

Health Effects from Chernobyl

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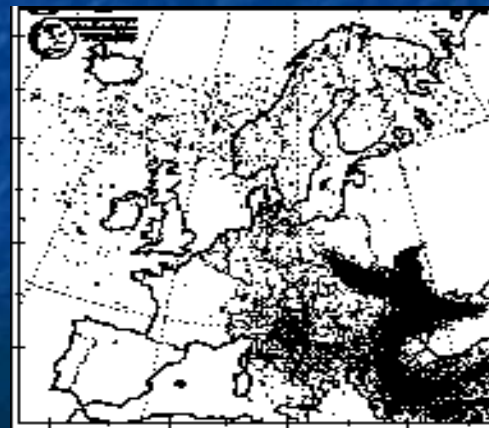
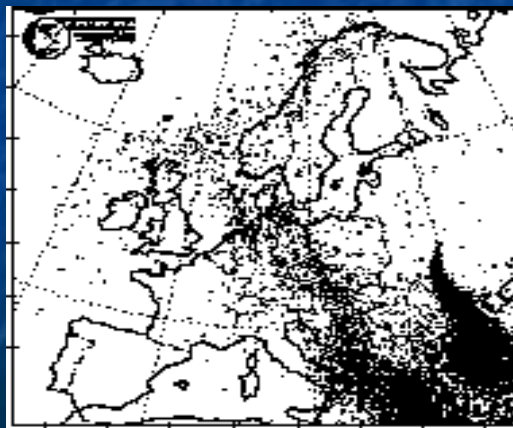
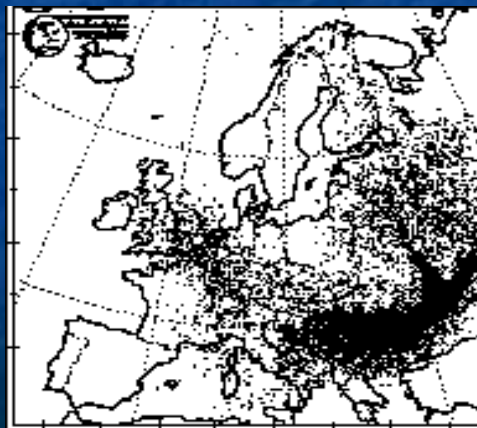
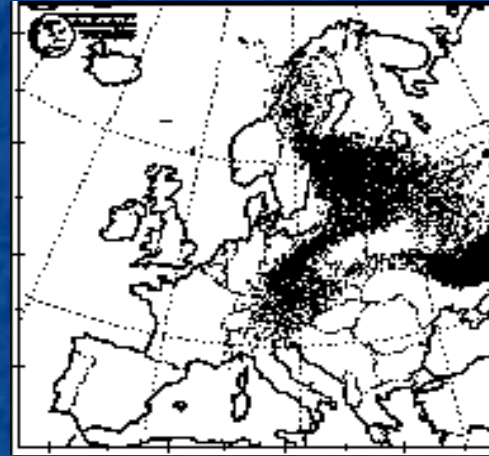
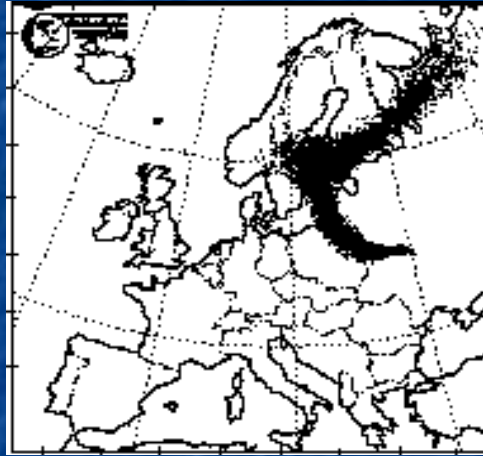
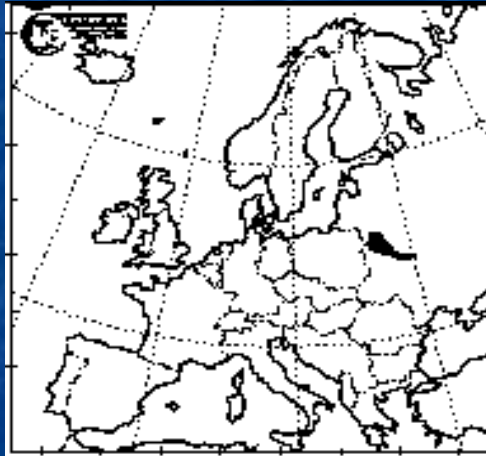
Chernobyl Accident (1986)

