Thyroid Cancer Risk After the Chernobyl Accident

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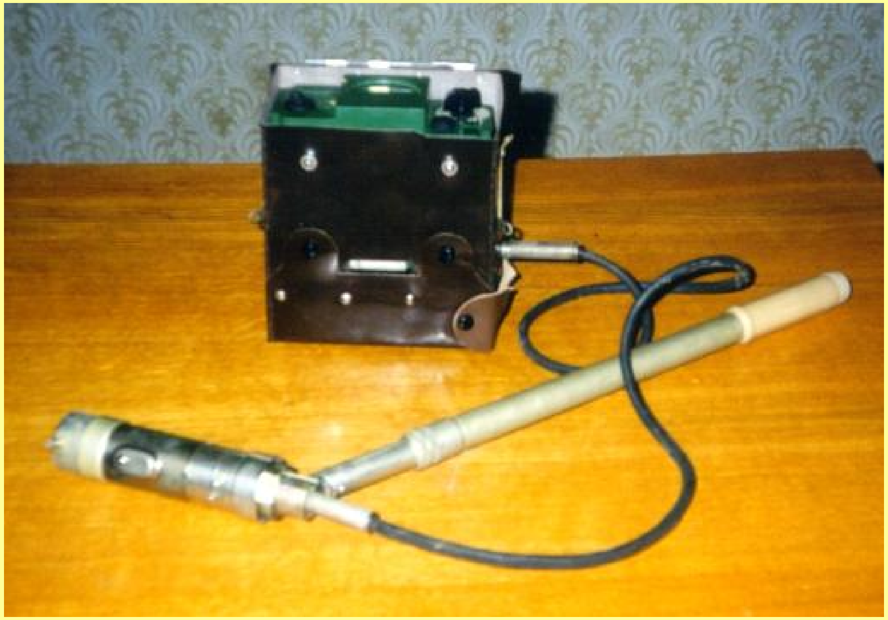
1. Dose

Country	Spectrometric measurements	Non-spectrometric measurements	Reference
Belarus	20,000	93,000	Gavrilin et al. Health Phys 76,105-119,1999
Ukraine	56,000	90,000	Likhtarov et al. Radiat Res 163, 125-136, 2005

