [Cleft lip and cleft palate birth rate in Bavaria before and after the Chernobyl nuclear power plant accident], Mund Kiefer Gesichtschirurgie 2004 Mar;8(2):106-10. (German). Strahlentelex, 416-417/2004, 4f., Fehlbildungen in Bayern nach Tschernobyl [Malformations of newborns in Bavaria]. (German)

109 Otto-Hug-report no. 24. Strahlentelex, 388-389/2003, 6f., Auch in Deutschland und anderen Ländern Europas starben nach Tschernobyl deutlich mehr Säuglinge, gab es mehr Fehlbildungen und Totgeburten [In Germany and other European countries, decidedly more infants also died since Chernobyl, and there were more malformations and stillbirths]. (German)

110 BEIR V: Health effects of exposures to low levels of ionising radiation. National Research Council, Committee on the biological effects of ionising radiation, Nat. Academy Press, Washington, 1990.

111 A.M. Kellerer: Reaktorkatastrophe und Säuglingssterblichkeit? [Reactor catastrophe and infant mortality?] GSF-Report 19/98. Neuherberg. (German)

112 Strahlenschutzkommission [Radiation Protection Commission]:Wirkungen nach pränataler Bestrahlung [Effects following prenatal radiation]; BMU ed., 1989.

113 K.S. Heiervang, S. Mednick, K. Sundet, B.R. Rund: Effect of low dose ionizing radiation exposure in utero on cognitive function in adolescence, Scandinavian Journal of Psychology 2010, Blackwell Publishing Oxford, DOI: 10.1111/j.1467-9450.2010.00814.In: Strahlentelex:556 -557,2010

Excursus: Chernobyl effects on animals in Europe

In Germany in the aftermath of Chernobyl, malformations were not only observed amongst people but also in animals. There have always been malformations amongst animals. The genetics department of the Faculty of Veterinary Medicine at the University of Giessen alone has about 8.000 specimens. One year after Chernobyl, there was an influx as had never been seen before: miscarriages and premature births by cows in Bavaria and Corsica, piglets without eyes, chicks with three legs, rabbits without legs, sheep without fleece or with only one eye, foals with areas of skin missing, baby goats with corkscrew legs or open abdomens. Some breeders reported a loss of up to 40% of young animals. Goats are regarded as the domestic animals most sensitive to radioactivity. In 1987, many breeding animals did not become pregnant. Further, there was an accumulation of miscarriages, premature births, stillbirths and problematic births, lambs that were too small, lambs that were too large, with no swallowing reflex, problems of the thyroid gland, premature deaths of lambs and serious malformations. The reports came from the Rhineland, Saarland, Saar-Pfalz, Rhineland-Pfalz and from the Sauerland. They often came in spite of some considerable pressure from goat breeders' associations, who did not want the problem to be reported.[114]

An above average increase in the occurrence of hermaphrodites, stillbirths and malformations was found amongst the goat population of the southern German states in a survey carried out in 1987 by the Institute for Animal Husbandry and the Genetics of Domestic Animals at the University of Gießen, under the direction of Prof. Dr. J. Steinbach. Data from before (1985-1986) and after the Chernobyl catastrophe (1987) was taken in 133 randomly chosen goat-keeping farms in eight Federal States. No permission was granted to the study group for Bavaria. A total of 890 litters prior to Chernobyl and 794 litters in the aftermath of the nuclear disaster were examined. According to the study, the litter-size decreased from 1.93 to 1.82 after Chernobyl. The proportion of hermaphrodites rose from 2.2 to 3.48%. Stillbirths increased from 4.66 to 5.77%. Congenital malformations of dead lambs increased from 0.93 to 1.32% and congenital malformations of live-born lambs from 0.31 to 1.1%. The effects appeared mainly in the southern States, which had been heavily contaminated by fallout from Chernobyl.[115]

Impressive evidence of genetic damage amongst animals can be taken from the scientific drawings of Cornelia Hesse-Honegger. Prior to Chernobyl, she had already been professionally involved with drawing genetic damage in flies following various kinds of stress. After Chernobyl, she spent many years documenting the different genetic changes found amongst leaf bugs (heteroptera). Apart from that she also documented the genetic changes to heteroptera in the vicinity of various nuclear facilities. Her drawings are not only artistically impressive – they also draw attention to a level of radiation damage which does not immediately come to mind, but which is none the less to be taken very seriously.[116]

In Great Britain, restrictive measures are still in force for 379 farming businesses with a total of 74,000 hectare and 200,000 sheep, 19 years after Chernobyl due to continuing radioactive pollution.[117] Similar restrictions are to be found in certain areas of other EU

114 Irene Noll, Strahlentelex, 9/1987, 1f.(German)

115 Strahlentelex, 31/1988, 5, Vermehrt Zwitter, Totgeburten und Missbildungen in süddeutschen Ziegenherden [More hermaphrodites, stillbirths and malformations in S. German goatherds].(Ger)

116 C. Hesse-Honegger: Heteroptera, Das Schöne und das Andere oder Bilder einer mutierenden Welt [Beauty and the other, or pictures of a mutating world]; Steidl-Verlag, Göttingen, 2003

117 Response of the European Commission to a question by the EP member Rebecca Harms, P-1234/05DE on 21.4.2005.

member countries, for example, in Sweden and Finland with regard to reindeer, as well as in Ireland. In a survey carried out by the European Commission in 2002, the commission received confirmation that, for example, in game (wild boar, deer), mushrooms and wild berries, as well as in carnivorous fish taken from lakes in certain areas of Germany, Austria, Italy, Sweden, Finland, Lithuania and Poland, contamination values of caesium-137 could sometimes reach levels as high as several thousand becquerel per kilogram.[118] [119]

4.3 Other countries

At the beginning of 1987, an increased frequency of congenital malformations was reported in western Turkey, which had been particularly badly affected. Ten babies were born without brains in November 1986 in Düzce on the west coast of the Black Sea. According to Faruk Tezer, head physician at a private clinic in Düzce, normal occurrence of the lethal malformation anencephaly would only occur in three cases. Another conspicuous malformation that was reported was neural tube defect.[120] [121] [122] [123] [124] [125] [126]

An increase in the rate of congenital malformations (including defects to the central nervous system (CNS) and malformations of limbs) was also registered in the more heavily contaminated areas of Finland. More cases of CNS-defects were also observed in Denmark, Hungary and Austria. [127]

Malformations of the heart, CNS and multiple anomalies were observed in the Pleven region of Bulgaria. At the University Clinic of Zagreb in Croatia, autopsies were carried out between 1980 and 1993, on all premature stillbirths and newborns that died within the first 28 days of life. An increased rate of CNS-anomalies was also found there following Chernobyl. [128]

L. Saxén et al. found a significant increase in premature births amongst children born between August and December 1986 in Finland, and whose mother had spent their first three

118 Th.D.: 19 Jahre nach Tschernobyl, britische Schafe sind immer noch radioaktiv verseucht [19 years after Chernobyl, British sheep are still radioactively contaminated]; Strahlentelex Nr.440-441/2005, 6f. (German)

119 A. McSmith: Chernobyl: A poisonous legacy; Independent, 14.3.2006.

120 Güvenc, H., Uslu, M.A., Güvenc, M., Ozkici, U., Kocabay, K., Bektas, S.: Changing trend of neural tube defects in Eastern Turkey; J. Epidemiol. Community Health, 1993, 47:40-41.

121 Caglayan, S., Kayhan, B., Mentesoglu, S., Aksit, S.: Changing incidence of neural tube defects in Aegean Turkey; Pediatric and Perinatal Epidemiology, 1990, 4:264-268.

122 N. Akar, Cavadaò, A.O., Arcasoy, A.: High incidence of Neural Tube defects in Bursa, Turkey; Pediatric and Perinatal Epidemiology 1988, 2:89-92.

123 Strahlentelex, 3/1987,1f. Mongolismus nach Tschernobyl zwei- bis dreimal häufiger [Down's syndrome since Chernobyl two to three times more frequent]. (German)

124 Hoffmann, W.: Fallout from the Chernobyl nuclear disaster and congenital malformations in Europe. Archives of Environmental Health 56 (2001) 478-484.

125 Mocan, H., Bozkaya, H., Mocan, Z.M., Furtun, E.M.: Changing incidence of anencephaly in the eastern Black Sea region of Turkey and Chernobyl; Pediatric and Perinatal Epidemiology 1990, 4:264-268.

126 Inge Schmitz-Feuerhake, Fehlbildungen in Europa und der Türkei [Malformations in Europe and Turkey], Strahlentelex, 374-375/2002, 9 f (German)

127 Hoffmann, W.: Fallout from the Chernobyl nuclear disaster and congenital malformations in Europe. Archives of Environmental Health 56 (2001) 478-484. Inge Schmitz-Feuerhake, Malformations in Europe and Turkey, Strahlentelex, 374-375/2002, 9 f. (German)

128 Akar 1994. Hoffmann, W.: Fallout from the Chernobyl nuclear disaster and congenital malformations in Europe. Archives of Environmental Health 56 (2001) 478-484. Inge Schmitz-Feuerhake, Fehlbildungen in Europa und der Türkei [Malformations in Europe and Turkey], Strahlentelex, 374-375/2002, 9 f. (German)

months of pregnancy living in those areas of Finland that had been heavily contaminated by Chernobyl fallout. The results of this study show that the level of radioactive fallout to which the Finnish population had been exposed was not sufficient to cause foetal damage to those children born after full gestation. This study does not, however, exclude the possibility of hereditary defects in children who were irradiated during their foetal development. They were also unable to explain the increased frequency of premature births of handicapped children in the more heavily contaminated areas of Finland.[129]

In 1991, J. Pohl-Rüling et al. published the results of a study on chromosome damage to the lymphocytes of people living in Salzburg (Austria) in the aftermath of the Chernobyl reactor disaster. The radiation doses absorbed by the tested persons in 1987, as a result of Chernobyl fallout, were between 15 and 68% higher than previous radiation levels. The radiation level in Salzburg prior to Chernobyl had a median value of 0.9 milligray per annum, after Chernobyl it was 2 milligray per annum. At the same time, the amount of damage to the lymphocyte chromosomes in the peripheral blood of the test persons initially increased about 6-fold compared to before Chernobyl. With higher additional doses the amount of chromosome damage was reduced. According to Pohl-Rüling et al. the dose/effect curve shows the same tendency as results from other studies.[130].