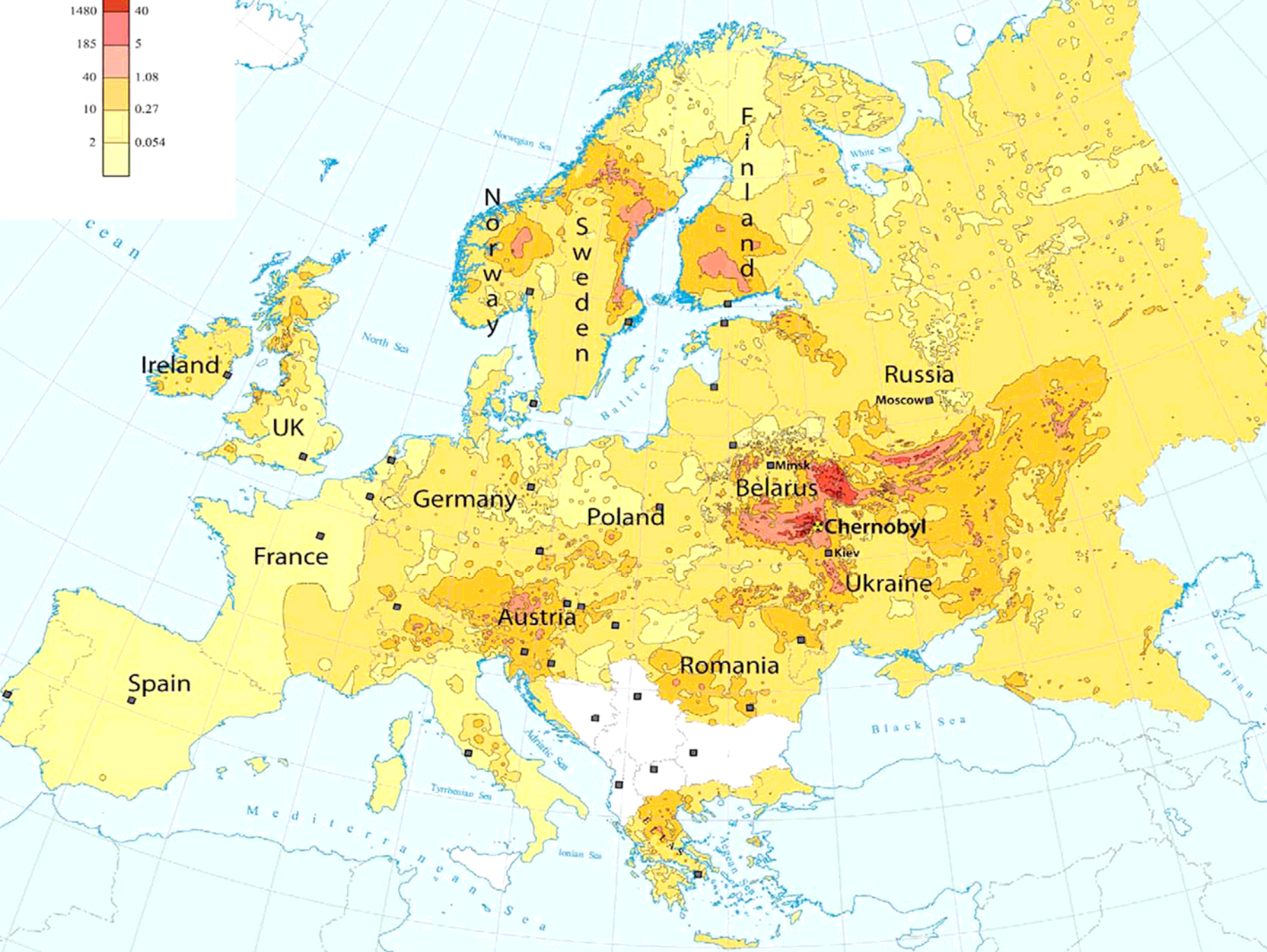
“..the foremost nuclear catastrophe in human history” IAEA (1996)

“..its magnitude and scope, the size of the affected populations, and its long-term consequences make it, by far, the worst industrial disaster on record” IAEA/WHO (2005)

“..radioactivity released ~200 times that from Hiroshima or Nagasaki” WHO/IPHECA (1995)

Chernobyl Fallout





Doses from Chernobyl (2006)

sources: *Cardis et al, 2005; ** TORCH (2006)

	Size	Average Dose (mSv)	Collective Dose (Person Sv)
Liquidators*	240,000	100	24,000
High contam areas*	270,000	50	13,500
Low contam areas*	5.2 m	10	52,000
Evacuees in 1986*	116,000	33	3,800
Rest of Europe**	600 m	~0.4	240,000
Rest of World**	4,000 m	$\sim 2.5 \times 10^{-2}$	100,000
TOTAL			~430,000
estimated deaths			~43,000

Updated doses from UNSCEAR 2008

<i>Population group</i>	<i>Size (1000s)</i>	<i>Aver eff dose 1986-2005 (mSv)</i>	<i>Coll eff dose 1986-2005 (man Sv)</i>
Recovery operation workers	530	117	61 200
Evacuees	115	31	3 600
Inhabitants of contam areas of Belarus, Russia and Ukraine	6 400	-	58 900
Inhabitants of Belarus, Russian Federation and Ukraine	98 000	1.3	125 000
Inhabitants of W Europe	500 000	0.3	130 000

New Book

"Chernobyl's radioactive contamination >37 kBq/m² (1986-87) is responsible for 3.8 to 4.4% of overall mortality in areas of Russia, Ukraine, and Belarus. In other European countries with contamination levels around 19 kBq/m² (1986-87), the mortality is about 0.3 to 0.7%. Reasonable extrapolation for additional mortality in the heavily contaminated territories of Russia, Ukraine, and Belarus brings the estimated death toll to about **900,000** for the first 15 years after Chernobyl."