Geiger-Müller counter →

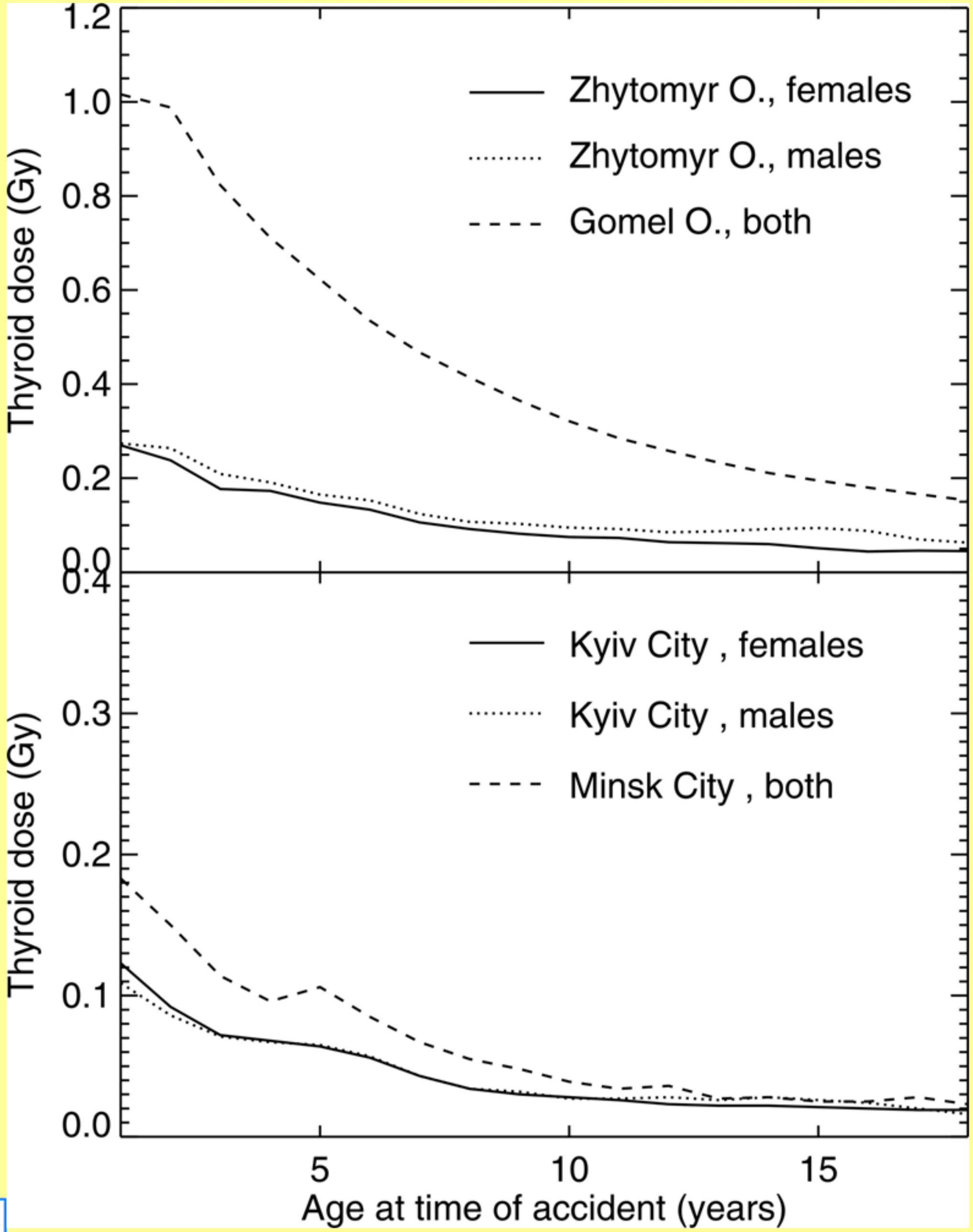
↓ NaI (Tl) scintillation counter



Photos: Institute of Radiation Medicine, Minsk

Most measurements were performed in buildings and without other (potentially contaminated) persons around, but not all.