In Scotland[131] and Sweden[132]- similar to Berlin and Belarus – there were sudden increases in cases of Down's syndrome (trisomie 21) following Chernobyl.[133]

Hoffmann believes that the current argument - calculated on the basis of model estimates – that fallout doses from Chernobyl in neighbouring countries are far too small to produce measurable effects, is refuted by the fact that there was proof of increased chromosome aberration following the accident from outside those countries directly affected by Chernobyl (Ukraine, Belarus and Russia). With the aid of biological dosimetry it could be shown that underestimations are included in the assumptions regarding the population's exposure to radiation.[134]

129 L. Saxén, T. Rytömaa, British Medical Journal 1989, 298: 995-997.

130 J. Pohl-Rüling, O. Haas, A. Brogger et al.: The effect on lymphocyte chromosomes of additional radiation burden due to fallout in Salzburg (Austria) from the Chernobyl accident. Mutation Research, 262(1991), 209-217, in: Strahlentelex, 106-107/1991, 1ff., Chromosomenschäden in Salzburg. (German)

131 Ramsay C.N. et al.: Down's syndrome in the Lothian region in Scotland – 1978-1989; Biomed. Pharmacother. 1991; 45:267-272, in: Hoffmann, W.: Fallout …

132 Ericson, A., Kallen, B.: Pregnancy outcome in Sweden after the Chernobyl accident. Environ. Res. 1994; 67:149-159.

133 Hoffmann, W.: Fallout from the Chernobyl nuclear disaster and congenital malformations in Europe. Archives of Environmental Health 56 (2001) 478-484. Inge Schmitz-Feuerhake, Fehlbildungen in Europa und der Türkei [Malformations in Europe and Turkey], Strahlentelex, 374-375/2002, 9 f. (German)

134 Ibid.

5. Thyroid cancer and other thyroid diseases

6.1 The Chernobyl region

On the second anniversary of the catastrophe the Soviet Minister for Health, E. Tschasow, wrote in "Pravda" (the central organ of the CPSU), "that today we can be sure that the disaster in the Chernobyl atomic power station had no effect upon the health of the population in the afflicted areas."

Prof. L.A. Ilyin et al. presented the first report on contamination patterns and possible consequences to health after Chernobyl in Moscow in March 1989, following years of secrecy [135]. Ilyin made the prognosis, amongst others, that in 39 districts in 9 relatively heavily contaminated areas 90 from 158,000 children (0-7 years old) would develop thyroid cancer in the following 30 years

If these prognoses are compared to the following facts it becomes apparent just how far removed they are from reality. Even today Ilyin represents Russia in the decisive international bodies on questions regarding radiation (ICRP, UNSCEAR) where he is still considered to be a competent expert on the effects of Chernobyl (s. also capital 10)

In January 1990, A.M. Kellerer, director of the Radiobiological Institute in Munich, presented a "report to the Red Cross"[136]. In it he wrote, "A particular problem is the fear regarding damage to thyroid function [...] As thyroid testing is now more widely carried out a great many more dysfunctions are being discovered. These are being attributed to radiation exposition, although in spite of high doses of radioiodine no pathological changes or dysfunctions are to be expected. [...] The population and the greater part of the medical world attribute the increased rates of illness to irradiation. A critical assessment of the situation however, leads to the conclusion that the increases could be due to any of three factors:

1. Changed and restricted living and nutritional conditions;
2. Serious anxiety states;
3. More frequent and intensive medical examinations and fuller reports on illness in the contaminated areas."

Four yeas after Chernobyl, D. Arndt, head physician in the department of radio medicine in the state office for nuclear safety and radiation protection in the GDR, wrote to S. Pflugbeil: "that the problems in the areas around Chernobyl are not of a radiobiological but of a psychosomatic nature and brought on by changed habits (vitamin deficiency / major confinement to the living quarters)."[137]

---

135 L.A. Ilyin et al.: Ecological particularities and medical, biological consequences of the accident of Chernobyl nuclear power plant. Report by 23 scientists for meeting of USSR Medical Sciences Academy, 21-23 of March.1989, in: A. Yaroshinskaya: Overview of Different Informations about Acute Radiation Syndrome among Inhabitants around Chernobyl; in: T. Imanaka (ed.): KURRI-KR-21.

136 A.M. Kellerer: Bericht an das Rote Kreuz über die Mission einer Expertengruppe der Liga der Organisation des Roten Kreuzes und des Roten Halbmondes in die vom Reaktorunfall in Tschernobyl betroffenen Gebiete der Sowjetunion]Report to the Red Cross on a mission undertaken by a group of experts from the league of Red Cross and Red Crescent organisations to those areas in the Soviet Union effected by the reactor accident in Chernobyl]. January 1990.

137 Dietrich Arndt: Letter to Dipl.-Phys. Pflugbeil from 24.4.1988, Pflugbeil archive.

It is this kind of uninformed expert position that has prevented timely and effective medical intervention – it would seem that ultimately, people in the area of Chernobyl only had themselves to blame if they did not go for walks and eat enough vegetables.

The first detailed information outside the USSR on the facts about thyroid diseases following Chernobyl appeared in autumn 1990 in Berlin.[138], Maria Ankudovich, a doctor in Minsk, reported that irradiation could not only cause thyroid cancer but, much more often, swellings in the thyroid gland, various types of autoimmune thyroiditis and hypothyroidism. Due to the changed hormonal status of children with an irradiated thyroid gland, there is a growing risk of dysfunctions and defective development amongst children and adolescents. Due to neuroendocrinal regulation disorders, there is an increased possibility of carcinoma occurring in other glands: in the pituary gland, the adrenal cortex, the pancreas, breast and ovaries. M. Ankudowitsch reported that approx. 5 % of children in the southern areas of Belarus received radiation doses of more than 10 Gray, about 20% of children in the areas that had not been controlled received approx. 1 Gray. Particularly noticeable is the development of thyroid cancer amongst children from Belarus. Thyroid cancer is an illness that usually occurs in older people. It is an extremely rare illness amongst children. Prior to 1986, there were 0-2 new cases amongst children in Belarus per annum. The figure was 7 by 1989, and by the autumn of 1990 there were 22 cases. At this point in time, it was already obvious that an avalanche was approaching – bigger and faster than had been held possible on the basis of previous experience. The candour of this courageous doctor seriously damaged her career chances.

The IAEA presented the results of the International Chernobyl Project in the spring of 1991. This extensive study states: “The children examined [...] were found to be generally healthy“. And: “The data did not show a marked increase in leukemia or thyroid tumours since the accident.“[139]

As the data on cases of thyroid cancer in Belarus are all collated in one place, a telephone call would have sufficed to learn the real figures. Today we know:

- that tissue samples from children in the Chernobyl region were already lying on the desk of one of the leading scientists of this project – Prof. F.A. Mettler, USA - he knew about it and was untruthful in what he wrote in the report.[140]
- that the scientists working on the Chernobyl Project were in possession of a report from the Belarussian Minister of Health, in which he explicitly drew attention to the significant increase in the incidence of thyroid disease amongst children in the heavily contaminated areas in the district of Gomel.[141] This report was ignored.

From November 20 to 23 in 1995, the World Health Organisation (WHO) hosted an international conference in Geneva, Switzerland on the effects on health of the Chernobyl reactor catastrophe and other nuclear accidents. Results of studies were presented at the conference showing that there had been a steep rise in the incidence of thyroid disease,

138 Maria Ankudovich: Gesundheitszustand der Kinder in der Umgebung von Tschernobyl [State of health of the children in the vicinity of Chernobyl]; in “Kinder von Tschernobyl”, Erstes Berliner Koordinationstreffen, 27.-28.10.1990, Berlin, Attachment 3,1-4. (German)

139 The International Chernobyl Project, An Overview, Assessment of Radiological Consequences and Evaluation of Protective Measures, Report by an International Advisory Committee, IAEA, Vienna, 1991.