Chernobyl: observed health effects

thyroid cancers

leukaemias

other solid cancers

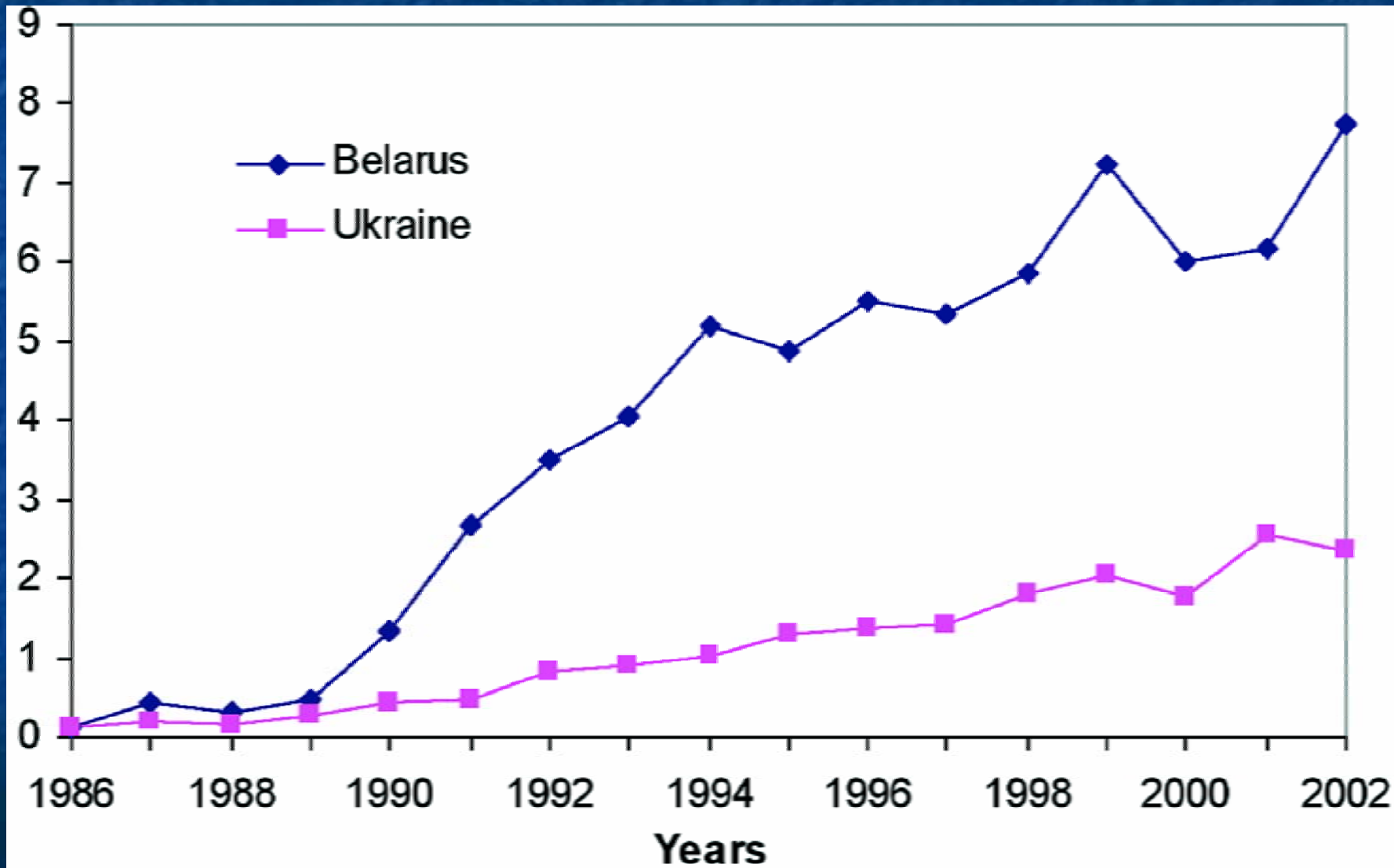
non-cancer effects

minisatellite mutations

mental health + psychosocial

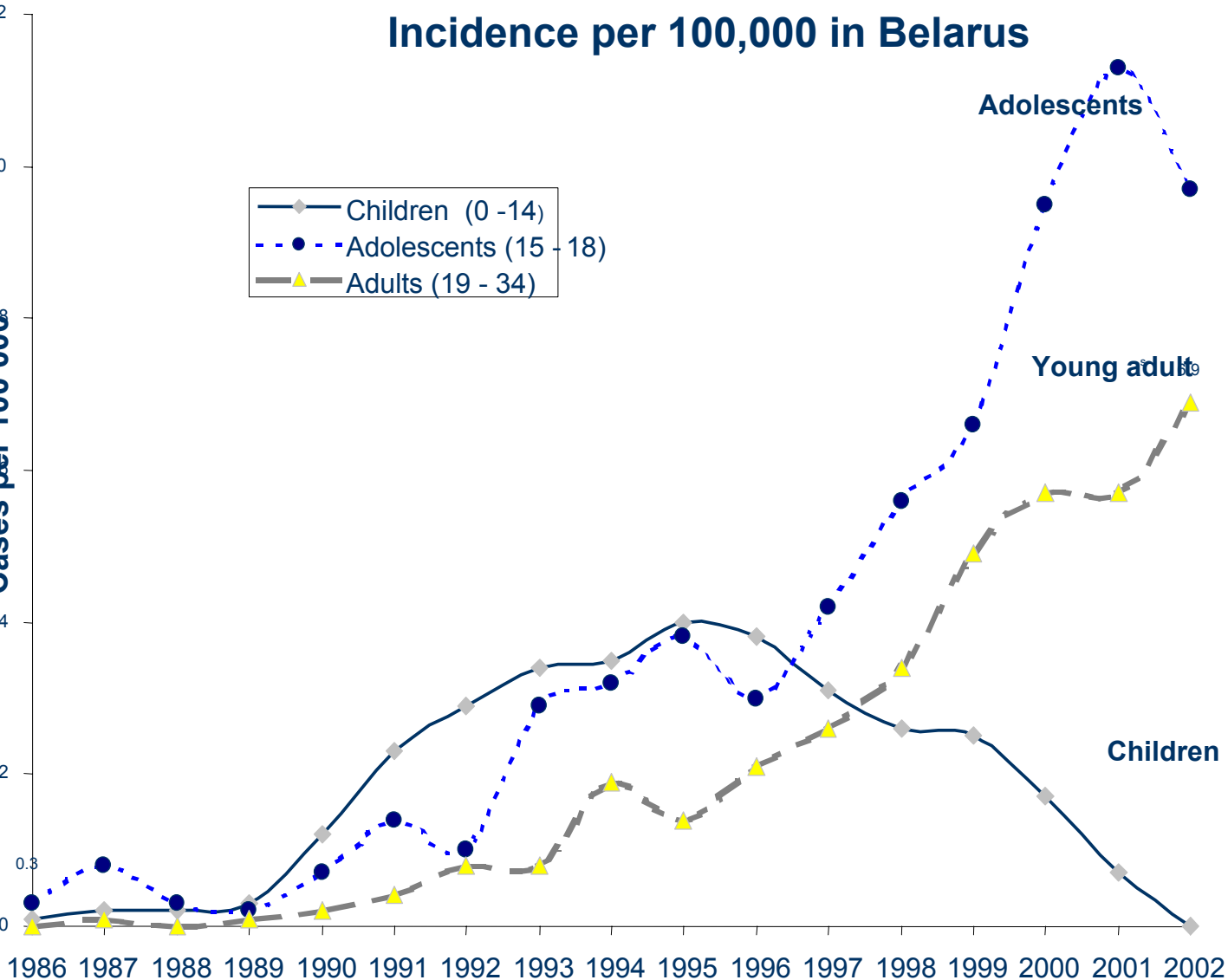
Thyroid Cancer Incidence

(in those who were children and adolescents in 1986) source: Jacob *et al* (2005)



Thyroid Cancer Incidence (2)

source: reproduced from lecture presentation by E Cardis to IAEA/WHO Conference Chernobyl: Looking Back to Go Forward. September 2005. Original data from Dr Yuri Demidchik.



How many excess thyroid cancers may occur?

- So far $>6,000$
- Cardis et al estimate 18,000 to 66,000 in Belarus alone
- assumes a constant relative risk over the whole of life