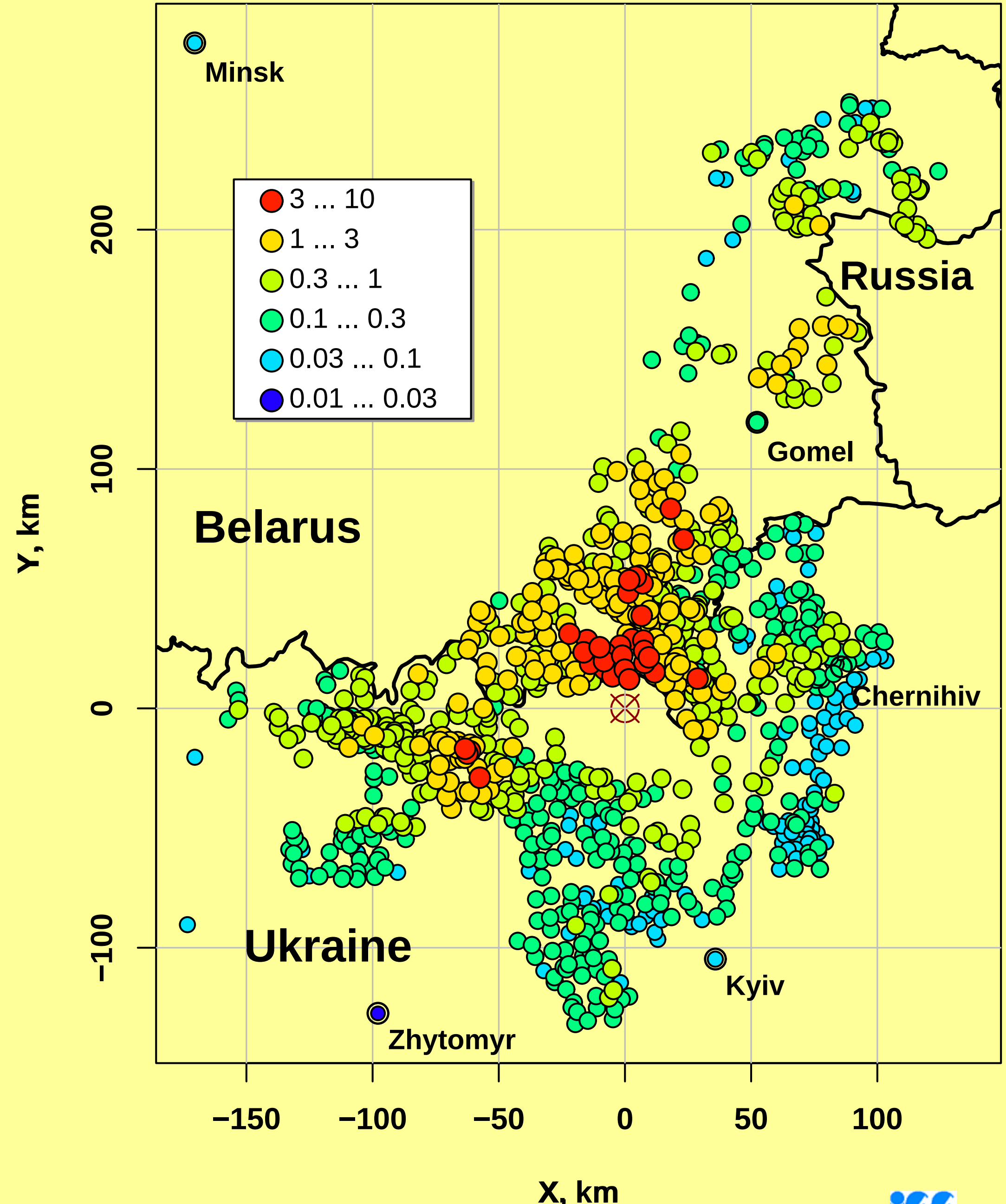
Photo: TASS



Jacob et al. J Radiol Prot 26, 51-67, 2006

Average thyroid dose of children and adolescents in 1034 settlements with more than 10 measurements of the ^{131}I activity in the human thyroid

Jacob et al. Radiat Res 165, 1-8, 2006



2. Case-control studies

3 studies performed in Belarus and Russia

All studies found a significant association between increase of thyroid cancer incidence and radiation dose

Some details about the largest study (Cardis et al. J Natl Cancer Inst. 97, 724-732, 2005)

276 case patients with thyroid cancer surgery, in Gomel, Mogilev in 1992-1998, or in Bryansk, Kaluga, Orel, Tula in 1998.

Age at exposure younger 15.

1300 control subjects matched by age, sex, oblast.

Doses estimates based on whereabouts and dietary habits.

Linear dose-response model for data up to 2 Gy resulted in relative risk at 1 Gy of 5.5 (95%CI: 2.2; 8.8).

The cancer risk at 1 Gy in subjects who consumed potassium iodide (mainly evacuated children in Belarus), relative to subjects who did not, was 0.34 (95%CI: 0.1; 0.9).

The cancer risk at 1 Gy in subjects living in areas in the lowest tertile of soil iodine relative to subjects living in the other areas was 3.2 (95%CI: 1.9; 5.5).

The main problem of the case-control study: dose estimates are not based on measurements and have a large uncertainty.

A re-analysis of the data by taking account of dose estimates might well raise the estimate of the relative risk at 1 Gy.

3. A cohort study

The study (Stezhko et al. Radiat Res 161, 481-492, 2004) includes 25,161 Belarusians and Ukrainians under the age of 18 years in 1986.

Individual thyroid doses are being estimated based on measurements of the ^{131}I activity in the human thyroid, performed in May/June 1986. 11,140 cohort members had doses below 0.3 Gy, 7,156 doses exceeding 1 Gy, 6,865 had intermediate doses.

Every 2 years the cohort members are being screened for thyroid diseases (palpation and ultrasound examination by a trained ultraonographer, and palpation by an endocrinologist).
About 100 thyroid cancer cases were detected during the first screening from Dec 1996 (Belarus) / April 1998 (Ukraine) to March 2001.

