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**Health effects due to radiation from
the Chernobyl accident**

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Sources

- The UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) 2008 Report (**UNSCEAR 2011**) concerning the “Health effects due to radiation from the Chernobyl accident”.
- This report has been discussed and approved in mid-2008 and the coverage of literature practically finishes at that time.
- **EC scientific seminar** on “Issues with internal emitters” (November **2010**): updating on radiation induced thyroid cancers by D. Williams
- **Recent** scientific findings and **publications**, mainly from 2008, reviewed by Art 31 RIHSS WG

Warning

Unfortunately not possible to take due account of the **large number of non translated publications** by Ukrainian, Russian and Byelorussian researchers. By the way, it is surprising that the competent international organizations did not give more interest in translating these multiple publications, particularly those on children's morbidity. This will be a real challenge in the future if we really want to cover correctly the situation.

Most exposed population groups

1. Workers (**liquidators**, or emergency and recovery operations workers): 600 000
2. Inhabitants who were **evacuated or relocated**: first 1 16 000, later 220 000 more
3. Inhabitants of contaminated areas who were not evacuated. About 5 million people continue to live in areas of Belarus, Ukraine and Russia that were contaminated by the accident (by convention, contaminated areas were defined as areas where the average deposition density of **^{137}Cs exceeded 37 kBq/m²**).

Radiation doses

Liquidators:

- average effective dose : about 120 mSv.
- range: from less than 10 to more than 1,000 mGy
- 85% in the range 20–500 mGy
- uncertainties from < 50% to up to a factor of 5
- average thyroid dose: ?

Radiation doses

Inhabitants of contaminated areas :

- mean effective dose up to 2005 : about 50 mSv
- **range: from a few mSv to some hundred mSv**
- Thyroid doses (Drozdovitch 2010):
 - Median : 0.37 in Belarus and 0.034 Gy in Russia
 - Highest individual thyroid doses 10.2 Gy in Belarus and 5.3 Gy in Russia
 - doses from short-lived radioiodines and radiotelluriums : up to 0.53 Gy.
 - uncertainty of the reconstructed individual thyroid doses: from 1.7 to 4.0

Highlight

Maybe the major think to underline regarding radiation doses to the exposed population is **their huge variability**, largely due to the **consumption of wild foods, especially mushrooms, and locally produced foods**, by a large part of the local population.

This has a major influence on any attempt to interpret or predict the effects of the accident on the health of (subsets of) the population.

Radiation induced thyroid cancers

- Papillary carcinomas in children: the main recognized direct consequence of exposure to fallout of Chernobyl
- Causal relation: no more doubt

Radiation induced thyroid cancers: **Size of the increase**

- **6848 cases** reported between 1991 and 2005 in the three affected republics (the whole of Belarus and Ukraine and the four most affected regions of the Russian Federation) amongst those **under age 18 years in 1986** ; **substantial fraction attributable**
- **No signs of diminishing**
- Previsions: variable but if **ERR constant** (as shown in previous studies) then currently only **top of the iceberg**

Radiation induced thyroid cancers: ERR

Estimation of the ERR

- Review of Chernobyl studies:
from 2.15 to 50/Gy
- Case-control and cohort studies:
about 7/Gy (=RX)

NB: LSS: mortality solid tumors: $< 1/\text{Gy}$

Radiation induced thyroid cancers: **modifying risk factors**

1. Age at exposure:

- first 3 years v/ 15-20 y: ERR x 10
(idem 2d cancers post-Rxth)
- Adults: lower (women A-bomb 0.7/Gy);
screening issue

2. Iodine deficiency (Cardis 2005)

3. Genetic susceptibility

Radiation induced thyroid cancers: Clinical aspects

- **Agressive** in small children (invasive, metastases)
- Lifetime treatment; surgical risks
- With increasing latency, smaller in size and less aggressive
- *Signature?: debated*

Radiation induced thyroid diseases **other than thyroid cancers**

- increased risk of thyroid adenomas and nodules
- chronic autoimmune thyroiditis (**Hashimoto**):
 - conflicting results
 - autoimmune reactions initially observed in several studies (6 to 8 years after the accident: Belarus) still present but with lower levels of thyroid **autoantibodies**; thyroid function remains normal : **future?**
 - Hashimoto = long term effect in Nevada cohort (age at exposure less than 7 year, time since exposure **24-35 years**)

Radiation induction of cancers other than thyroid cancers: *Leukaemia's*

- Liquidators (Romanenko 2008; Kesminiene 2008; RADRUE dose reconstruction method): significantly increased ERR, with a linear dose-response
- **Childhood** leukaemia's: *debated* (methodology) but significantly increased ERR in **Ukraine** (Davis 2006; Noshchenko 2010)

Radiation induction of cancers other than thyroid cancers: **Breast cancer**

- Belarus and Ukraine: **significant 2-fold increase** (1997-2001), in the most contaminated districts (average estimated cumulative dose of 40 mSv or more) compared with the least contaminated districts (Pukkala 2006)
- Unlikely due to increased diagnostic activity

Radiation induction of cancers

- Many of the cancer consequences of exposure to atomic bomb radiation were not observed until decades after the event
- There are major uncertainties over the individual doses from the Chernobyl accident
- It is certainly wrong to consider that we are “at the end of the story” (sic)
- It will be necessary to continue for a long time the follow up of these populations.