Thyroid cancer in other countries

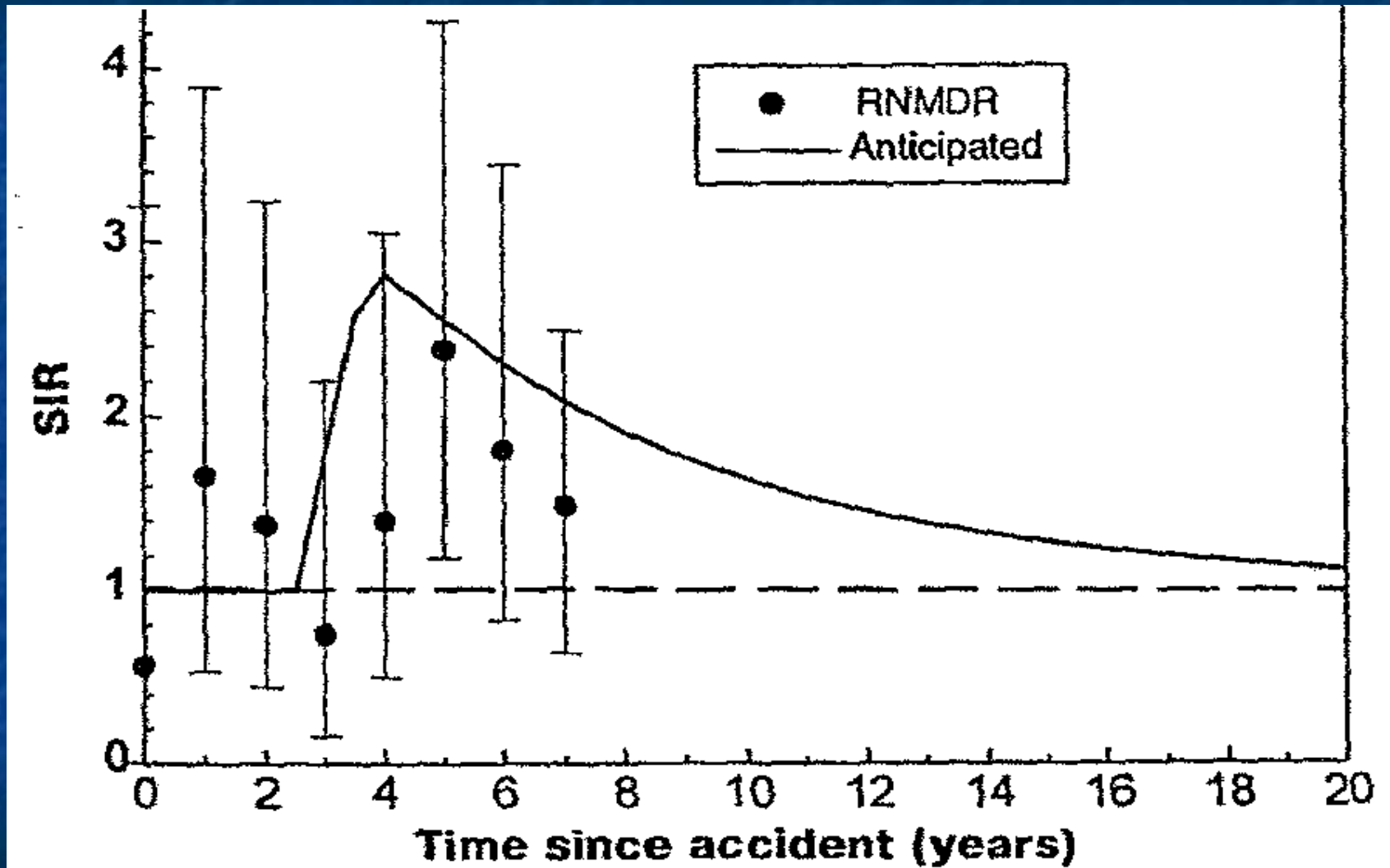
Czech Republic

- Murbeth et al (2004)
- after 1990, incidence increased by 2.6% per year (95%-CI: 1.2-4.1) in all age categories

North England (greatest incidence in Cumbria)

- Cotterill et al (2001)
- incidence in children/young adults, (1987-97 rate)/(1968-1986 rate) = 2.3

Leukaemia in Clean-up Workers



source: Ivanov (1997)

Leukaemia in Europe

Some reports of increased incidence of infant leukaemia

- not correlated with dose
- uncertainties in dose estimates
- European Childhood Leukaemia-Lymphoma Incidence Study (IARC)
- possible *in utero* effect

Solid cancers

Okeanov et al (2004)

- data from Belarus National Cancer Registry
- 40% increase in cancer incidence 1990-2000 cf 1976-85

Solid Cancers

RR in cancer incidence (for ages 20-85 per 100,000 population) in Belarus liquidators 1997-2000, compared with control adults in least contaminated area (Vitebsk)

Cancer	Incidence in controls	Incidence in liquidators	RR	95% confidence intervals
All sites	373.3	449.3	1.20*	1.14 – 1.27
Bladder	10.9	17.0	1.55*	1.21 – 1.99
Colon	17.0	22.3	1.31*	1.03 – 1.67
Lung	52.4	67.3	1.28*	1.13 – 1.46
Kidney	14.8	17.9	1.21	0.97 – 1.50
Stomach	41.7	44.9	1.08	0.92 – 1.26
Breast ♀	58.6	61.3	1.05	0.81 – 1.35
Rectum	19.0	18.4	0.97	0.77 – 1.23

source: Okeanov *et al* (2004) *statistically significant differences

Breast Cancer

Recent ecologic study (Pukkala et al, 2006) of incidence in Belarus and Ukraine

- in most contaminated districts, average dose > 40 mSv
- relative risk in Belarus 2.2
- relative risk in Ukraine 1.8

Non-cancer effects in A-bomb survivors (Preston and Pierce, 2003)

Condition	ERR/Sv	95% CI
respiratory disease	0.18	0.06 to 0.32
heart disease	0.17	0.08 to 0.26
digestive disease	0.15	0.00 to 0.32
stroke	0.12	0.02 to 0.22

Non-cancer effects

Many reported effects (IAEA/WHO 2005)
but evaluation is difficult

- different diagnostic criteria
- insufficient control groups
- low statistical power
- confounding factors