140 BBC 2: Chernobyl – 10 years on. In the TV series HORIZON, 1.4.1996.

141 V.S. Ulashchik: Some Medical Aspects of the Consequences of the Accident at the Chernobyl Nuclear Power Plant (Based on Belarussian Data). Appendix 5 of the Draft Proposal “The Radiological Consequences in the USSR from the Chernobyl Accident: Assessment of Health and Environmental Effects and Evaluation of Protective Measures”. The International Chernobyl Project. IAEA, Vienna, 1990-04-18.

particularly amongst children living in highly contaminated areas. The rates of illness had increased much faster than had been expected.[142]

In the view of the WHO expert Keith Baverstock, the time span between the reactor accident and the increase in the incidence of cancer was “surprisingly short”. In addition, the tumours that the children in Belarus are suffering from are unusually aggressive and spread to other parts of the body.[143]

The starkest increase in the incidence of thyroid cancer in children occurred in the Gomel area, which had been most heavily affected by Chernobyl. About 50 percent of all cases of thyroid cancer amongst children in Belarus have occurred in this region. This area also takes first place in the number of thyroid cancer cases amongst adults. The annual number of new cases of illness amongst children between 0 and 18 years of age in the Gomel area in 1998 was already 58 times higher than in the 13 years prior to Chernobyl.[144] [145]

The majority of the children with thyroid cancer were younger than 6 at the time of the accident, more than half of them were younger than 4. The incidence rate of the disease amongst children (0-14 years old) in Belarus peaked in 1995. At an early stage it was established that the rate of growth of thyroid cancer amongst children was aggressive and the development of metastases in other organs – particularly in the lungs – rapid. The cases that occurred were almost all identified as papillary thyroid carcinomas.

The Chernobyl *super-GAU* also led to an increase in cases of thyroid cancer in Ukraine. Following Chernobyl, the amount of radioactive iodine in the thyroid glands of 110,000 children and 40,000 adults was measured and a cancer registry was created. 418 cases of thyroid cancer amongst children were registered by 1993. By encoding the information into areas, a clear relationship to ionising radiation became evident.[146]

Thyroid disease in Belarus, as well as in Ukraine and Russia, were the subject of a widely applied study by M. Fuzik et al.[147] The study is based on figures from the cancer registries in Belarus, Russia and Ukraine. The data from these three states also shows that the highest incidence rates of illness were amongst people who were small children at the time of the reactor catastrophe. It appears that those children born before Chernobyl (1982-1986) and those who had just been born or were only a few years old at the time of the reactor catastrophe, are more likely to develop thyroid cancer than children born in the years following Chernobyl (1987-1991).

The fact that children were strongly affected is taken as a robust indication of the sensitivity of the thyroid glands of infants and small children to the carcinogenic effect of ionising radiation. The aggressiveness of thyroid cancer amongst children in Belarus can be identified by the early development of metastases. In the primary tumour stage pT1 of the TNM

142 Heiko Ziggel: Schilddrüsenkrebs nimmt schneller zu als erwartet [Thyroid cancer increases faster than expected], Strahlentelex 214-215/1995, 1ff. (German)

143 Strahlentelex 138-139/1992, p. 1ff. Die Kinder erkranken jetzt öfter an Krebs [Children developing cancer more frequently]. (German)

144 Strahlentelex 326-327/2000, p. 6 f., Desinformation über Schilddrüsenerkrankungen nach Tschernobyl [Disinformation on cases of thyroid cancer since Chernobyl]. (German)

145 Edmund Lengfelder et al.: Münchner Medizinische Wochenschrift – Fortschritte in der Medizin [Progress in medicine]. 43(2000)355-357. (German)

146 Nature, 375(1995), 365.

147 M.M. Fuzik, A.Ye. Prysyazhnyuk, V.G. Gristchenko, V.A. Zakordonets, Ye.M. Slipenyuk, Z.P. Fedorenko, L.O. Gulak, A.Ye. Okeanov, V.V. Starinsky, Thyroid cancer, Peculiarities of epidemiological process in a cohort being irradiated in childhood in Republic of Belarus, Russian Federation, and Ukraine, International Journal of Radiation Medicine 2004, 6(1-4): 24-29.

classification – only 1 tumour nodule of 10 mm maximum diameter unilaterally in one thyroid lobe – 43% of the cases show involvement of the regional lymph nodes. In 3% of cases, metastases have also developed in other organs.[148]

According to the study by Fuzik et al., in all 12 areas investigated in the three states most affected by Chernobyl - Belarus, Russia and Ukraine - there was a significant increase in thyroid cancer amongst children 0 to14 years old with a latency period of about 4 to 5 years after the reactor catastrophe. [149] The areas involved were the Ukrainian regions of Vinnitsa, Zhytomir, Cherkassy, Chernigov Land, Kiev and Kiev city, the Belarussian regions of Gomel and Mogilev, as well as the Russian regions of Bryansk, Kursk, Orjol and Tula. The area where the increase was greatest was the Gomel region, followed by the regions of Bryansk, Orjol, Kiev city, Kiev, Chernigov, Mogilev and Zhytomir.

According to Vassili Kazakov from the ministry of health in Minsk, the incidence of thyroid cancer amongst children in Belarus in 1992 was up to 80 times higher than the global average.[150]

According to Lengfelder et al., by the end of 2001 there were already more than 1,000 cases of thyroid cancer amongst children and young adults in Belarus alone.[151]

In a paper published in 2004 Okeanov et al. stated that the rate of thyroid cancer amongst children in Belarus had increased 100-fold.[152]

Okeanov et al. pointed out that the incidence rate of thyroid cancer had also increased amongst adults. Prior to Chernobyl, thyroid cancer was a relatively rare disease amongst Belarussian adults. Since 1990 – four years after Chernobyl – there has been a massive increase in the incidence rate of the disease, reaching the highest worldwide level ever seen. The standardized annual rate of illness for thyroid cancer amongst adults over 30 was 1.24 per 100,000 inhabitants in 1980. By 1990, the index was 1.96 and in the year 2000 it was 5.67[153]

Pavel I. Bespalchuk (2007) calculated that after the catastrophe more than 12,000 people developed thyroid cancer in Belarus alone[154].

Lengfelder et al. pointed out that with the increased temporal distance to the accident ever more children who had been contaminated by iodine in 1986 would become adolescents and

---

148 Edmund Lengfelder, Christine Frenzel: 16 Jahre nach Tschernobyl. Weiterhin dramatisches Ansteigen der Schilddrüsenkarzinome in Belarus. Der Heilungserfolg ist bei zahllosen Patienten weiter von intensiver westlicher Hilfe abhängig [16 years after Chernobyl. Continuing dramatic increase in thyroid carcinoma in Belarus. Recovery chances of numerous patients still dependent upon intensive Western aid]. Otto Hug Strahleninstitut MHM. Sept. 2002.(German)

149 M.M. Fuzik, A.Ye. Prysyazhnyuk, V.G. Gristchenko, V.A. Zakordonets, Ye.M. Slipenyuk, Z.P. Fedorenko, L.O. Gulak, A.Ye. Okeanov, V.V. Starinsky, Thyroid cancer, Peculiarities of epidemiological process in a cohort being irradiated in childhood in Republic of Belarus, Russian Federation, and Ukraine, International Journal of Radiation Medicine 2004, 6(1-4): 24-29.

150 V. Kazakov: Nature, 3. September 1992.

151 Edmund Lengfelder, Christine Frenzel: 16 Jahre nach Tschernobyl. Weiterhin dramatisches Ansteigen der Schilddrüsenkarzinome in Belarus. Der Heilungserfolg ist bei zahllosen Patienten weiter von intensiver westlicher Hilfe abhängig [16 years after Chernobyl. Continuing dramatic increase in thyroid carcinoma in Belarus. Recovery chances of numerous patients still dependent upon intensive Western aid]. Otto Hug Strahleninstitut MHM. Sept. 2002. (German)

152 A. E. Okeanov, E. Y. Sosnovskaya, O. P. Priatkina, A national cancer registry to assess trends after Chernobyl accident, Swiss Medical Weekly 2004, 134: 645-649.

153 Ibid.

154 P. I. Bespalchuk et al. (2007) Thyroid Cancer after Chernobyl, International Congress series, Vol. 1299, February 2007, Pages 27-31

then reach adulthood. They will carry the risk of cancer – which they will be unable to get rid of for the rest of their lives – with them into the older age groups. But the risk of cancer amongst those who were already adults at the time of the catastrophe has also risen starkly: Fact is, in the age group 50 to 64 the incidence rate of thyroid cancer since Chernobyl (1986-1998) has increased 5-fold, as compared to the period before Chernobyl (1973-1985). The incidence rate was still 2.6 times higher even amongst the over 64 year-olds.

Table: Thyroid cancer in the Gomel area (Belarus) for 13 years before and 13 years after the Chernobyl catastrophe[155]

Age	1973-1985	1986-1998	Increase
0-18	7	407	58-fold
19-34	40	211	5.3-fold
35-49	54	326	6-fold
50-64	63	314	5-fold
>64	56	146	2.6-fold

In Belarus alone, there were over 3,000 excess cases of thyroid cancer amongst adults by the year 2000.[156]

In the mean time, excess cases of thyroid cancer in Belarus since Chernobyl amongst children, young adults and adults amount to more than 10,000.[157]

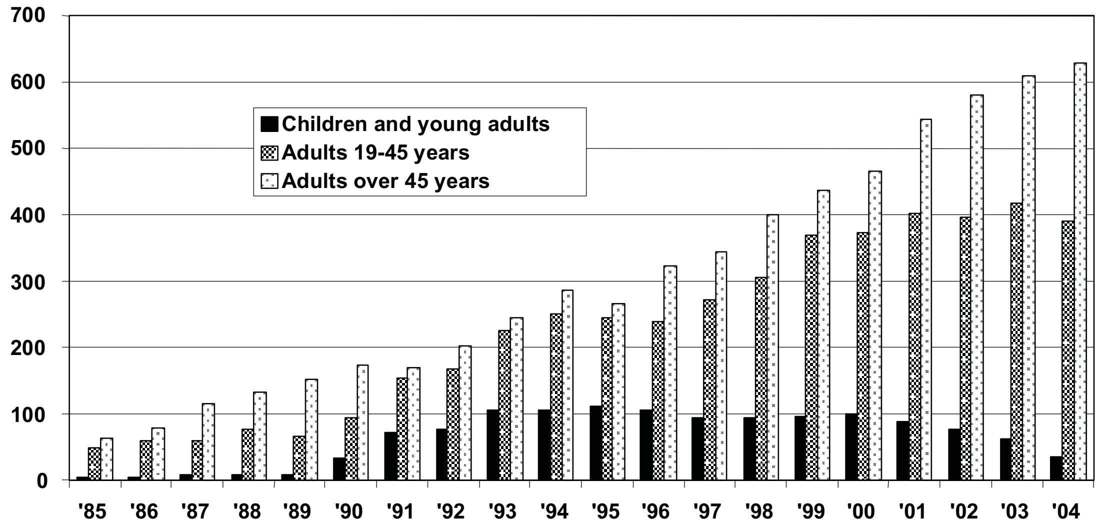
An international symposium on radiation and the thyroid gland was held in Cambridge (MA) in July 1998. It was hosted by the European Commission, the US Department of Energy and the National Cancer Institute of the US Health Department.

