El accidente de Chernóbil. Perspectiva epidemiológica a los 25 años

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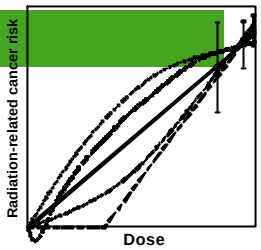
Jornada PR – 14 abril 2011

Scientific bases for radiation protection today

- Enormous amount of information on health effects (cancer, cataracts, hereditary effects) from:
  - Epidemiology
    - ✓ atomic bomb survivors
    - ✓ patients irradiated for therapeutic purposes
    - ✓ populations with occupational exposures (miners)
    - ✓ populations with environmental exposures (Radon, ^{131}I)
  - Animal experiments
  - Mechanistic studies

Status



- Questions in radiation protection
  - Cancer
    - ✓ Effects of low doses and dose-rates
    - ✓ Effects of different types of radiation and of mixtures
    - ✓ Extrapolations over time and across countries
    - ✓ Effects of factors which might modify risks
      - – Age, sex
      - – Environmental exposures
      - – Host factors, including genetic polymorphisms, iodine deficiency
  - Non-cancer effects
    - ✓ Cardiovascular effects at low doses and dose-rates
    - ✓ Cognitive effects

Chernobyl – what have we learnt?

- Numerous reviews of the health effects of Chernobyl in recent years
- Current presentation mainly based on
  - Health report from UN Chernobyl Forum – Looking back to go forward
    - ✓ *UN Chernobyl Forum. Health Effects of the Chernobyl Accident and Special Health Care Programmes. WHO . 2006.* *http://www.who.int/ionizing_radiation/chernobyl/en/index.html*
    - ✓ *Cardis E, Howe G, Ron E, Bebeshko V, et al Cancer consequences of the Chernobyl accident: 20 years after. J Radiol. Prot. 2006 Vol 26: 2, pp 125-137.*
  - More recent publications
    - ✓ *UNSCEAR 2008 (published March 2011)*
    - ✓ *Cardis and Hatch, The Chernobyl Accident-An Epidemiological Perspective. Clin Oncol. 2011 Mar 9.*

Main exposed populations

For comparison, dose from natural background radiation (excluding radon): 1 mSv/year average - i.e. 20 mSv over 20 years

Population	Approximate size of population	Mean effective dose (mSv)♣
Liquidators (1986–1987, NPP + 30 km zone)	240,000	100
1986 evacuees	116,000	33
Persons living in contaminated areas:		
Cs^{137} deposition density >555 kBq/m^2 *	270,000	50
Cs^{137} deposition density >37.5 kBq/m^2	5,000,000	10
Belarus, Ukraine and most contaminated areas of Russia	66,500,000	2.5
"Europe"+	570,000,000	0.5

* Strict control zones
♣ Accumulated doses: 1986-2005
+ Excludes most of Russia (IARC WG paper)

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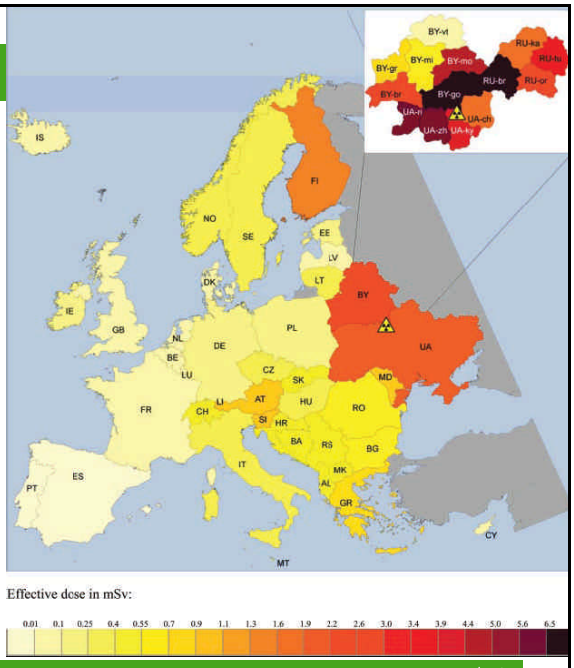
*Spatial distribution of average country-specific **effective doses** from Chernobyl in Europe accrued in the period **1986–2005**.*