Cardiovascular disease

- seen in A-Bomb survivors (Pierce *et al*, 2003) $ERR/Sv = 0.17$
- (Ivanov *et al*, 2000) study of Russian cleanup workers, $ERR/Sv = 0.54$ ie comparable to A-bomb survivors

Heritable Effects

- germline minisatellite mutation rates

Dubrova et al (1996, 1997, 2002)

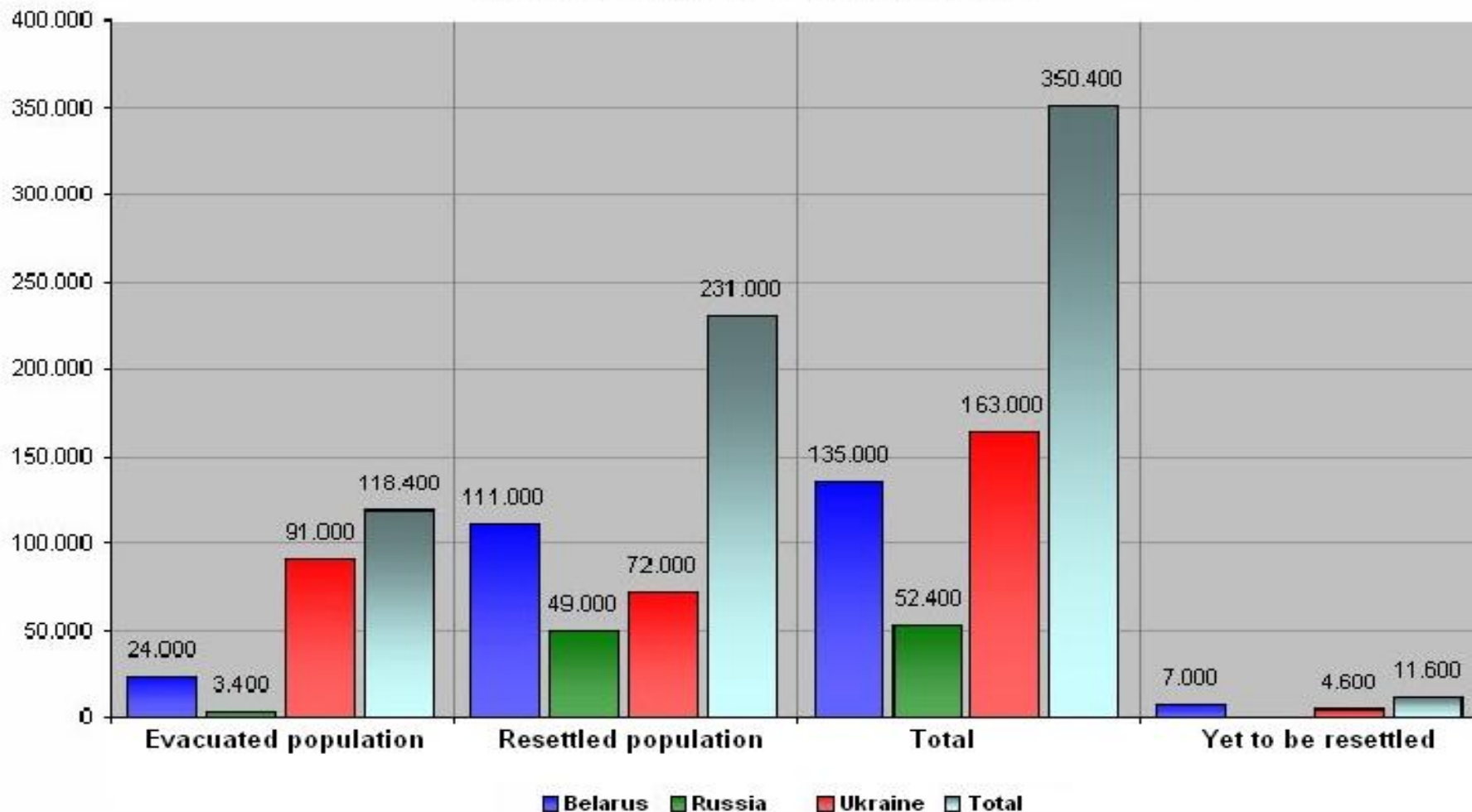
- 2 x increase in groups from Belarus and Ukraine
- mutation induction in fathers not mothers

Collective dose and cancer deaths

- best global estimate = 600,000 person sieverts
- using risk factors of 5% and 10% per sievert
= 30,000 – 60,000 predicted excess cancer deaths
- about 1/3 in Belarus, Ukraine and Russia, the rest in northern hemisphere, mostly in W Europe
- depends on the assumption of LNT

Displaced Persons (UNDP 2002)