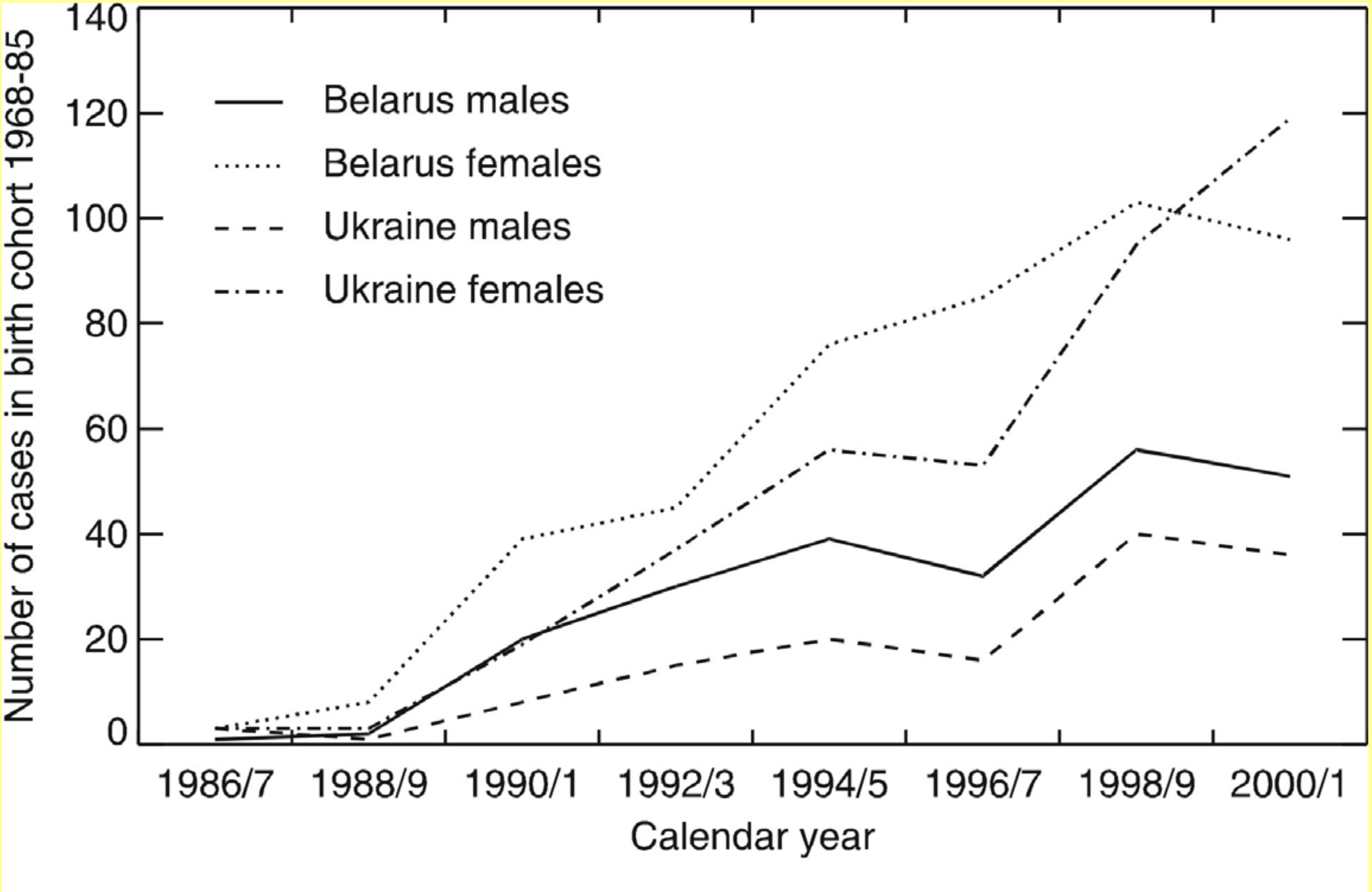
In the Ukrainian subcohort the odds ratio at 1 Gy was 6.3 (95%CI: 2.5; 15.6) Tronko et al. J Natl Cancer Inst, in print, 2006.

Advantages of the study are the large number of cohort members, individual dose measurements, large dose range, identical screening of all cohort members since the start of the study.