Drozdovitch V, et al, Radiat Prot Dosimetry.2007; 123(4):515-28



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Distribution of thyroid dose from I^{131}

Population	Size of population	Mean thyroid dose (Gy)		
		0-7 years	Adults	Total
Evacuees of 1986	116 131	1.82	0.29	0.48
villages, Belarus	*24 725*	*3.1*	*0.68*	*1.0*
villages, Ukraine	*28 455*	*2.7*	*0.40*	*0.65*
Pripyat town	*49 360*	*0.97*	*0.066*	*0.17*
Belarus				
Entire country	10 00 000	0.15	0.038	0.053
Gomel Oblast	*1 680 000*	*0.61*	*0.15*	*0.22*
Ukraine				
Entire country	55 000 000	-	-	0.013
Region close to Chernobyl	*500 000*	-	-	*0.38*
Russian Federation				
Entire country	150 000 000	-	-	0.002
Bryansk Oblast	*1 457 500*	*0.14*	*0.026*	*0.041*
Kaluga, Orel, Tula Oblasts	*4 000 000*	-	-	*0.010*

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Thyroid dose distribution (mGy)

		Median	Maximum
I-131	Belarus	355.7	9 528
	Russia	39.4	5 257
Short-lived	Belarus	1.6	534
	Russia	0.1	26
External	Belarus	2.4	98
	Russia	0.9	31
Long-lived	Belarus	1.2	42
	Russia	0.4	12
Total	Belarus	365.4	10 163
	Russia	40.4	5 314

Cardis E, Kesminiene A, et al. Risk of thyroid cancer following ^{131}I exposure in childhood. JNCI, 2005; 97(10): 724-732.

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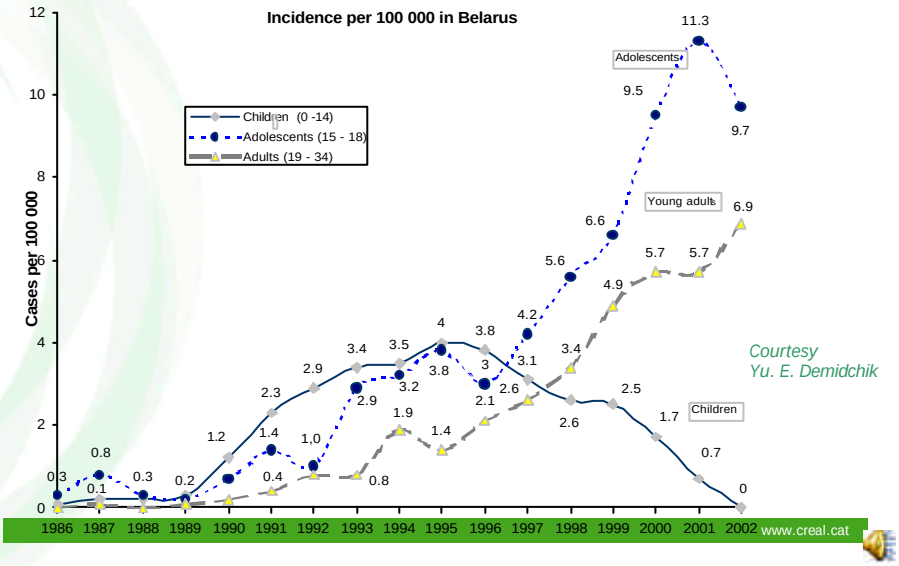
Thyroid cancer in young people after Chernobyl

In memory
LN Astakhova,
G. Howe, E. Ron

- Major increase in risk :
  - Nearly 6,000 cases among those who were below 18 at the time of the accident (1992-2005)
  - *most among those who were below 15 !*
- Many epidemiological studies
  - Confirm increased risk
  - Attribute a large proportion of the cases to radiation from the accident
- Prognosis to date is good
  - 15 deaths up to 2006 among those exposed in childhood

UNSCEAR 2008 – section D (published 2011)

Increase in thyroid cancer incidence in young people



Courtesy
Yu. E. Demidchik

Thyroid cancer risk – what have we learnt?