155 E. Lengfelder et al.: Aus der Tschernobyl-Katastrope lernen. Jod-Prophylaxe auf alle Altersstufen ausweiten [Learning from the Chernobyl catastrophe. Extend iodine prophylaxis to all age groups]. MMW-Fortschr. Med. 41(2000)355-356.(German)

156 Edmund Lengfelder, Christine Frenzel: 16 Jahre nach Tschernobyl. Weiterhin dramatisches Ansteigen der Schilddrüsenkarzinome in Belarus. Der Heilungserfolg ist bei zahllosen Patienten weiter von intensiver westlicher Hilfe abhängig [16 years after Chernobyl. Continuing dramatic increase in thyroid carcinoma in Belarus. Recovery chances of numerous patients still dependent upon intensive Western aid]. Otto Hug Strahleninstitut MHM. Sept. 2002 (German)

157 In a telephone message from Edmund Lengfelder on February 1, 2006. Cp. also E. Lengfelder, H. Rabes, H. Scherb, Ch. Frenzel: Factors influencing the assessment of Chernobyl health consequences and the contribution of international non-governmental organisations to research and treatment of thyroid pathologies in Belarus. 4th International Conference, June 2-6, 2003, Kiev, Ukraine, Chernobyl Children – Health effects and psychosocial rehabilitation, Proceedings, International Journal of Radiation Medicine 2003, Addendum.

Fig. Incidence of thyroid cancer in Belarus 1985-2004[158]



At this symposium, representatives of the World Health Organisation (WHO) developed a prognosis based on the temporal progress of cases of childhood thyroid cancer that had occurred so far. Out of all of the 0 to 4 year-old children in the Gomel area at the time of the reactor catastrophe, one third will develop thyroid cancer during their lifetime.[159] According to the WHO prognosis, this means that, in the Gomel area of Belarus alone, more than 50,000 people who were 0-4 years old at the time of the catastrophe will develop thyroid cancer. If the prognosis is extended to all age groups (including adolescents and all adult groups) of people living in the Gomel area at the time of the reactor catastrophe, then in this area alone more than 100,000 cases of thyroid cancer can be expected in the aftermath.[160]

The number of patients being treated in the Gomel area also gives an impression of the extent of thyroid cancer there. According to Lengfelder et al., more than 70,000 patients had already undergone extensive thyroid therapy in the thyroid centre in Gomel by the year 2002. [161]

158 Edmund Lengfelder, Christine Frenzel: 20 Jahre nach Tschernobyl. Erfahrungen und Lehren aus der Reaktorkatastrophe [20 years after Chernobyl. Experiences and lessons from the reactor catastrophe]. Otto Hug Strahleninstitut MHM. Information, February 2006. (German)

159 E. Cardis et.al. Observed and predicted thyroid cancer following the Chernobyl accident: Evidence for factors influencing susceptibility to radiation induced thyroid cancer. In: G. Thomas et al.: Radiation and Thyroid Cancer. EUR 18552 EN, World Scientific, Singapore 1999, 395-405.

160 Edmund Lengfelder, Christine Frenzel: 20 Jahre nach Tschernobyl. Erfahrungen und Lehren aus der Reaktorkatastrophe [20 years after Chernobyl. Experiences and lessons from the reactor catastrophe]. Otto Hug Strahleninstitut MHM. Information, February 2006. (German)

161 Edmund Lengfelder, Christine Frenzel: 16 Jahre nach Tschernobyl. Weiterhin dramatisches Ansteigen der Schilddrüsenkarzinome in Belarus. Der Heilungserfolg ist bei zahllosen Patienten weiter von intensiver westlicher Hilfe abhängig [16 years after Chernobyl. Continuing dramatic increase in cases of thyroid carcinoma in Belarus. Recovery chances for many patients still dependent upon intensive Western aid]. Otto Hug Strahleninstitut MHM. Sept. 2002 (German)

5.2 Germany

Following Chernobyl in 1986 an increased rate of thyroid under-function (hypothyroidism) was discovered amongst newborns during the course of regular early-diagnosis examinations in the Federal State of Hesse. The information was given by the State Office for Medical, Nutritional and Veterinary Inspection in Dillenburg, Middle Hesse.[162]

In 1986 an increase in cases of thyroid disease was also discovered in Berlin. Fourteen children were born with thyroid gland insufficiency (hypothyroidism) in 1986. In previous years, the median value had only been three to four, at the most seven. The Paediatric Clinic of the Free University of Berlin in the "Kaiserin-Auguste-Viktoria-Haus" (KAVH) gave this information to the " Strahlentelex " journal at the end of June 1987.[163]

The data needed to carry out extensive investigations into thyroid diseases in Germany, before and after Chernobyl, has not been made available to date.

5.3 Other countries

A study carried out by the Radiobiological Institute of the University of Munich (Stefan Mürbeth, Prof. Lengfelder), the Czech NGO Fakultni Nemocnice Plzen in Pilsen, Czech Republic (Milena Rousarova) and the GSF Research Centre for Environment and Health in Neuherberg (Hagen Scherb) found an increase in the incidence of thyroid cancer amongst adults in the Czech Republic.[164] The Czech Republic was affected by Chernobyl fallout in a similar way to East Germany and Bavaria. The investigations were carried out in the Czech Republic because they – as opposed to Germany – also keep a cancer registry for adults. The study is particularly revealing as it draws on data from a large population over a long period of time –a total of 247 million person-years all told.

From 1975 onwards, there was a collective increase in the incidence of thyroid cancer amongst men, women and both sexes together. However from 1990 on, following Chernobyl there was a significant increase in the rate of thyroid cancer for both sexes from 2.0 percent per annum to 4.6 percent per annum (95%-CI: 1.2-4.1, p=0.0003). The values for women are noticeably higher than those for men, the increase being significant as early as 1989 (p=0.0005). All in all, since Chernobyl there have been 426 excess cases of thyroid cancer in the Czech Republic alone (95%-CI: 187-688).

It was found that there was a minimal latency period of 4 years from the reactor catastrophe to the outbreak of illness. This latency period is comparable to that in the Chernobyl region.

There were also increases in the incidence of thyroid cancer cases amongst adolescents and adults in Poland[165] and in the North of England[166].

162 Strahlentelex 20/1987, 6, Hesse: Nach Tschernobyl vermehrt Kinder mit Schilddrüsenunterfunktion geboren [More children born with underfunctioning thyroid since Chernobyl]. (German)

163 Strahlentelex 12/1987, 2, Berlin: Vermehrt Schilddrüsenerkrankungen bei Neugeborenen [More thyroid disease amongst newborns]. (German)

164 Stefan Mürbeth, Milena Rousarova, Hagen Scherb, Edmund Lengfelder: Thyroid cancer has increased in the adult populations of countries moderately affected by Chernobyl fallout. Med Sci Monit, 2004; 10(7): CR300-306.

165 Z. Szybinski, P. Olko, E. Przybylik-Mazurek, M. Burzynski: Ionizing radiation as a risk factor for thyroid cancer in Krakow and Nowy Sacz regions. Wiad Lek, 2001, 54(Suppl. 1): 151-156 (Polish).

166 S.J. Cotterill, M.S. Pearce, L. Parker: Thyroid cancer in children and young adults in the North of England. Is increasing incidence related to the Chernobyl accident? Eur J Cancer, 2001, 37(8): 1020-1026.

6. All cancers and leukaemia

There are a number of different approaches to and models for estimating the risk of cancer following Chernobyl. An analysis of the LSS cohorts of atomic bomb survivors in Hiroshima and Nagasaki by Preston et. al. (2007) also found a significant dose–effect relationship for the level of 0.15 Gy and less.[167] The radiation-related increase in the number of cancer cases persists, independent of age at the time of exposure.

The estimated whole–body doses for the affected population in the area around Chernobyl ranged from 0 – 1.5 Gy. At the same time, it must be noted that an increasing number of Chernobyl studies from the three countries affected have come to the conclusion that the risk of cancer due to chronic low-level radiation is higher in comparison with the results from studies on atomic bomb survivors. The multi-centre study that was carried out on nuclear industry workers in 15 countries shows that the risk for all cancers, except leukaemia and lung cancer, is approximately 3-times higher than for the atomic bomb survivors. It must therefore be ascertained that the results of studies carried out on atomic bomb survivors cannot be applied to the Chernobyl population, as they systematically underestimate the risk[168].

Malko (2007)[169] estimated the risk for 70 years (1986 – 2056) in Belarus alone to be 62,500 additional cases of cancer and leukaemia as a result of Chernobyl. He arrives at the figure of 239,900 additional cancer and leukaemia cases for the whole of Europe.