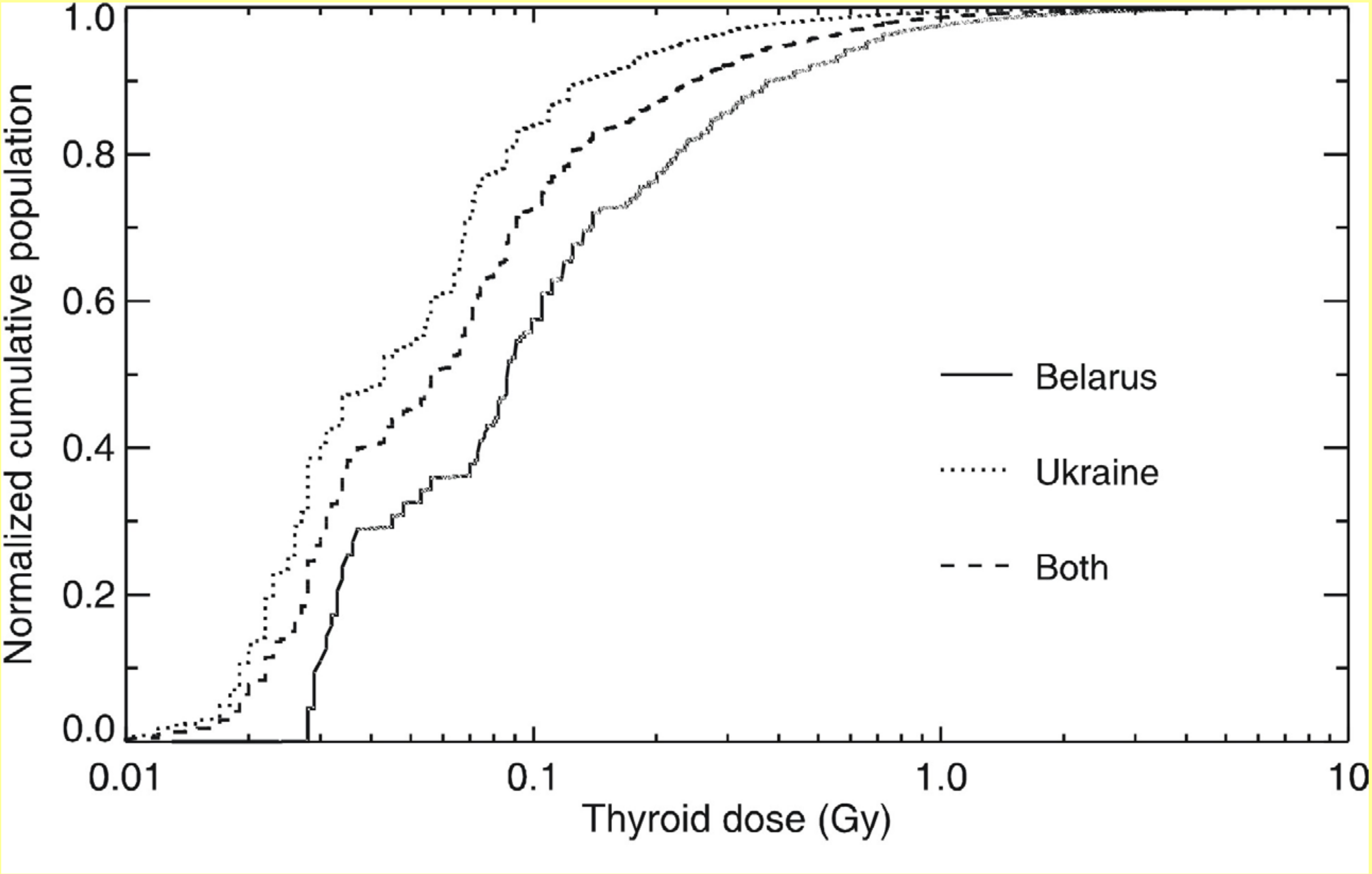
Disadvantages are uncertainties of dose estimations (which are, however, considerably less than in the case-control studies) and that excess risks in the cohort may differ from excess risks in the population (see results below of a study at the Michael Reese Hospital in Chicago, Schneider et al, J Clin Endocrinol Metab 77, 362-369, 1993).

