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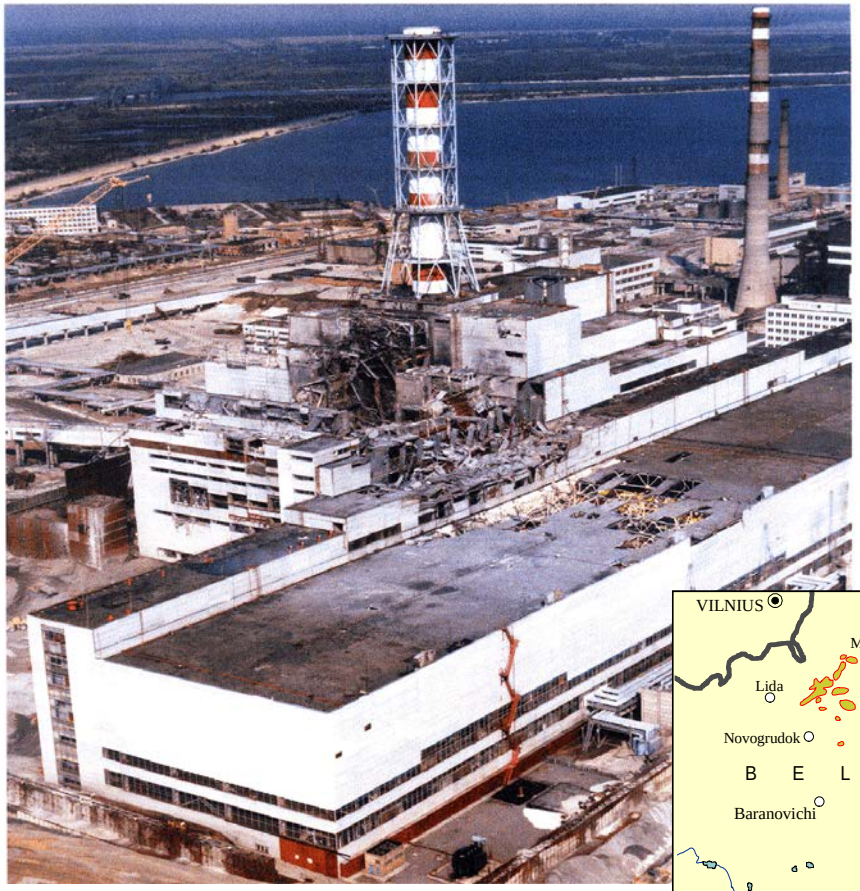