Evacuated and resettled population



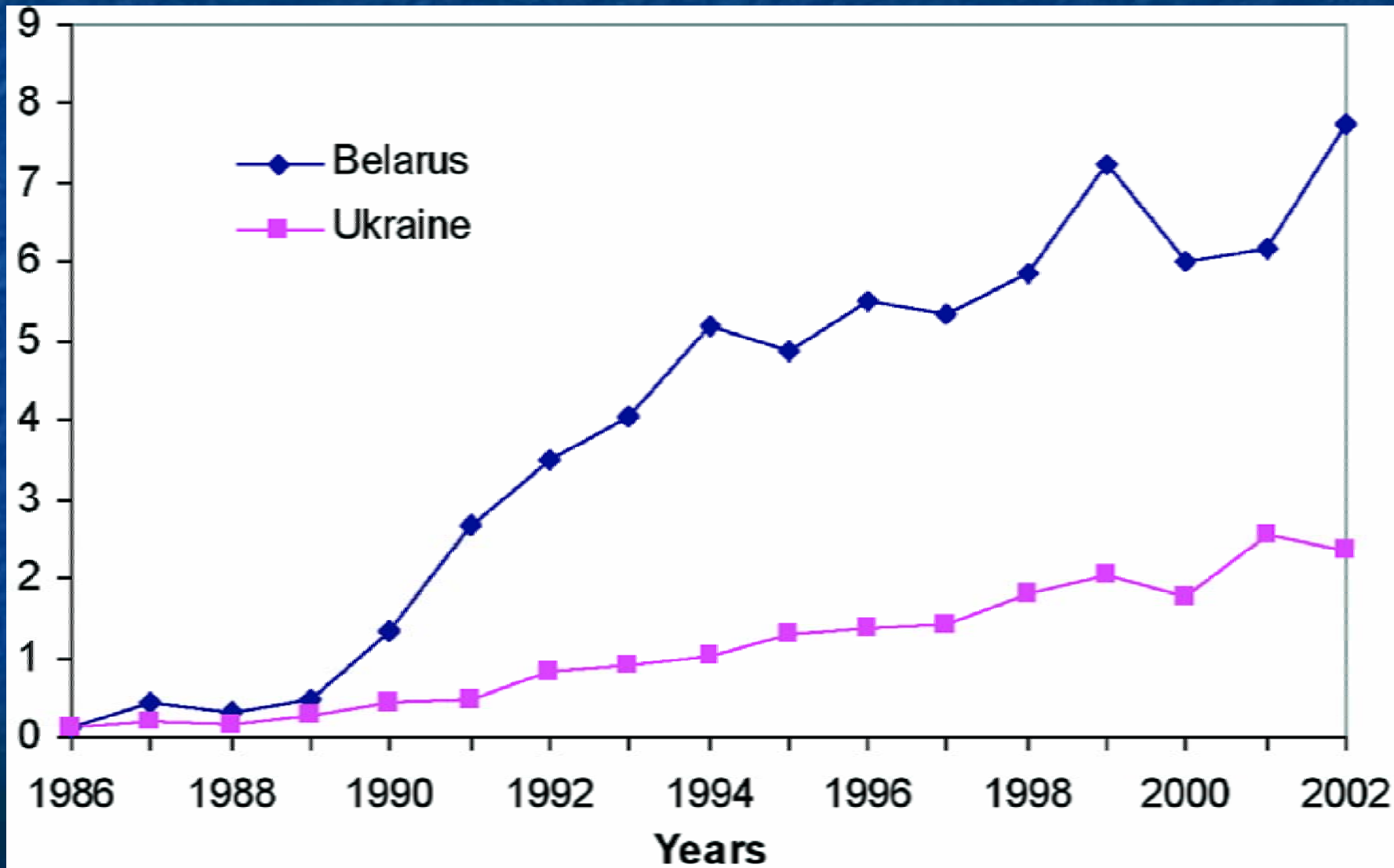
Epidemiology studies: care required

- differing diagnostic criteria used
- insufficient/poorly matched control groups
- small numbers – low statistical power
- confounding factors and biases
- nil or poor dose estimates