- Increase in thyroid cancer following exposure to ^{131}I *in childhood* - clearly demonstrated
  - Suggestions, based on small numbers of cases, of increased risk for exposure in utero
- Risk related to ^{131}I exposure appears to be similar or a little less than risk from external photon exposure
- Stable iodine status
  - Iodine deficiency appears to increase risk per Gy
  - Dietary iodine supplements may reduce risk

  … potentially important implications – need confirmation

Thyroid cancer risk – What more is there to learn?

- Uncertainties
  - Pattern over time – no information

    … increased risk likely to continue for many more years
  - Effect of uncertainties in radiation dose estimates
  - Effect of exposure as an adult – *unclear*
    - ✓ *Suggestion of increased risk among liquidators*
      (Kesmiene et al, submitted)

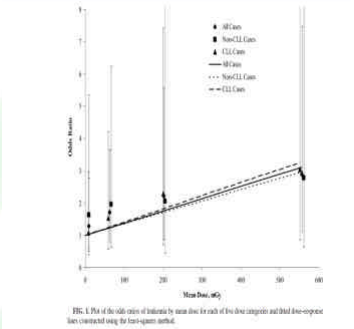
Leukaemia

- Associated with radiation exposure in a-bomb survivors and other exposed populations
  - "Marker" of radiation effect
  - Appears early (2-5 years after exposure)
  - Risk per Gy is high in those exposed as children
- *Exposure in utero and in children*
  - ECLIS, Belarus, Russia, Ukraine, Sweden, Finland, Germany, Greece
  - Results inconsistent
  - Doses low
  - Limited statistical power of studies

… cannot conclude about increase or not related to Chernobyl

Leukaemia (cont'd)

- Exposure as an adult
  - Liquidators
    - ✓ Case-control studies in Belarus/Russia/Baltic countries and in Ukraine with individual dose reconstruction
    - ✓ Dose-related increase – similar to that in a-bomb survivors and other low dose studies



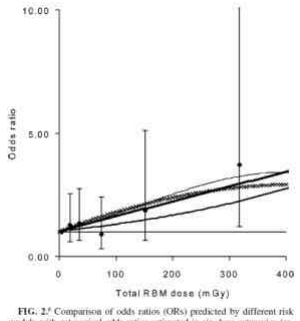


FIG. 2.[5] Comparison of odds ratios (ORs) predicted by different risk models with categorical odds ratios estimated in six dose categories (results based on the main data set[5]). ◆, OR and 95% CI; —, log-linear model—linear dose response; — log-linear model—linear-quadratic dose response; — ERR model—linear dose response; and × ERR model—linear-quadratic dose response.

Romanenko et al 2008, *Kesminiene et al 2008*

Leukaemia (cont'd)

- Exposure as an adult
  - General population
    - ✓ Increases in incidence reported, but not related to contamination levels
    - ✓ Methodological limitations /little power

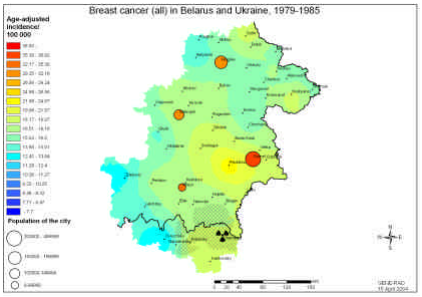
… Difficult to conclude

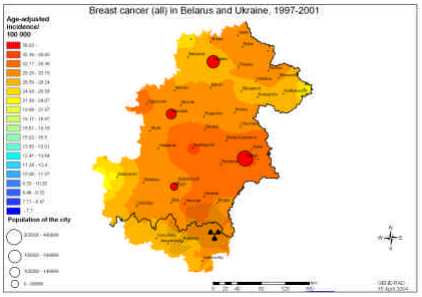
Ivanov V K, Tsyb A F, Gorski A et al 2003 Elevated leukemia rates in Chernobyl accident liquidators [electronic letter] *Br. Med. J.*