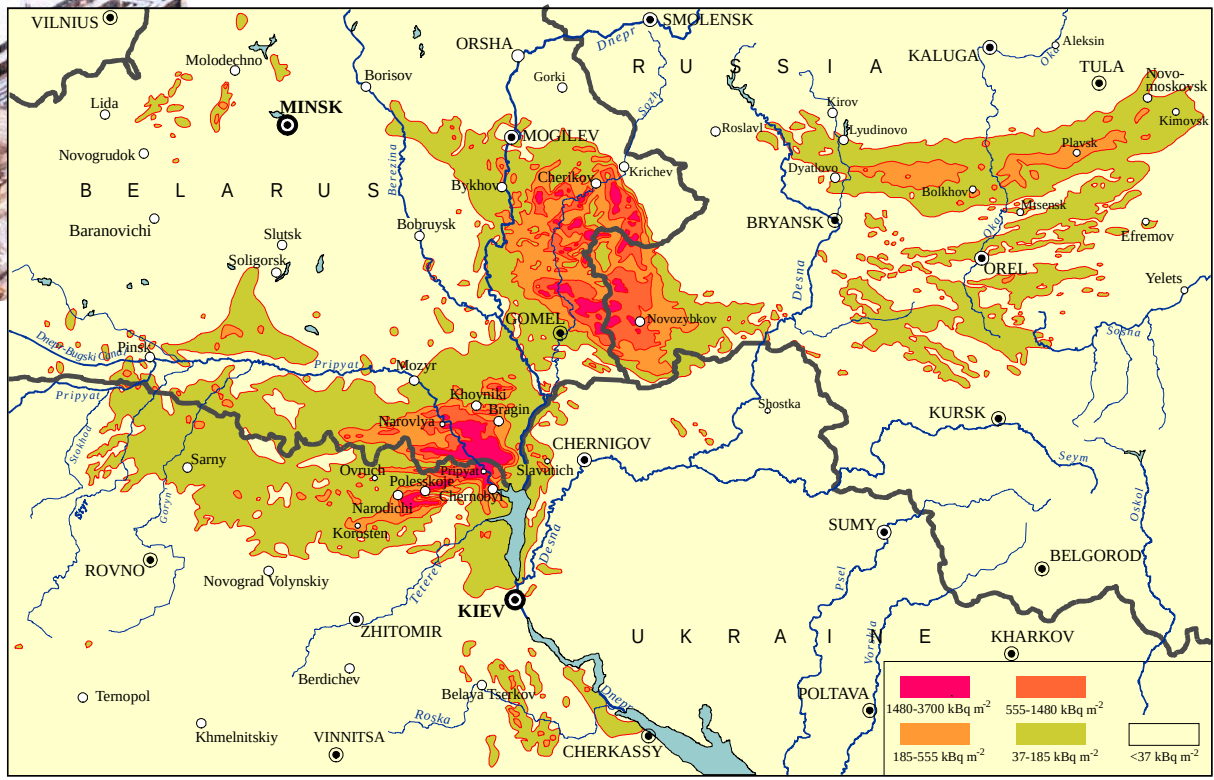
Late Health Effects of the Chernobyl Accident