6.1 The Chernobyl region

A national cancer registry, in which information on all malignant tumours is collated, has been maintained in Belarus since 1973. A study by Okeanov et al. compared cancer cases from the years 1976 to 1985 with those from 1990 to 2000[170]. The study showed a significant increase in cancer rates in Belarus of about 39.8%. Prior to Chernobyl, the annual rate of illness had been 155.9 cases per 100,000 inhabitants. The rate of illness since Chernobyl was 217.9 cases. The main increases applied to cancer of the colon, lung, bladder and thyroid gland.

The increase in the rates of cancer was significant in all areas of Belarus. In the Gomel area however, which had received the highest radiation dose from Chernobyl, the increase in the cancer rate by 55.9 percent was significantly higher than in those areas of Belarus that had been less contaminated. The cancer rate in Gomel prior to Chernobyl - an annual 147.5 cases per 100,000 inhabitants - had been below the state average (155.9). The rate of cancer in Gomel since Chernobyl - 224.6 cases - was clearly above the state average (217.9). The Vitebsk area, where there had been less radioactive fallout, served as a "control area". The

---

[167] Preston, D.L et al. (2007):Solid Cancer Incidence in Atomic Bomb Survivors, 1958 -1998// Radiat. Res.-2007-V. 168 No. 1,P.1-64

[168] Goncharova, R. (2010): New insight into cancer risk from radiation exposure of low dose and low dose rate; http://www.ippnw2010.org/fileadmin/user_upload/Plenary_presentations/Plen4_Slides_Goncharova_Basel_291008.pdf

[169] Malko, M.V. Assessment of Chernobyl malignant Neoplasms in European Countries; http://www.physiciansofchernobyl.org.ua/eng/Docs/Malko.pdf

170 A. E. Okeanov, E. Y. Sosnovskaya, O. P. Priatkina: A national cancer registry to assess trends after Chernobyl accident, Swiss Medical Weekly 2004, 134: 645-649.

direct comparison of the two Belarussian regions showed that the increase in the rate of illness was also significantly higher in Gomel than in Vitebsk. The greatest increase in the regression coefficient from 2.79 to 5.8 was registered in Gomel, although there was no significant increase in the regression coefficient shown in other Belarussian areas (All of Belarus has 3.76 or 3.15).

The increase in the rate of cancer was especially high amongst the Gomel population living in areas with a particularly high caesium 137-exposure of above 555,000 becquerel/m^2. Between 1993 and 2002, the above-average rate of development of cancer of the digestive and respiratory organs was significantly higher compared to the areas with the lowest exposure to radiation (rates of development of cancer in digestive organs: 141.5 in the most contaminated areas compared to 104.7 in the least contaminated areas. Cancer development rates in respiratory organs: 83.7 against 53.1).

The rate of breast cancer development amongst women is continuingly conspicuous. In the areas with a particularly high caesium contamination – Gomel and Mogilev – cancer of the breast is typically found in women between the ages 45 and 49, this is 15 years earlier than in the area of Vitebsk, which was less affected by Chernobyl. The disease rate curves show that the shift in the time of onset of the illness toward younger age groups is particularly strong amongst the more heavily irradiated rural population in contaminated areas.

A paper that appeared in the International Journal of Cancer confirms the increase in the incidence of breast cancer.[171] The authors found an increase in the incidence of breast cancer in the areas of Gomel and Mogilev (Belarus) and Chernigov, Kiev and Zhytomyr (Ukraine). They also found an approx. 2-fold risk increase in the most contaminated areas, for the period 1997-2000, as compared to the least contaminated areas. The authors consider it improbable that these increases are due to increased diagnostic activity in these areas.

A study carried out in the district of Lugyny (Ukraine) draws attention to the distinct decrease in the remaining lifespan following a diagnosis with stomach and lung cancer since Chernobyl.[172] Whereas in 1985, it was still 57 or 42 months following the diagnosis of stomach or lung cancer, 10 years after Chernobyl it had gone down to 2.3 or 2 months.

The same paper also called attention to an increase of destructive forms of tuberculosis amongst diagnosed cases of tubercular disease. Whereas in 1985, 17.2% of tuberculoses were destructive, in 1995 it was 50%. Godlevsky attributed both phenomena to disruption of the immune system.

Table: Life expectancy following the diagnosis of malign stomach and lung tumours before and after the Chernobyl accident (District of Lugyny, Schitomir area, Ukraine)

Year	Life expectancy (in months) following the diagnosis of	
	Stomach cancer	Lung cancer
1984	62	38
1985	57	42
–	–	–

171 E. Pukkala, S. Poliakov, A. Ryzhov, A. Kesminiene, V. Drozdevich, L. Kovgan, P. KKyyronen, I.V. Malakhova, L. Gulak, E. Cardis: Breast cancer in Belarus and Ukraine after the Chernobyl accident. International Journal of Cancer, 2006, February 27th.

172 Ivan Godlevsky, O. Nasvit: Dynamics of Health Status of Residents in the Lugyny District after the Accident at the ChNPP; in: T. Imanaka (ed.): Research Activities about the Radiological Consequences of the Chernobyl NPS Accident and Social Activities to Assist the Sufferers by the Accident, KURRI-KR-21, 149-159.

1992	15.5	8.0
1993	11.0	5.6
1994	7.5	7.6
1995	7.2	5.2
1996	2.3	2.0

Yuri Orlov et al. reported on CNS tumours amongst children of up to 15 years of age, over a period of 25 years (Ukraine excluding the Districts Dnepropetrovsk, Donetsk, Zaporozzhye and Charkov). A total of 2,633 children were treated during this time. In the 10-year period prior to Chernobyl (1976-1985), there were 756 patients, in the 10 years following Chernobyl (1986-1995) - 1,315 children i.e. 76.9% more than in the previous period - were treated despite a simultaneous decrease of more than three million in the numbers of children in the population.[173]

Even more unsettling is the situation amongst infants. Orlov and Shaversky reported on a series of 188 brain tumours amongst children under three, 9 cases from the years 1981-1985 and 179 cases from the period 1986-2002. The number of patients rose in comparison to the 5-year period prior to Chernobyl (9 cases 1981-1985) 5.1-fold 1986-1990 (46 cases), 7.7-fold 1991-1995 (69 cases) and 5.3-fold 1996-2000 (48 cases). In the period 2001-2002, 16 children were operated on. The number of sick children rose from 1.8 to 14 with the highest values in 1988 and 1994 (18 patients).

The increase in the number of tumours of the central nervous systems amongst nursing infants was even greater. There was not one single histological case examination in the period between 1981 and 1985. There were 4 cases from 1986 to 1990, 16 from 1991 to 1995, and 11 cases from 1996 to 2000.

Altogether, the number of patients under three years of age increased 5.8-fold; amongst children under one there were ten times as many patients. If the simultaneously sinking birth rate is taken into consideration, the increase becomes very evident. Not only is there a considerably increased frequency of malignant tumours, but also of benign tumours. Even though benign tumours do not create metastases and do not spread into other tissues, they do constitute a serious life-threatening illness, particularly in the brain, and especially in the brains of infants, because they displace healthy brain tissue.[174] [175]

Radioactive fallout from the Chernobyl accident in 1986 affected more than 4 million people in Ukraine. In order to examine the effects of radiation on pregnancy and the development of leukaemia, Noshchenko et al. examined the incidence of different types of leukaemia amongst children who were born in the accident year of 1986. The development of the children was followed over the ten-year period up to 1996 and the cumulative rate of disease amongst children from contaminated and non-contaminated areas was compared. The relative risk of developing any type of leukaemia is significantly higher in contaminated areas; this applies to girls as well as boys and to both sexes together. The rate of risk for acute lymphatic leukaemia (ALL) is dramatically increased for boys as well as for girls, although the increase here is not quite so severe. For both sexes combined, the relative risk of acute lymphatic leukaemia is

173 Y.A. Orlov e al.: Tumors of the central nervous system in children (morbidity rates in Ukraine for 25 Years); Int. J. Rad. Med. 2002, 4(1-4): 233-240.

174 Y.A. Orlov, A.V. Shaversky: Indices of neuro-oncological morbidity dynamics among younger children in Ukraine; Int. J. Rad. Med. 2004 6(1-4): 72-77.

175 Y.A. Orlov et al.: Tumors of the central nervous system in children; morbidity rates in Ukraine for 25 years. Intern. J. Rad. Med. 2002, 4(1-4):233-240.

more than three times higher in contaminated than in non-contaminated areas (relative risk RR = 3.4). The results of the study suggest that the increased risk of developing leukaemia for children born in 1986, who continued living in radioactively contaminated areas is due to Chernobyl fallout.[176]

Just one year later, Noshchenko et al. published the results of a case-controlled study that examined the risk of radiation-induced acute leukaemia in the period 1987-1997 amongst those aged 0 -20 years at the time of the catastrophe. They found a statistically significant increase in the leukaemia risk for men whose estimated radiation exposition had been greater than 10 mSv. The correlation of acute leukaemia to radiation exposure was significant in the period 1993-1997, particularly of acute lymphatic leukaemia. An analogous correlation was also found for acute myeloid leukaemia for the period 1987-1992.[177]

In his most recent research into the leukaemia risk, Noshenko 2010[178] found that the risk of leukaemia was significantly higher for those children in the exposed areas of Ukraine who had received a dose of 10 mGy or more.