Cancers other than thyroid and leukaemia

- Ionising radiation associated with risk of cancer at many sites in a-bomb survivors and other populations
- Liquidators (Russia, Belarus, Ukraine)
  - No consistent increase in risk for all cancers combined
  - Slight non-significant increase per Gy
- Population in contaminated regions
  - Incidence of all cancers not significantly different from general population
  - Increases in incidence of specific cancer types reported periodically
    - ✓ No information about dose level ... difficult to conclude about radiation effects
    - ✓ Breast cancer incidence:
      - – Increases reported in Belarus and Ukraine
      - – Ecological study (Belarus and Ukraine)

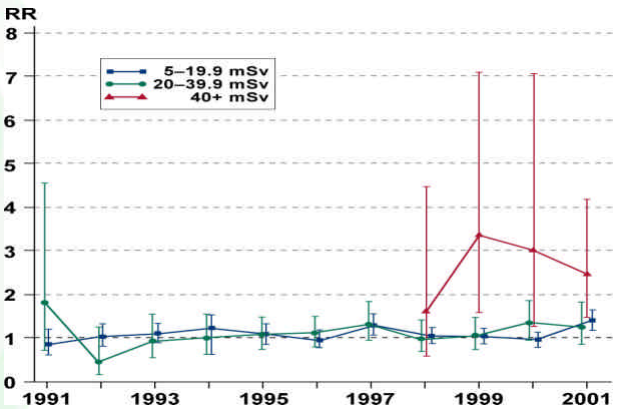
Breast cancer incidence





Pukkala,E.; Kesminiene,A.; Polyakov,S.; Ryzhov,A.; Drozdovitch,V.; Kovgan,L.N.; Kyyronen,P.; Malakhova,I.; Gulak,L.; Cardis,E. Breast cancer in Belarus and Ukraine after the Chernobyl accident. International Journal of Cancer. Epub ahead of print. 2006 www3.interscience.wiley.com, doi: 10.1002/ijc.21885

Breast cancer incidence
(Pukkala et al, 2006)



Time trend in breast cancer RR by average cumulative dose category in territories of Belarus and Ukraine most contaminated by the Chernobyl accident
(doses lagged by 5 years; age at exposure <45)

Non – cancer effects

- Cataracts have long been known to occur at high doses
  … Studies of liquidators suggest they may occur at lower doses – 0.25 Gy
- High doses (radiotherapy) can cause cardiovascular diseases
  - Reports of increased mortality among Russian liquidators
  - But limited dosimetry and methodological limitations

Conclusions – 25 years after

- No clearly demonstrated increase in the incidence of cancers (other than thyroid) or other diseases that can be attributed to radiation from the accident
- *Increases in incidence have been reported, but no association with radiation dose*
  … much of the increase appears to be due to other factors, including improvements in diagnosis, reporting and registration
- Recent findings suggest:
  - An increase of leukaemia risk among Chernobyl liquidators
  - an increase in the incidence of pre-menopausal breast cancer in the very most contaminated districts,
  - possible effects on risk of cataracts and cardiovascular diseases.

  … need to be further investigated

ARCH

- *Health impact of accident not comprehensively studied*
  - Lack of coordination
  - Lack of consensus on impact, feasibility and usefulness of study
  - Potentially unique situation for providing answers to current questions in radiation protection
- *Objectives*
  - **Development of a comprehensive long-term strategic research agenda**
    - ✓ discussing the implications both in terms of public health and of knowledge of radiation effects
  - **Development of detailed project proposals for short term priority research topics**