Radiation Epidemiology & Dosimetry Course

National Cancer Institute www.dceg.cancer.gov/RadEpiCourse

The Chernobyl Accident: April 26,1986

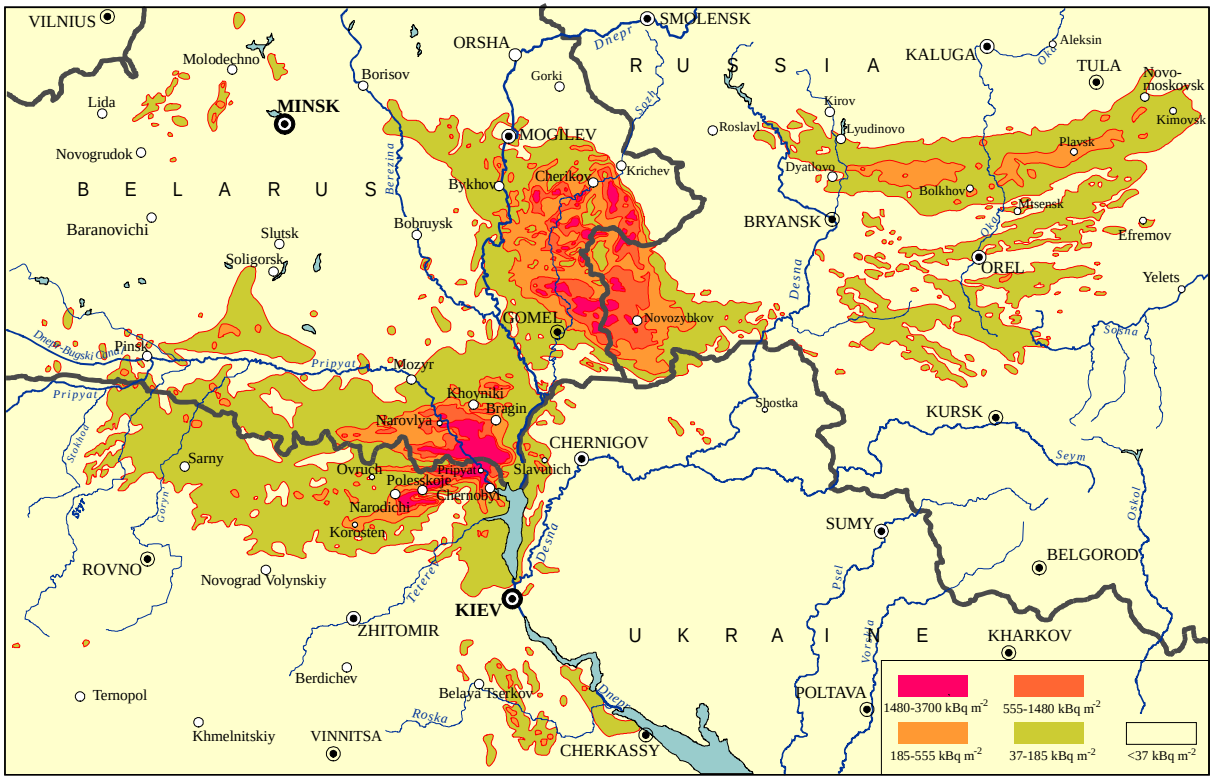


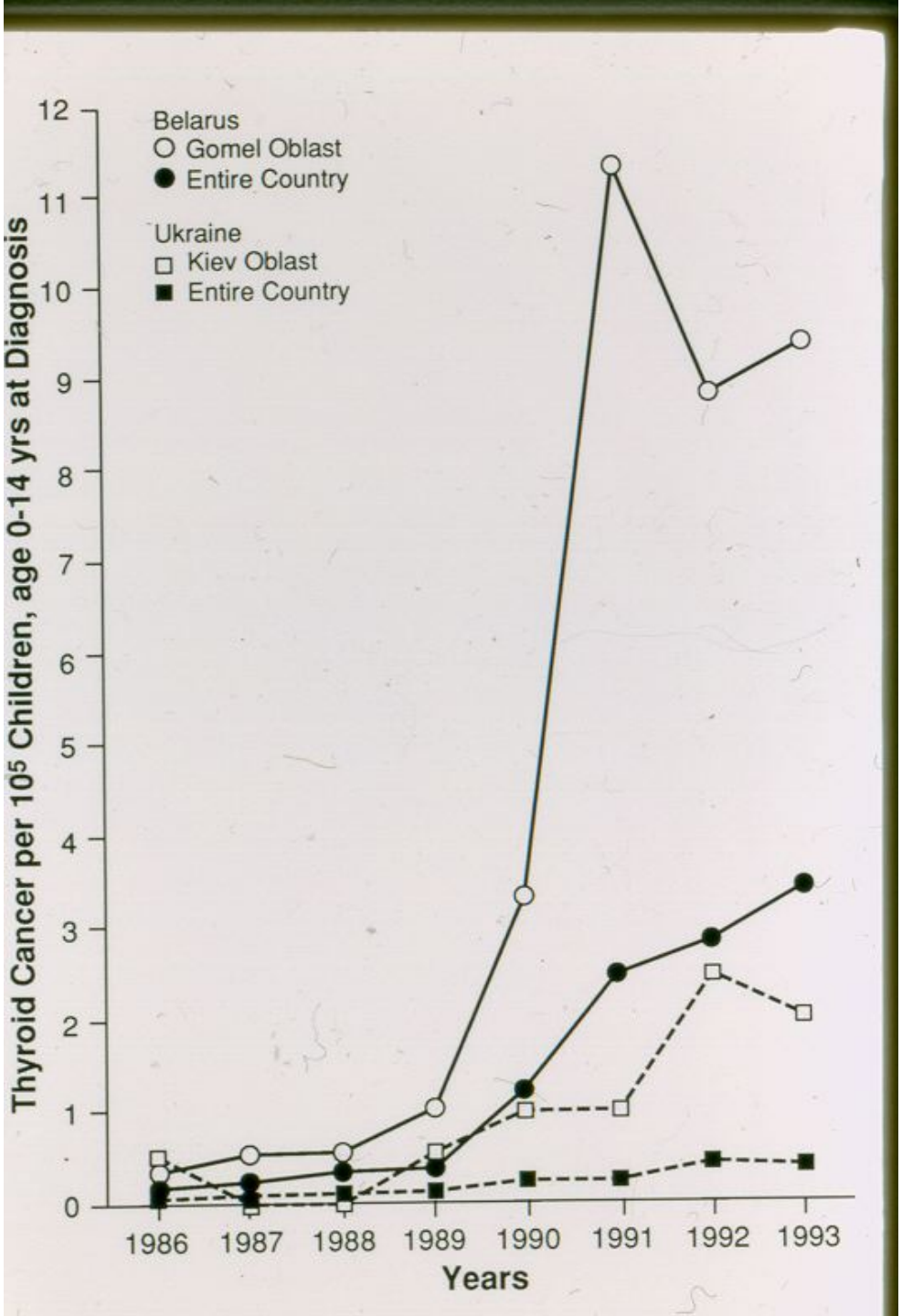


Health Effects of the Accident

Thyroid Cancer

40m Ci of I-131





Thyroid Cancer Post-Accident in Belarus and Ukraine

Other Cancers

Leukemia

Breast Cancer

The thyroid gland, bone marrow and breast are especially sensitive to radiation

Predicted Lifetime Excess

- 4,000 excess cancer and leukemia deaths among Liquidators, evacuees and residents of the exclusion zone
- 5,000 cancer deaths among residents of other contaminated areas

Cardis et al. 2006

Other Somatic Effects

Non-cancer thyroid disease
Cataracts
Cardiovascular Disease
Premature aging
Neuropsychiatric changes
Stillbirths, altered sex ratio
Congenital malformations

Effects on Mental Health

Suicide/Alcohol-related Deaths

Neuropsychiatric abnormalities

Depression, anxiety, PTSD

Cognitive Impairment

Genetic/Teratogenic Effects

Differential gene expression

Dose-related increases in rearrangements

In offspring:

Minisatellite mutations

Chromosome aberrations

Post-Chernobyl Thyroid Cancer

- 2-5-fold increased risk in **exposed children and adolescents**
- Strong, linear dose-response
- Magnitude of risk similar to external radiation exposure in childhood

Post Chernobyl Thyroid Cancer-2

	N	Dose (Gy)	EOR/Gy (95% CI)
Ukraine	45	0.08 (mean)	5.3 (1.7, 28)
Belarus	85	0.56 (mean)	2.2 (0.8, 5.5)
Belarus/	220	0.37 (median)	
Russia	56	0.04 (median)	4.5 (1.2, 7.8)