In 1994 Ja. I. Vygovskaja et al. reported a noticeable increase in the incidence of cancer of the haematopoietic system amongst the child and adult population in the Rovno area (Ukraine), in the years following the Chernobyl reactor catastrophe. The study compared more heavily radioactively contaminated areas of Ukraine with less contaminated areas. The six northern districts of the Rovno area had been particularly heavily contaminated with radionuclides. The scientists compared the five years prior to Chernobyl (1981-1985) with the six years following Chernobyl (1987-1992). The analysis of the data showed that the incidence of haemoblastoma following Chernobyl was higher than before the nuclear catastrophe. The median standardized incidence value for malign blood diseases for the entire Rovno area prior to Chernobyl was 11.53; following Chernobyl it was 15.06 ($p<0.05$). The increase in the number of cases of chronic lymphatic leukaemia, myelomas and malign lymphomas proved to be significant. There was a steep increase in the incidence of acute leukaemias in heavily contaminated areas as compared to less contaminated areas.[179]

A study published in 1996 by Netschai on the development of haematological diseases in the Gomel area of Belarus, showed a clear increase in the incidence of malign blood diseases: it investigated the 5-year period before and the two 5-year periods after Chernobyl. The analysis showed a clear and continuous increase in the incidence of acute leukaemia, chronic lymphatic leukaemia and of the myelodysplastic syndrome in both the first and second 5-year periods following Chernobyl. [180]

176 Andrey G Noshchenko, Kirsten B Moysich, Alexandra Bondar, Pavlo V Zamostyan, Vera D Drosdova, Arthur M Michalek: Patterns of acute leukaemia occurrence among children in the Chernobyl region, Int. Journal of Epidemiology. 2001;30:125-129.

177 A.G. Noshchenko, P.V. Zamostyan, O.Y. Bondar, V.D. Drosdova: Radiation-induced Leukemia risk among those aged 0-20 at the time of the Chernobyl accident: a case-control study: Int. J.Cancer 99,609-618(2002).

178 Noshchenko AG, Bondar OY, Drozdova VD.: Radiation induced Leukaemia among children aged 0-5 years at the time of the Chernobyl accident; Int J Cancer 2010 Jul 15;127(2):412-26.

179 Ja. I. Vygovskaja, B.V. Katschorovskij, A.A. Mazurok, L.M. Lukavezkij, V.V. Orlik, Incidence of haemoblastoma in the Rovno area (Ukraine) before and after the accident in the nuclear power station in Chernobyl, Haematologye and Transfusiology, 39/1994, 22-24 (Russ.).

180 V.V. Netschai, Epidemiology of several blood diseases in the Gomel area prior to and following the catastrophe in Chernobyl, Chernobyl, Ecology and Health, 2/1996, 42-44 (Russ.).

Table: Incidence of blood diseases in the Gomel area (number)[181]

Disease	Five year period		
	1981-1985	1986-1990	1991-1995
AL	115	162	210
- of children	55	71	66
CLL	191	255	266
CML	84	95	147
Erythraemia	42	64	63
Other CL	50	70	64
All leukaemias	482	646	752
Multiple myeloma	50	79	82
Myelodisplastic syndrome	n.d.	8	43
Aplastic anaemia	24	38	22

Table: Incidence increases in the 1st and 2nd 5-year periods following the catastrophe compared to the 5-year period prior to the catastrophe (absolute (in %)) in the Gomel area[182]

Disease	Increase in incidence against 1981-1985	
	1986-1990	1991-1995
AL	+47(40.9%)	+95(82.6%)
- of children	+16(29.1%)	+11(20.0%)
CLL	+64(33.5%)	+75(39.2%)
CML	+11(13.1%)	+63(75.0%)
Erythraemia	+22(52.4%)	+21(50.0%)
Other CL	+20(40.0%)	+14(28.0%)
All leukaemias	+164(34.0%)	+270(56.0%)
Multiple myeloma	+29(58.0%)	+32(64.0%)
Myelodisplastic syndrome	-	-
Aplastic anaemia	+14(58.3%)	-2(8.3%)

The Belarussian Ministry of Extraordinary Situations and the National Academy of Sciences made the following statements in a national report to the Belarussian Parliament in 1998[183]:

- there was an annual average of 624 new cases of leukaemia in the years 1979-1985.

181 V.V. Netschai: Epidemiology of several blood diseases in the Gomel area prior to and following the catastrophe in Chernobyl, Chernobyl, Ecology and Health, 2/1996, 42-44 (Russ)

182 Ibid.

183 Belarus Ministry of Extraordinary Situations, National Academy of Sciences of Belarus: Chernobyl accident: Overcoming the consequences, national report 1998, (Russ)

- there was an annual average of 805 new cases of leukaemia in the years 1992-1994.

The report alleges, "that a significant increase in the incidence of leukaemia and lymphomas can be observed in Belarus following the Chernobyl disaster. The increased frequency of all leukaemias including the unspecific forms was:

- 9.34 per 100,000 persons in the 7 years before the disaster;
- 11.62 per 100,000 persons in the 7 years after the disaster."

"In the aftermath of the disaster at the nuclear power station in Chernobyl:

- chronic lymphatic leukaemias
- multiple myelomas
- Hodgkin lymphomas and
- non-Hodgkin lymphomas

have significantly increased."

The following data was given in detail[184]:

Table: Leukaemia in Belarus in cases per annum[185]

	7 years before Chernobyl	7 years after Chernobyl
Chronic lymphatic leukaemia	2041	2830*
Multiple myeloma	782	1055*
Non Hodgkin lymphoma	1554	2285*
Hodgkin Lymphoma	1760	2029*

Note: *significant, p<0.05

The report gave the following averages for new cases per 100.000 inhabitants of Belarus per annum before and after Chernobyl:

Table: Average incidence rate for leucocytes, lymphomas and myelodysplastic syndrome in Belarus[186]

		1979-1985	1986-1992	1993-1996
Leucocytes	adults	7.99	9.91	8.76
	children	4.34	4.42	3.69
Lymphoma	adults	6.35	7.91	7.3
	children	1.12	2.31	1.82
Myelodysplastic syndrome	adults	0.03	0.13	0.50
	children	0.01	0.18	0.14

184 Belarussian Ministry of Extraordinary Situations, National Academy of Sciences in Belarus: Chernobyl accident Overcoming the consequences, national report 1998, (Russ.).

185 Ibid.

186 Ibid.

Prysyazhnyuk gives standardised incidence ratios (SIR) for different forms of leukaemia in the most heavily radioactively contaminated areas of Ukraine. He compares the data from two 5-year periods (1986-1991 and 1992-1998) with the period 1980-1985. We have shown the data for 1986-1991. It is evident that in these years leukaemia rates were higher than the expected values.

Table: SIR for different forms of leukaemia in the most heavily radioactive-contaminated areas of Ukraine[187] 1986 – 1991

Code ICD-9	Leukaemia type	Observed	Expected	SIR	Confidence interval (95%)
204-208	All leukaemias	132	90.1	146.44	121.46-171.42
204-208.0	All acute leukaemias	65	44.3	146.59	110.95-182.22
204-208.1-9	All chronic leukaemias	64	38.8	165.00	124.58-205.43
204	Lymphatic leukaemia	70	48.3	144.95	110.99-178.91
204.0	Akute lymphat. leukaemia	20	7.8	256.01	143.81-368.22
204.1-9	Chron. lymphat. leukaemia	47	35.4	132.73	94.78-170.67
205	Myeloische leukaemia	24	6.3	379.64	227.75-531.52
205.0	Akute myeloic leukaemia	10	2.9	339.42	129.04-549.79
205.1-9	Chron. myeloic leukaemia	14	3.4	414.74	197.49-631.99
206-208	Other leukaemias	38	35.5	106.97	72.96-140.98
206-208.0	Other acute leukaemias	35	33.6	104.22	69.69-138.74

6.2 Germany

A study, published in 1993 by the children's cancer registry in Mainz, gave evidence of a statistically significant cluster - in the more heavily contaminated areas, two years after Chernobyl - of a very rare childhood tumour, the so called neuroblastoma, amongst children born in 1988. The incidence of neuroblastoma increased in ratio to ground-contamination. This proof of a dose-effect correlation is taken as evidence of a causal relationship. According to the authors of the study, the discovery of the neuroblastoma cluster represents "one of the most conspicuous fluctuations in the existence of the children's cancer registry". It is being debated whether this could be due to parental germ cell damage prior to conception. [188]

187 A. Prysyazhnyuk et al.: Results of long-term monitoring of solid cancers and leukaemia in population still living in the most contaminated with radionuclides territories of Ukraine after the Chernobyl accident; Int. J. Rad. Med. 2003, 5(1-2): 60-72.