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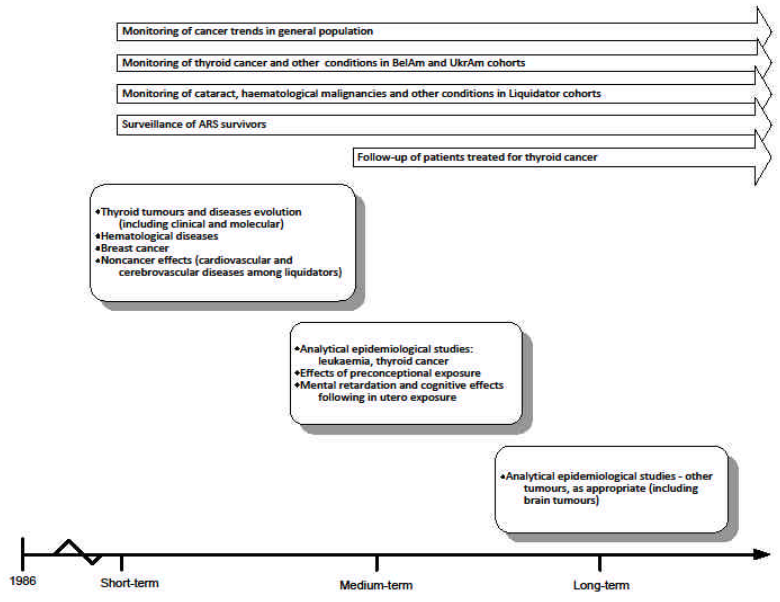
ARCH – SRA … why now ?

- *Several reasons why now, 25 years after the accident it is important that the EC supports a long-term coordinated research programme on the health effects of the Chernobyl accident.*
  - Health effects from this European accident continue and future effects are uncertain.
  - Past knowledge of radiation effects is largely based on atomic bomb studies, but Chernobyl involved a very different type of exposure.
  - Assumptions on the risk of low dose exposure have been challenged by recent advances in radiobiology.
  - Estimates of deaths due to the Chernobyl accident vary widely.

What is proposed ?

- **Chernobyl Health Effects Research Foundation (CHERF)**
  - a mechanism to coordinate and fund studies to enable assessment of the overall long-term health effects of this disaster.
  - a virtual institute consisting of
    - ✓ a MB with representatives of the funding organisation(s) and the countries most involved, both inside and outside the EU,
    - ✓ a Scientific Advisory Board which would help determine priorities for funding and advise the MB on projects to be supported.
- A key to the success of the ARCH recommendations is the creation, maintenance and follow-up of **Life Span cohorts**, including
  - cohorts exposed to fallout as children in Belarus and Ukraine with detailed thyroid dose measurements *(BelAm, UkrAm cohorts)*
  - cohorts of liquidators
  - *If feasible, cohorts of evacuees and offspring*

Prioritization of projects aimed at answering key public health and research questions



What is needed ?

- **We recommend that the EC should take the initiative in creating CHERF, with the following aims:**
  - **to initiate and support the conduct of comprehensive research on the health effects of the Chernobyl accident,**
  - **to provide and disseminate an accurate unbiased assessment of the long-term consequences,**
  - **to provide public health organisations with the information needed to mitigate the consequences in the event of any similar exposure to radiation,**
  - **to deepen scientific understanding of the interaction of radiation with tissue, with special attention to internal exposures,**
  - **to inform radiation protection organisations of the short and long-term consequences of the Chernobyl accident relevant to radiation protection standards.**

Conclusion – what will we learn?

- If priority studies can be conducted, they will allow
  - Direct evaluation of specific effects of radiation from the Chernobyl accident
  - Comparison with predictions from other information
  - Possibly new information about radiation risks

… And perhaps, in 5 or 10 years, we will begin to be able to evaluate more fully the radiological impact of the accident

ARCH - List of experts and advisors

- *Keith Baverstock, Finland; Dmitryi Bazyka, Ukraine; Andre Bouville, USA; David Brenner, USA; Elisabeth Cardis, Spain; Zhanat Carr, WHO, Switzerland; Vadim Chumak, Ukraine; Malcolm Crick, UNSCEAR, Austria; June Crown, UK; Scott Davis, USA; Yuri Demidchik, Belarus; Vladimir Drozdovitch, Belarus, currently USA; Yuri Dubrova, UK; Ian Fairlie, UK; Bernd Grosche, Germany; Maureen Hatch, USA; Viktor Ivanov, Russian Federation; Ausrele Kesminiene, IARC/WHO, France; Christoph Reiners, Germany; Sisko Salomaa, Finland; Margot Tirmarche, France; Klaus Trott, UK; Richard Wakeford, UK; Dillwyn Williams, UK; Shunichi Yamashita, Japan.*

- *www.arch.iarc.fr*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