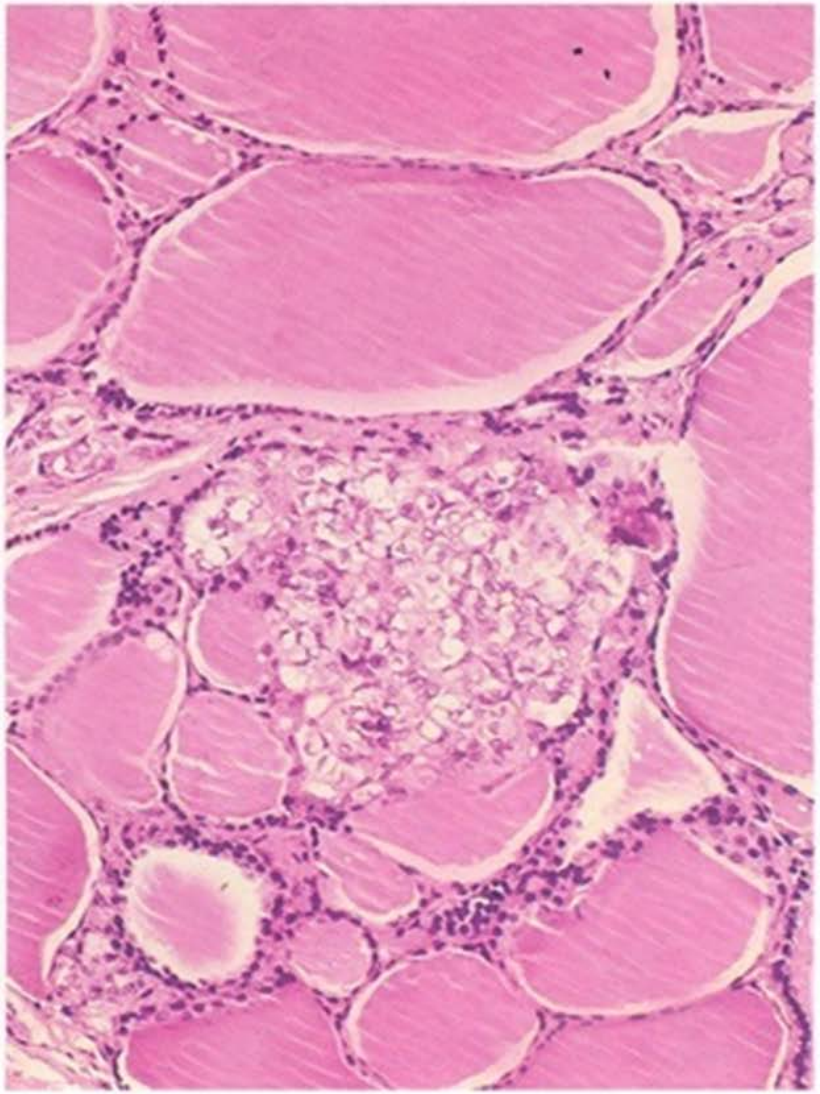
Slide courtesy of Ethel Gilbert

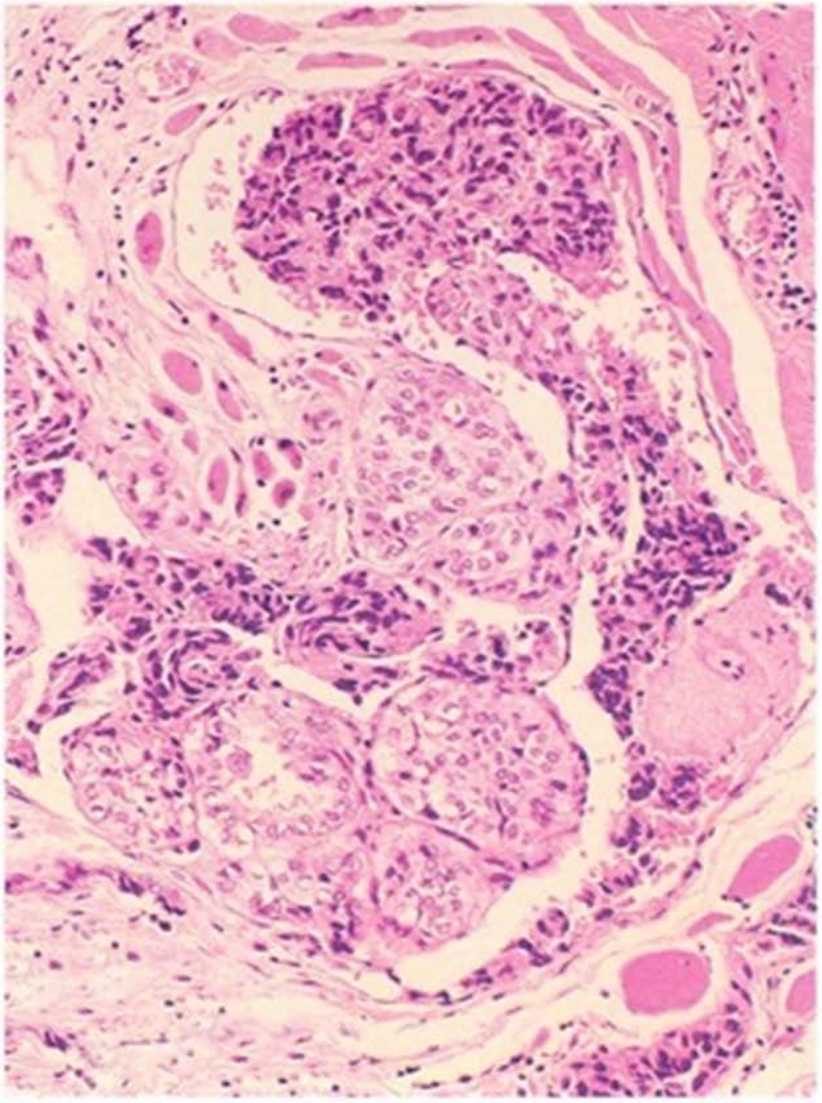
Post-Chernobyl Thyroid Cancer-3

- Risk greatest for those **youngest at exposure**

  (high uptake of contaminated milk, small thyroid mass)
- **Increase persists** after two decades, with no significant downturn
- **Solid subtype** associated with young onset, short latency)

Papillary Thyroid Cancer (PTC) in Ukraine: Solid subtype, Classic PTC





Role of Stable Iodine

- Exposure to I-131 occurred against a backdrop of **Iodine Deficiency (ID)**
- **ID can increase uptake of radioiodines**
- Difficult to measure: urinary iodine reflects only recent exposure
- One study using soil iodine levels showed greatest risk for I-131 exposure in lowest tertile of soil iodine, lowest risk in those taking Potassium Iodine (KI)
- Overall, results inconsistent for ID as modifying factor

Post-Chernobyl Thyroid Cancer-4

- Suggestive increased risk among those **exposed *In Utero***

  (EOR/Gy=11.7, P=0.12, based on 8 cases in Ukraine)

- Increased risk among those **exposed at ages 1-5**

  (***EOR/GY=3.24, P=0.01, based on 13 screening cases)***

(Hatch et al. 2009)

Post-Chernobyl Thyroid Cancer - 5

- Some evidence of increased risk following **exposure in adulthood**

  (IARC study of Baltic, Belarusian, Russian liquidators)

- **NCI-Ukraine:** Study of liquidators in progress

Non-Cancer Thyroid Disease

- Increase in **follicular adenoma**