Time	Rate (cases per 10^4 PY)	ERR per Gy
Before 1974	26	9.2
After 1974	157	1.8

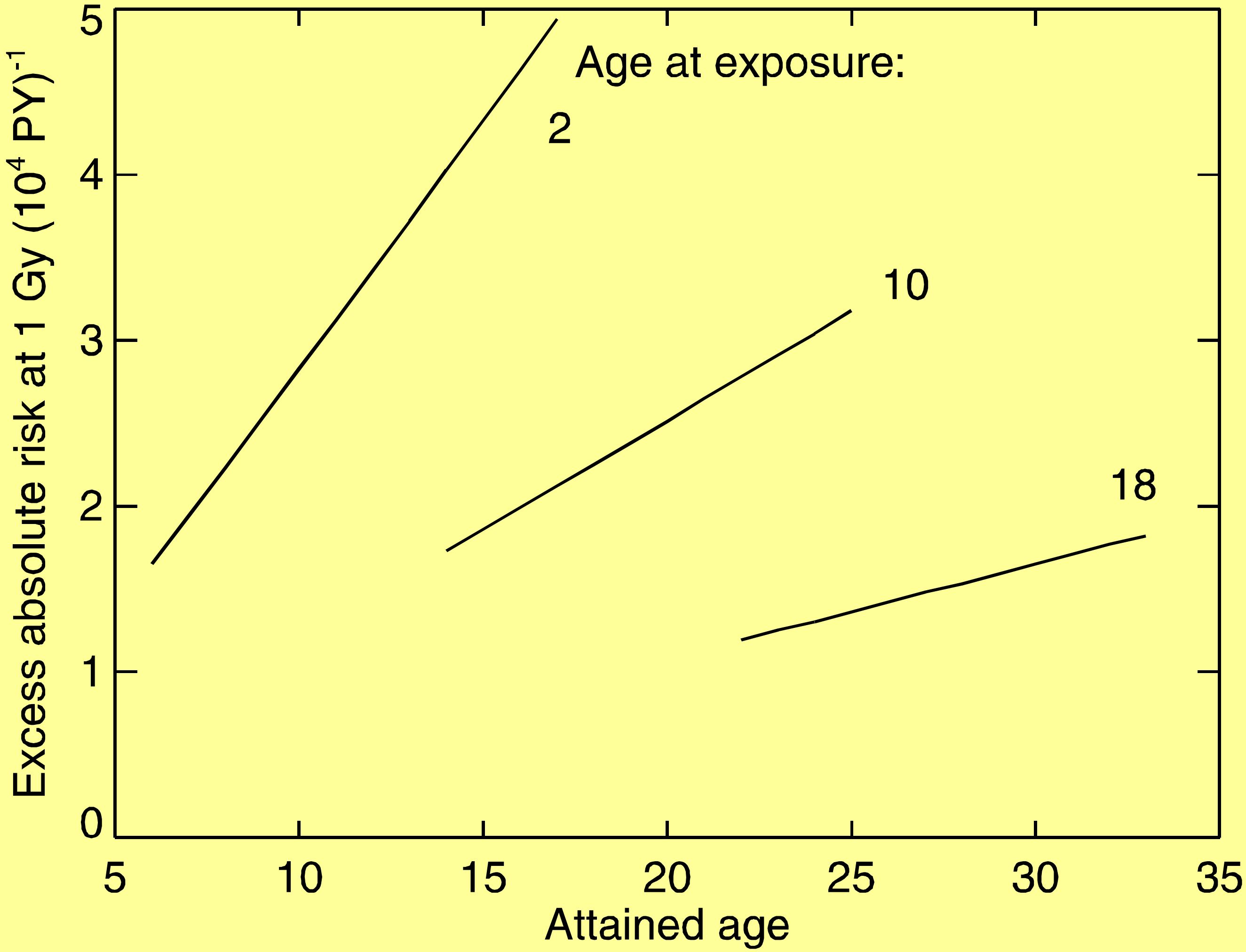
4. An ecological study



1034 settlements, 1.63 million inhabitants in birth-year cohort 1968-1985, 1089 thyroid cancer cases in period 1990-2001.
Jacob et al. Radiat Res 165, 1-8, 2006



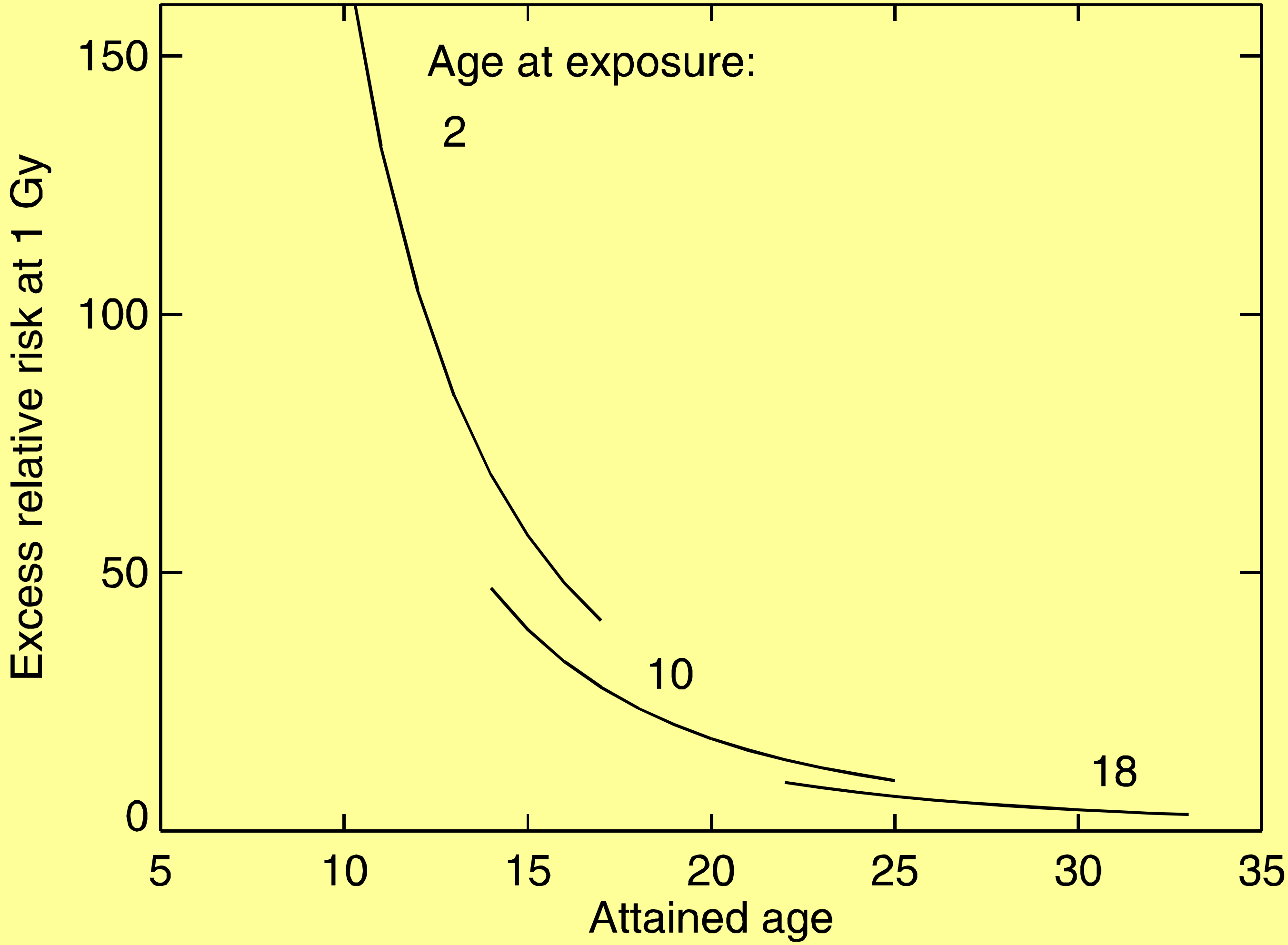
95%-dose range 0.017 – 0.69 Gy



EAR increases with time after exposure.