188 J. Michaelis et. Al., Fall-Kontrollstudie zum Anstieg der Neuroblastom-Inzidenz für im Jahr 1988 geborenen Kinder [Case controlled study on the rise in incidences of neuroblastoma in children born in 1988]; Medizinische Informatik, Biometrie und Epidemiologie 76/1993. Strahlentelex, 166-167/1993, S. 4, Dr. Hayo Dieckmann, Tschernobylfolgen auch in Deutschland messbar [Chernobyl effects also measurable in Germany] (German)

According to Prof. Dr. Günter Henze, the affected children come from areas in Southern Germany that were subject to higher radiation levels following Chernobyl.[189]

J. Michaelis et al. found that in West Germany, in the aftermath of Chernobyl, one and a half times as many children under one year of age developed leukaemia than the average for the 1980s. The authors investigated the leukaemia cluster amongst German infants born in West Germany between July 1, 1986 and December 31, 1987. Michaelis expressed astonishment at the results: 35 from just less than 930,000 under one-year-old children developed leukaemia. This is equivalent to a 1.5-fold increase in the incidence rate compared to that of the 1980s.[190]

6.3 Other countries

Children in Greece, still growing in their mother's wombs at the time of the Chernobyl reactor catastrophe, developed leukaemia 2.6 times more often than children born either before or a certain length of time after the catastrophe. E. Petridou et al. analysed all cases of childhood leukaemia in Greece since Chernobyl. They found that in children born relatively soon after the Chernobyl accident (between July 1, 1986 and December 31, 1987), leukaemia occurred in the first year of life 2.6 times more often than in children born before or after this period (between January 1, 1980 and December 31, 1985 and between January 1, 1988 and December 31, 1990). The authors surmise that this incident rate increase is due to *intra uterine* radiation exposure following the Chernobyl accident.[191]

Leukaemia in children under four in Scotland rose by 37% in 1987.[192] The study counted a total of 48 cases of childhood leukaemia in 1987. That amounts to 13 cases more than were to be expected. They included as many as 33 diagnosed cases of children less than four years of age.

There are also reports from Rumania of childhood leukaemia following the Chernobyl catastrophe. Davidescu et al. carried out an ecological study in five East Rumanian districts over the period 1986 – 2000. The exposed group numbered 137,072 children (37 leukaemia cases), the non-exposed group numbered 774,789 children (204 leukaemia cases). Exposure is ascribed to food being contaminated over a three-year period with Cs134, Cs137, Sr90 and I-131. The leukaemia incidence for the age group 0-10 is not significantly higher in the contaminated areas than it is in the comparison area (270 against 263, $p>0.05$). If, however, the leukaemia incidence rate of children born between July 1986 and March 1987 is examined, it is found to be significantly higher than for those born between April 1987 and December 1987 (386 against 173, $p=0.03$). The most noticeable effect is in the age group 0-1. The incidence rate correlates with the equivalent dose for red bone marrow.[193]

189 Günter Henze, 30.10.91, FU Berlin, in Strahlentelex, 122-123/1992, 8, Vermehrt Neuroblastome bei Säuglinge in Süddeutschland [Increased neuroblastoma in infants in southern Germany]. (German)

190 J. Michaelis, U. Kaletsch, W. Burkart, B. Grosche, Infant leukaemia after the Chernobyl accident, Nature, Vol. 387, 15 May 1997, 246. J. Michaelis, Mainz, press release from 11.06.1997.

191 Nature, 24.7.1996, in Strahlentelex, 230-231/1996, 12, Leukaemie in Griechenland [Leukaemia in Greece]. Strahlentelex, 252-253, 1f., Kinderleukämien. Nach dem Tschernobyl-Unfall erkrankten mehr Säuglinge in Deutschland an Blutkrebs [Child leukaemias, Following the Chernobyl accident more children in Germany developed cancer of the blood].

192 The Lancet Sept. 1988; Strahlentelex, 42/1988, Mehr Leukämie in Schottland [More leukaemia in Scotland]

193 Doina Davidescu et al.: Infant leukaemia in eastern Romania in relation to exposure in Utero due to the Chernobyl accident; Int. J. Rad. Med. 2004, 6(1-4): 38-43.

According to calculations from Martin Tondel et al., by 1996 the Chernobyl reactor catastrophe had led to 849 excess cases of cancer in the fallout areas of northern Sweden. The authors carried out a cohort study that embraced all the inhabitants of northern Sweden who were 60 and under at the time of the catastrophe (1986-1987; 1,143,182 persons). Ground pollution with caesium-137 was compared to the number of cancer cases (22,409 persons from 1988 to 1996). The cancer risk for all forms of cancer put together, as well as the risk of lung cancer, increased with the amount of fallout exposure. The risk increase is calculated to be 11% per 100,000 Bq/m² (95%CI= 0.03-0.20).[194]

Tondel et al. Have continued their investigations and they believe that these results are also verified in their latest publication.[195]

194 M. Tondel et al.: Increase of regional total cancer incidence in north Sweden due to the Chernobyl accident? J. Epidemiol. Community Health 58(2004)1011-1016.

195 M. Tondel, P. Lindgren, P. Hjalmarsson, L.Hardll, B. Persson: Increased Incidence of Malignancies in Sweden After the Chernobyl Accident – A Promoting Effect?: American Journal of Industrial Medicine 49:159-168 (2006).

7. Other illnesses following Chernobyl

The following tables give an overview of the changes in health statistics following Chernobyl for morbidity groups for which the relationship to radiation exposition was not immediately noticed. Although for several years now there has been data pertaining to this area from the victims of Hiroshima and Nagasaki, there is a reluctance to connect non-cancerous illnesses to radiation incidents. Missing data additionally hampers investigations into this field.

The data in the following tables is taken from a paper by A. Nyagu et al.,[196] in which a population in the regions around Chernobyl was repeatedly examined using the same methods and over a number of years. Distinct to enormous increases in illness rates are apparent for all the given morbidity groups. In each case, the figures are per 100,000 inhabitants; it is evident that a lot of inhabitants are suffering from more then one illness.

Table: Dynamic psychosomatic illnesses amongst inhabitants of northern Ukraine who were affected by the accident at the nuclear power plant in Chernobyl (1987 - 1992)[197]

	Registered illnesses per 100,000 inhabitants					
	Adults and adolescents					
Illness/organ	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**
III Endocrinal system	631	825	886	1,008	4,550	16,304
V Psychological disturbances	249	438	576	1,157	5,769	13,145
VI Neural system	2,641	2,423	3,559	5,634	15,518	15,101
VII Circulatory system	2,236	3,417	4,986	5,684	29,503	98,363
IX Digestive organs	1,041	1,589	2,249	3,399	14,486	62,920
XII Skin & subcutaneous tissue	1,194	947	1,262	1,366	4,268	60,271
XIII Muscular-skeletal system	768	1,694	2,100	2,879	9,746	73,440

The following table is taken from the same source. It shows the decrease in the numbers of healthy members of four population groups over time. Whereas, for example, 78.2% of liquidators were still healthy in 1987, by 1996 the proportion of healthy liquidators had decreased to 15%.

The most alarming group is IV – children of affected parents. These are children who were themselves not affected by Chernobyl fallout, but the children of parents who witnessed Chernobyl. The state of these children's health has deteriorated considerably over time. This is an indication of the possibility that genetic changes may have already taken place. A lot of questions are, however, still unanswered.

196 Nyagu, A.I.: Medical consequences of the Chernobyl accident in Ukraine, Chernobyl ministry of Ukraine, Scientific Centre for Radiation Medicine, Academy of Medical Sciences in Ukraine, Scientific-Industrial Union PRIPJAT, Scientific-Technical Centre Kiev - Chernobyl 1994 (Russ.).

197 Ibid.

Table: Deterioration in the states of health of the affected population in Ukraine[198]

	Healthy proportion of the population in %									
Category of the victim	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
I Liquidators	78.2	74.4	66.4	53.3	35.8	28.8	23	19.8	17.6	15
II Evacuees	58.7	51.6	35.2	26.2	29.7	27.5	24.3	21.1	19.5	17.9
III Inhabitants in the effected areas	51.7	35.4	35.2	26	31.7	38.2	27.9	24.5	23.1	20.5
IV Children of effected parents	80.9	66.8	74.2	62.9	40.6	n.d.	36.9	32.4	32.1	29.9

The following table describes the changes in the health spectrum of children from the highly contaminated Gomel area in southern Belarus. The table begins in 1985. This column raises the question of whether the children's state of health had not been less intensively recorded in 1985. But even if this column is not taken into account, a strong dynamic is still to be found in the remaining columns from 1990 to 1997. It is evident that the majority of illnesses is in the non-cancerous category. It is noticeable from looking at the data of the original diagnoses that a considerable proportion of the children are suffering from more than one illness simultaneously.

How radiation exposure exactly "functions" in the non-cancerous group is only now beginning to be understood. The question is not being actively pursued because official recognition of the entire range of the morbidity group as having radiation-induced illnesses would cause the figure for the number of all radiation victims (not only in relation to Chernobyl) to suddenly shoot up. Investigations of this question in the Western World are almost impossible, as no relevant data exists, nor is there a registry.

Table: New illnesses amongst children in the Gomel area (Belarus) per 100,000 children[199]

Morbidity group/Organ	1985	1990	1993	1994	1995	1996	1997
Total primary diagnoses	9,771.20	73,754.20	108,567.50	120,940.90	127,768.80	120,829.00	124,440.60
Infectious illnesses and parasites	4,761.10	6,567.70	8,903.30	13,738.00	11,923.50	10,028.40	8,694.20
Neoplasm *	1.40	32.50	144.60	151.30	144.60	139.20	134.50
Endocrinological diseases and disturbances of the nutritional, metabolic and immune systems	3.70	116.10	1,515.50	3,961.00	3,549.30	2,425.50	1,111.40
Blood & haematopoietic tissue	54.30	502.40	753.00	877.60	859.10	1,066.90	1,146.90
Mental disorders	95.50	664.30	930.00	1,204.20	908.60	978.60	867.60
Neural and sense organs	644.80	2,359.60	5,951.80	6,666.60	7,649.30	7,501.10	7,040.00
Circulatory diseases	32.30	158.00	375.10	379.80	358.20	422.70	425.10
Respiratory organs	760.10	49,895.60	71,546.00	72,626.30	81,282.50	75,024.70	82,688.90
Digestive organs	26.00	3,107.60	5,503.80	5,840.90	5,879.20	5,935.90	5,547.90

198 Ibid., Kryshanovskaja: Data for 1993-1996, personal memorandum.

199 Organisational-methodical dept. of the Gomel district hospital, state health centre for the Gomel area: Basic data on inhabitant morbidity in the Gomel area from 1985-1997, Gomel 1998.