- I-131-related increase in **hypothyroidism**

  No association with hyperthyroidism or AIT (autoimmune thyroiditis)

Non-Thyroid Cancers

Leukemia

External/ Cs 137

Leukemia

Radiation and the Risk of Chronic Lymphocytic and Other Leukemias among Chornobyl Cleanup Workers

Lydia B. Zablotska,1 Dimitry Bazyka,2 Jay H. Lubin,3 Nataliya Gudzenko,2 Mark P. Little,3 Maureen Hatch,3 Stuart Finch,4 Irina Dyagil,2 Robert F. Reiss,5,6 Vadim V. Chumak,2 Andre Bouville,3 Vladimir Drozdovitch,3 Victor P. Kryuchkov,7 Ivan Golovanov,7 Elena Bakhanova,2 Nataliya Babkina,2 Tatiana Lubarets,2 Volodymyr Bebeshko,2 Anatoly Romanenko,2 and Kiyohiko Mabuchi3

Leukemia-2

Radiation and the Risk of Chronic Lymphocytic and Other Leukemias among Chornobyl Cleanup Workers

Table 2. ERR/Gy (95% CIs) for leukemia within categories of various factors.

All	117	2.38 (0.49, 5.87)	0.004
Leukemia subtype			
Non-CLL	52	2.21 (0.05, 7.61)	0.039
CLL	65	2.58 (0.02, 8.43)	0.047

Childhood Leukemia

- Data are scant, studies underpowered, or with potential bias in design.
- Conclusions can’t yet be drawn.

Breast Cancer

- Increased risk of **pre-menopausal breast cancer** observed in the most contaminated districts of Belarus and Ukraine
- In districts with the highest average dose levels, increase seen in **women youngest** at the time of the accident.

Cataracts

Cataracts among Chernobyl clean-up workers: implications regarding permissible eye exposures.

Worgul BV[1], Kundiyev YI, et al.