Only use reliable studies

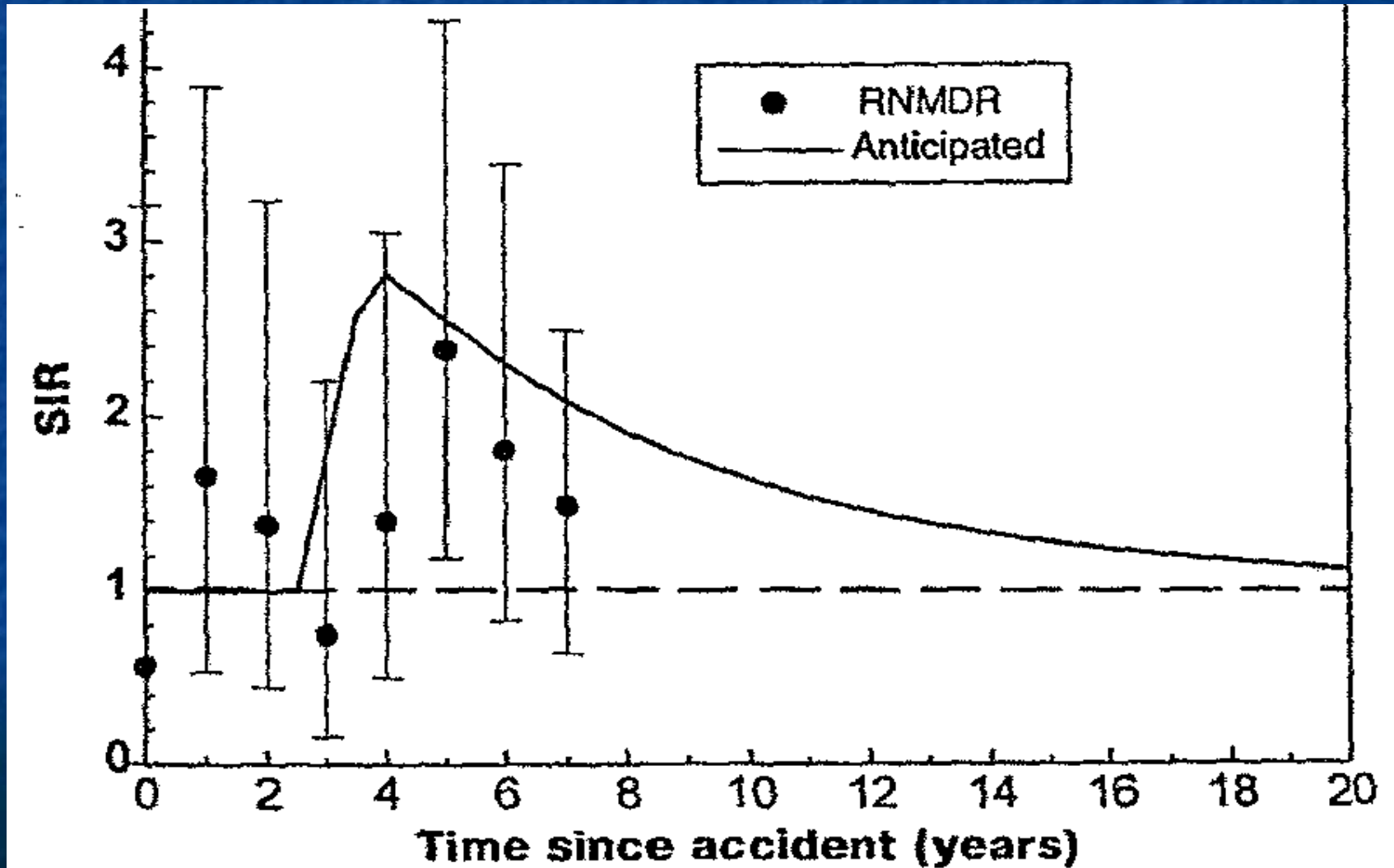
Thyroid Cancer Incidence

Jacob *et al* (2005)



Leukemias in Clean-up Workers

Ivanov (1997)



Solid Cancers

Okeanov *et al* (2004), Pukkala *et al* (2006)

Cancer	Relative Risks	95% CIs
All sites	1.20*	1.14 – 1.27
Bladder	1.55*	1.21 – 1.99
Colon	1.31*	1.03 – 1.67
Lung	1.28*	1.13 – 1.46
Breast	2.2	N/A

*RRs statistically significant at 95%

Cardiovascular Disease

Russian cleanup workers

$ERR/Sv = 0.54$ (Ivanov *et al*, 2000)

(is consistent with A-Bomb studies $ERR/Sv = 0.17$)
(Pierce *et al*, 2003)

Non-cancer effects in A-bomb survivors

(Preston and Pierce, 2003)

	ERR/Sv	95% CIs
heart disease	0.17	0.08 to 0.26
stroke	0.12	0.02 to 0.22
respiratory disease	0.18	0.06 to 0.32
digestive disease	0.15	0.00 to 0.32

all statistically significant at 95% level

Transgeneration Effects

Dubrova et al (1996, 1997, 2002)

- DNA minisatellite mutation incidence doubled in Belarus and Ukraine
- mutations in fathers not mothers
- passed to their children

Chernobyl: conclusions

- terrible consequences
- health effects still occurring
- different health effects appearing
- need more research + funding
- need to question denials by many governments

Uncertainties in Dose Coefficients

Goossens LHJ, Harper FT, Harrison JD, Hora SC, Kraan BCP, Cooke RM (1998) Probabilistic Accident Consequence Uncertainty Analysis: Uncertainty Assessment for Internal Dosimetry: Main Report. Prepared for U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, USA. And for Commission of the European Communities, DG XII and XI, B-I049 Brussels Belgium. NUREG/CR-6571 EUR 16773.

Nuclide	Intake	Organ	U Range = (ratio of 95th/5th percentiles)
Cs-137	ingestion	red bone marrow	4
I-131	inhalation	thyroid	9
Sr-90	ingestion	red bone marrow	240
Pu-239	ingestion	red bone marrow	1,300
Sr-90	inhalation	lungs	5,300
Ce-144	inhalation	red bone marrow	8,500
Pu-239	ingestion	bone surface	20,000

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