EAR at 1 Gy in 1996 for age at exposure 10: 2.7 (95% CI: 2.2; 3.1) / 10^4 PY.

The EAR is by a factor 1.5 (95%CI: 1.3; 1.9) higher for females than for males.



ERR decreases with time after exposure.
ERR at 1 Gy in 1996 for age at exposure 10: 19 (95% CI: 11; 27).
The EAR is by a factor 3.8 (95%CI: 2.4; 6.2) smaller for females than for males.

The main disadvantage of ecological studies is the danger of an ecological bias, which may be due to a misclassification of cases, or due to uncontrolled confounding factors.

First simulation calculations (Blettner et al. Veröffentlichungen der SSK, Band 56, 141-154, 2005) indicated that the ecological bias of the ecological study by Jacob et al. (Brit J Cancer 80, 1461-9, 1999) is small, because:

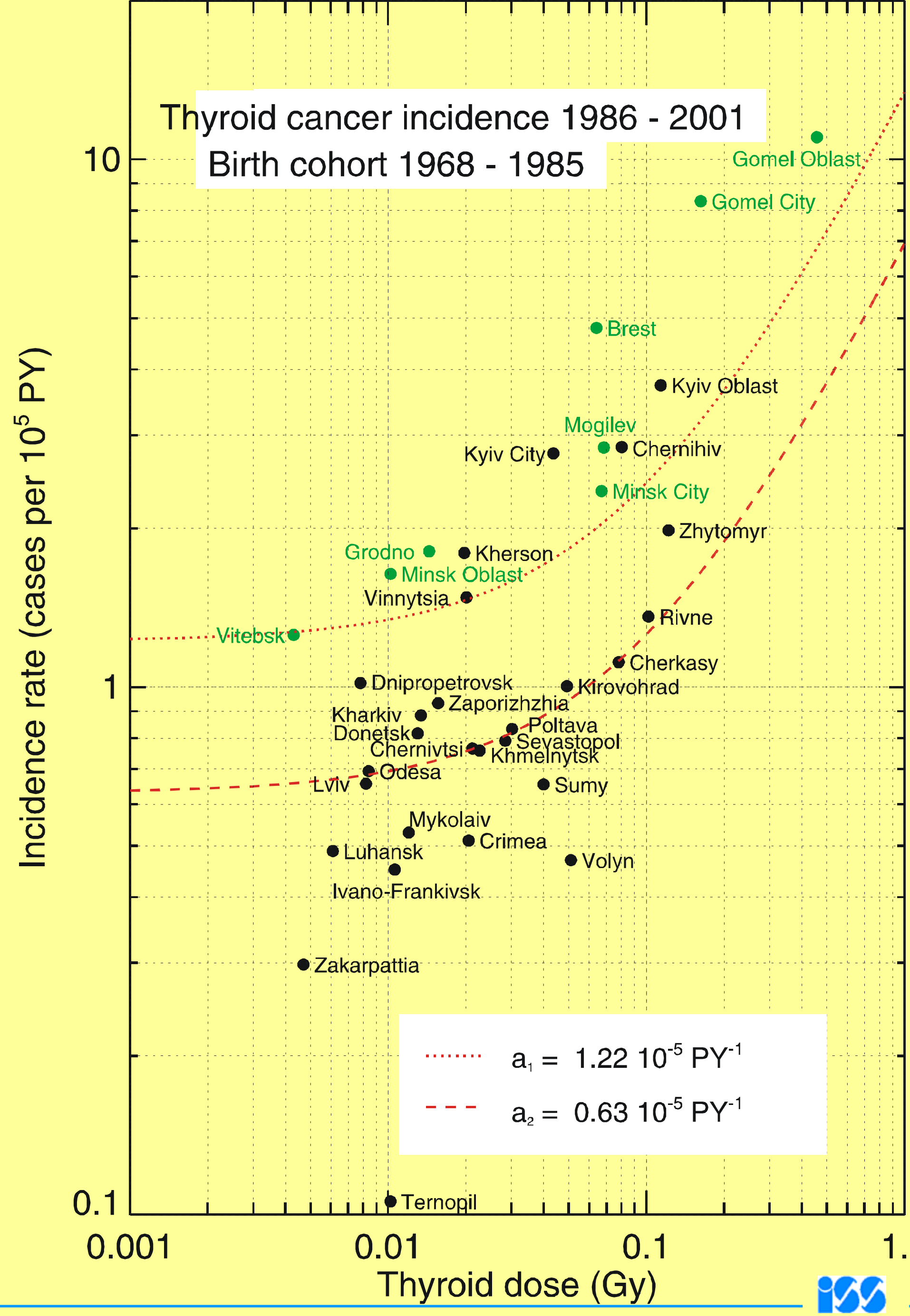
* radiation is the dominating cause of thyroid cancer in the study area
* the study is based on a large number of dose measurements
* the uncertainty of the dose estimates is smaller than the variability of the true doses within the age-gender groups of the single settlements
* the variability of screening intensities seems to play a minor role for the risk estimation within the study area.