Abstract

The eyes of a prospective cohort of 8,607 Chernobyl clean-up workers (liquidators) were assessed for cataract at 12 and 14 years after exposure. The prevalence of strictly age-related cataracts was low, as expected (only 3.9% had nuclear cataracts at either examination), since 90% of the cohort was younger than 55 years of age at first examination. However, posterior subcapsular or cortical cataracts characteristic of radiation exposure were present in 25% of the subjects. The data for Stage 1 cataracts, and specifically for **posterior subcapsular cataracts, revealed a significant dose response**. When various cataract end points were analyzed for dose thresholds, the confidence intervals all excluded values greater than 700 mGy. Linear-quadratic dose-response models yielded mostly linear associations, with weak evidence of upward curvature. The findings do not support the ICRP 60 risk guideline assumption of a 5-Gy threshold for "detectable opacities" from protracted exposures but rather **point to a dose-effect threshold of under 1 Gy**. Thus, given that cataract is the dose-limiting ocular pathology in current eye risk guidelines, revision of the allowable exposure of the human visual system to ionizing radiation should be considered.

Cardiovascular Disease

- Dose –related increases reported in Russian liquidators, for:

  -ischemic heart disease (ERR=0.42, (0.05, 0.78))

  -cerebrovascular (ERR=0.45 (0.11,0.80))

  (Ivanov et al. 2006)

- Other?

Cognitive Impairment

- In liquidators
- In children exposed prenatally and postnatally

Mental Health - 1

A 25 Year Retrospective Review of the Psychological Consequences of the Chernobyl Accident

E.J. Bromet*, , J.M. Havenaar†, L.T. Guey‡,

Conclusions

- **First responders and clean-up workers** had the greatest exposure to radiation. Recent studies show that their rates of **depression and post-traumatic stress disorder remain elevated two decades later.**
- Very young children and those *in utero* who lived near the plant when it exploded or in severely contaminated areas have been the subject of considerable research, but the findings are inconsistent. Recent **studies of prenatally exposed children conducted in Kiev, Norway and Finland point to specific neuropsychological and psychological impairments associated with radiation exposure, whereas other studies found no significant cognitive or mental health effects in exposed children grown up.**

Mental Health - 2

- General population studies report **increased rates of poor self-rated health as well as clinical and subclinical depression, anxiety, and post-traumatic stress disorder.**
- **Mothers of young children exposed to the disaster remain a high-risk group for these conditions,** primarily due to lingering worries about the adverse health effects on their families.
- Long-term mental health consequences continue to be a concern. The unmet need for mental health care in affected regions remains an important public health challenge 25 years later.
- **Future research is needed that combines physical and mental health outcome measures to complete the clinical picture.**

Fukushima Health Survey

- Basic Survey
- Detailed surveys, including:

  -Mental Health and Lifestyle Survey

  -Pregnancy Survey: follow-up includes support for concerned women

Molecular/Genetic Effects (Selected)

- *RET/PTC3* rearrangements in childhood thyroid cancers post-Chernobyl correlate with solid morphology/aggressive tumors

- Differential I-131 dose-expression seen in certain genes in tissues from Chernobyl thyroid cancer cases

Genetic Effects in Offspring

- Elevated rates of minisatellite mutations in children born post-accident in Ukraine and Belarus
- Preliminary data suggestive of chromosomal damage and genomic instability in offspring of Chernobyl-exposed parents
- **NEW: NCI Trio Study of preconception parental radiation exposure in Chernobyl liquidators and evacuees and genetic alterations in offspring**

Reported Late Health Effects

- Thyroid cancer
- Leukemia
- Breast cancer
- Benign thyroid disease
- Cataracts
- Cardiovascular disease
- Premature aging
- Neuropsychiatric changes
- Stillbirths, altered sex ratio
- Suicide
- Depression, anxiety, PSTD
- Cognitive impairment
- Changes in gene expression, rearrangements
- Minisatellite mutations
- Chromosome aberrations

Late Health Effects of the Chernobyl Accident

What can we conclude?

1. Late effects are many and diverse.
2. We have learned a great deal.
3. Further follow-up is essential!

Questions and Answers

U.S. Department of Health and Human Services
National Institutes of Health | National Cancer Institute
www.dceg.cancer.gov/RadEpiCourse
1-800-4-CANCER
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