Hereditary effects

- Exposed families from rural areas of Ukraine and Belarus: increases in the rate of **minisatellite DNA mutations** in children born to exposed parents after Chernobyl (Dubrova)
- **Role** of minisatellites? (“associations” with diseases)
- Studies in families of Chernobyl **cleanup** workers globally **failed** to show increases
- Birth defects could also be due to germline mutations

Further studies are essential to address the currently somewhat neglected issue of hereditary effects

Birth defects

- not dealt with in UNSCEAR 2011.....
 - Reason: prevalence at birth of the malformations recorded in the registry in Belarus: similar positive trend in areas of low and high contamination
- Scientific Seminar FANC-SCK April 2006
 - From oblasts to districts
 - **Clear excess** of the congenital anomalies under study in the highly contaminated districts **during the three first years** (mainly polydactyly, reduction defects of limbs, multiple congenital malformations)
- Down syndrome cluster in Belarus 9 months after Chernobyl (Zatsepin 2004)

Birth defects: recent observations

- **Wertelecki 2010** (University of South Alabama)
 - Ukraine oblast of Rivne: one of the populations most exposed to chronic low-dose radiation from Chernobyl
 - births between 2000 and 2006: overall rate of **neural tube defects** (including spina bifida) among the highest in Europe
 - limitations of this study: lack of data regarding levels of low-dose radiation, diet, possible folate deficiency, prenatal alcohol exposure.
- **Dancause 2010: exposure routes** in Rivne
 - Alcohol intake was low
 - **Wild foods**, especially mushrooms and berries, and locally produced foods, especially milk related, were major radiation exposure routes

Children's morbidity

- **Many claims** concerning the health of children in the contaminated territories around Chernobyl, which seem to suffer from **multiple diseases** and co-morbidities with repeated manifestations (compilation in Yablokov 2009)
- **Reports from international organizations did not give until now much interest: “psycho-social”**
- **But** most studies **not available in English and not translated!**

Although many studies do not meet the scientific and editorial criteria generally required in the Western peer reviewed literature, scientists cannot refuse to take the available information into account or at least to verify it !

Children's morbidity: recent initiatives (1/2)

- Series of **IRSN** studies:
 - **Rats** exposed to $^{137}\text{Caesium}$ contamination during several months through drinking water (150 Bq/day/animal: comparable with a typical **low intake** in the contaminated territories (Handl's: 100 Bq/day but with variations from 20 up to 2000 as when excess consumption of mushrooms)
 - *Although the animals tested in these studies did not show induced clinical diseases, a **number of important biological effects** were observed on various systems: increase of CK and CK-MG, decrease of mean blood pressure and disappearance of its circadian rhythm; EEG modifications, perturbations of the sleep-wake cycle, neuro-inflammatory response, particularly in the hippocampus, etc*
 - currently clinical research (**EPICE**) on children in the area of Bryansk, particularly on cardiac rhythm and ECG perturbations. First results would be available in 2013

Children's morbidity: recent studies (2/2)

- Series of longitudinal studies initiated recently in Ukraine in conjunction with the [US University of South Carolina](#):
 - Stepanova 2008: 1993 to 1998: significant reduction in red and white blood cell counts, platelet counts and haemoglobin with increasing residential soil contamination (cfr Techa River)
 - Svendsen 2010 : 1993 to 1998: spirometry: statistically significant evidence of both airway obstruction and restriction with increasing soil contamination (immune mechanism?)
- **“The optimism of the UN reports may be based on too few studies published in English, conducted too soon after the event to be conclusive”.**

Children's morbidity

We really **need further good quality research** on morbidity in children living in contaminated territories. This may have major influence on our evaluation of the **radiotoxicity**, particularly for children and infants, of major radioisotopes susceptible to cause **chronic internal exposures** of the population in any future nuclear accident

Cfr tritium effects on preimplantation embryos, IRSN report on ECRR, adequacy of effective dose (Sv/Bq) as risk indicator,

Morbidity of liquidators, particularly heart diseases

- Numerous studies have been published concerning non cancer diseases in liquidators, many of them also not published in English, and often being controversial:
same issue
- Risk of **ischemic heart disease and cerebrovascular diseases** seems increased (soon results from EU FP7 CARDIORISK project)
- Ukrainian American Chernobyl Ocular Study (UACOS): significant lowering of the supposed **cataract** “threshold” radiation dose (Worgul 2007): the evidence points to a dose threshold no greater than 700 mGy.

Follow up and research needs

Many of the **cancer and non-cancer** consequences of exposure to atomic bomb radiation were not observed until decades after the event, so that other thyroid and non-thyroid effects will probably occur in the future in those exposed to fallout, particularly as there are **major uncertainties over the individual doses** from the Chernobyl accident. It is therefore necessary to continue the **follow up** of these populations, while really taking into account **all of the available evidence**.