Urogenital system	24.50	555.20	994.80	1,016.00	961.20	1,163.70	1,198.80
Skin and subcutaneous tissue	159.00	4,529.10	5,488.30	6,748.20	7,012.60	6,455.00	7,100.40
Muscular-skeletal system/ connective tissue	13.40	266.00	727.70	937.70	847.40	989.90	1,035.90
Congenital malformations **	50.80	121.90	265.30	307.90	210.10	256.20	339.60
Accidents and toxication	2,590.20	3,209.70	4,122.70	4,409.80	4,326.10	4,199.10	4,343.00

* 1985 only malign neuroplasms, ** high estimation of unreported cases through abortions

Diabetes

Endocrinologists from the Heinrich-Heine-University in Düsseldorf and the Belarussian endocrine advice centre in Minsk cooperated on an investigation into the development of diabetes amongst children and young adults in Belarus. Over a lengthy period, 1980 to 2002, the incidence rate (new illness accumulation per annum) of diabetes mellitus Type1 – diabetes with insulin deficiency, mainly amongst young adults – was observed in two areas of Belarus that had been contaminated to very different degrees. Data from the highly contaminated Gomel area was compared with that of the comparatively slightly contaminated area of Minsk, during the periods 1980-1986 and 1987-2002. A total of 643 patients from the Gomel area and 302 patients from the Minsk area were involved in the analysis. In the years 1980 -1986 (before Chernobyl) there was no significant difference between the incidence rates in Gomel and Minsk. In contrast to this, for the years following Chernobyl (1987-2002), there was evidence of a significant difference ($p<0.001$) in the incidence rates of both areas. The authors also discovered that the incidence rate in the Minsk area before and after Chernobyl was not significantly different, but it was in the highly contaminated Gomel area ($p<0.05$), where annually about twice as many children and young adults developed diabetes mellitus Type 1 after Chernobyl, as compared to the years before Chernobyl. The highest mean incidence rate was registered in the Gomel area in 1998.[200]

Neural damage and mental disorders following exposure to radiation

Psychological disorders suffered by many of the former adult inhabitants of the Chernobyl region could be a result of damage to the nerve cells by nuclear radiation. Nadejda Gulaya from the Pallaguin Institute for Biochemistry in Kiev expressed this view as early as 1992[201]. Another explanation could be that, as ionising radiation particularly damages the blood vessels, this could impair the cerebral blood flow, which in turn could result in organic damage to the brain. This theory was suggested by Zhavoronkova from the Institute of Neurophysiology of the Russian Academy of Sciences in Moscow.

Scientists from various countries support the opinion that the effect of the Chernobyl catastrophe on the mental health of the population constitutes the largest problem. (At this point the issue is not 'radiophobia', a pseudo-illness invented by Moscow that is alleged to be the 'real' source of all other health problems, in order to avert attention from radioactivity as the cause of illness.) The expert group on health from the WHO and IAEA Chernobyl Forum designated the following four areas as warranting particular attention: stress-related symptoms, effects on the developing brains of small children, organic brain damage amongst

200 A. Zalutskaya, T. Mokhort, D. Garmaev, S. R. Bornstein: Did the Chernobyl incident cause an increase in Type 1 diabetes mellitus incidence in children and adolescents? Diabetologia 2004 Jan; 47(1): 147-8.

201 Strahlentelex 136-137/1992, 8.

highly exposed clean-up workers and suicide rates. K.Loganovsky points out that there is already a high rate of schizophrenia amongst Japanese survivors of the nuclear bombings, i.e. 6 percent. There can be no doubt that Chernobyl liquidators also carry the greatest risk of mental illness not only from radiation but also because of other causes occurring in the aftermath of the accident.[202]

Loganovsky points to a number of different investigations into morbidity risks for liquidators of non-cancerous disease that have produced statistically significant results. According to these, the risk increase per gray absorbed dose (excess relative risk ERR/Gy) is: for mental disturbance ERR/Gy=0.4 (95%CI= 0.17-0.64); for neurological and sensitivity disorders ERR/Gy=0.35 (95%CI=0.19-0.52); for hormonal (endocrinal) disorders ERR/Gy= 0.58 (95%CI=0.3-0.87) (Biriukov et al. 2001 and Buzunov et al. 2001, 2003). Amongst the mental disorders, the greatest risk is of neurotic disorders with ERR/Gy=0.82 (95%CI= 0.32-1.32) (Biriukov et al. 2001). The highest risk increase overall is however of blood circulatory disorders of the brain (cerebrovascular dysfunction) with ERR/Gy=1.17 (95%CI=0.45-1.88) (Ivanov et al. 2000). Moreover, a significant risk increase for external radiation doses larger than 150 Milligray (mGy) with a risk increase of ERR pro 100 mGy per day = 2.17 (95%CI 0.64-3.69) has been recently quoted for cerebrovascular dysfunction (Ivanov et al. 2005). These results were not, however, achieved by using properly designed psychiatric studies and standardised diagnostic procedures, but are based simply on analyses of information from the state health system on mental disturbances. The textbook knowledge of psychiatry in the successor countries of the Soviet Union, however, encourages dramatic underestimations of mental disturbances, misinterpreting them as physical illnesses, as well as false diagnoses within the system of the mental disturbances (e.g. neurotic instead of psychotic or organic). Thus, the Ukrainian Ministry of Health gives the figure of 2.27% for the occurrence of mental disturbance amongst the Ukrainian population in 1990, 2.27% for 1995 and 2.43% for 2000. However, using standardised procedures, the World Mental Health (WMH) Survey Initiative of the World Health Organisation has calculated 20.5% (95%CI=17.7-23.3%) for Ukraine – the state health system apparently underestimated the occurrence of mental disturbance by at least tenfold. The WMH System includes so-called psychological disturbances such as angst, depression, psychosomatic disturbances, and alcohol abuse, and avoids using terminology such as psychosis, organically based mental disorders and mental backwardness (retardation).

202 Strahlentelex 454-455/2005, 1ff. Krebs, Leukämie und Geisteskrankheiten finden russische, weißrussische und ukrainische Forscher jetzt vermehrt bei ihren Mitbürgern [Cancer, leukaemia and mental illnesses are being found more frequently by Russian, Belarussian and Ukrainian researchers amongst their fellow citizens]. (German)

Excursus: Consequences of a *super-GAU* in Germany

Following Chernobyl scientists estimated the consequences of a *super-GAU* in Germany. The 7-10-fold higher population density was taken into consideration. A risk factor of 500 respective 1,000 cancer and leukaemia deaths per 10,000-person sievert was assumed. In alternative1, the same radiation exposure as that following Chernobyl was assumed. In alternatives 2 and 3 – based on figures from the German Risk Study of nuclear power stations (phase B) – greater radiation exposure following a *super-GAU* was assumed (alternatives 2 and 3).

Alternative 1:[203]
Collective dose: 2.4 million man sievert (Chernobyl)
10-fold higher population density in Germany allowed for
Cancer cases per 10,000 person sievert: 1,000
2,400,000:10,000x1,000 x10
Cancer deaths[204]: 2.4 million

Alternative 2:[205]
as alternative 1, but
5-fold higher emission than Chernobyl (equivalent high-pressure meltdown F1-SBV in the German risk study, phase B), maximal release
Collective dose 12 million sievert
12,000,000:10,000x1,000x10
Cancer deaths 12 million

Alternative 3:[206]
Collective dose 4.8 million person sievert
7 times higher population density as Chernobyl allowed for
Cancer deaths per 10,000 person sievert: 500
4,800,000:10,000x500x7
Cancer deaths: 1.7 million

---

203 Olav Hohmeyer: Soziale Kosten des Energieverbrauchs [Social costs of energy consumption]. Berlin, 1989.

204 In estimates of this kind, cancer mortality is often confused with cancer morbidity. In view of the inaccuracy of the estimates and the size of the numbers of both illnesses and deaths this confusion of terms is only of secondary importance. The UNSCEAR reports 1994 and 2000 give a lifetime risk factor for death from cancer and leukaemia of 1,200 for 10,000 person Sievert, the basic risk factors in alternatives 1 and 2 of 1,000 for 10,000 person Sievert are therefore not exaggerated.

205 Olav Hohmeyer: Stand der internationalen und nationalen Diskussion der Sozialen Kosten verschiedener Energietechnologien [State of international and national debates on the social costs of diverse energy technologies]. In: Deutsche Gesellschaft für Sonnenenergie (Hrsg.): 7. Internationales Sonnenforum. Rationelle Energieverwendung und Nutzung erneuerbarer Energiequellen im regionalen und kommunalen Bereich. Welchen Beitrag können sie zur Abwehr der Klimabedrohung leisten? [Rational use of energy and utility of renewable energy sources in the regional and local context. What can they contribute towards averting the threat to the climate?] Frankfurt, 9.-12.10.1990. DGS-Sonnenenergie Verlag München, 1990, 2039-2044 (German)

206 Hans-Jürgen Ewers, Klaus Rennings: Abschätzung der Schäden durch einen sogenannten Super-GAU [Estimating the damage caused by a so-called *super-GAU*]. In: PROGNOS-Schriftenreihe „Identifizierung und Internalisierung externer Kosten der Energieversorgung“, Band 2, 1992. Expertise commissioned by the German Ministry of Economics. (German)