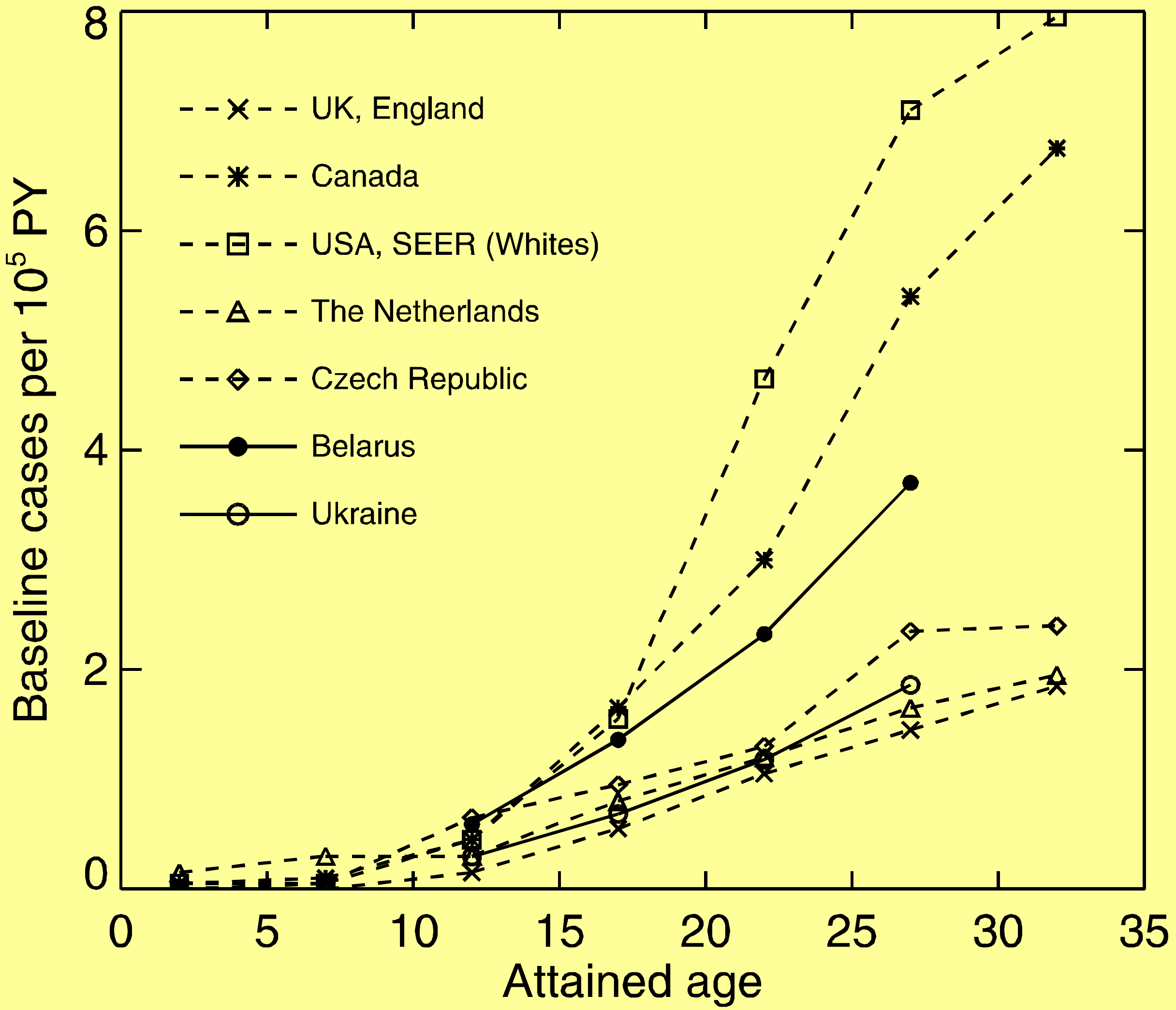
5. Comparison of excess risks

Reference	Exposure mode	Time after exposure	EAR at 1 Gy $(10^4\ PY)^{-1}$	ERR at 1 Gy
Cardis et al.,J.Natl. Cancer Inst. 97, 724-732, 2005	^{131}I	≈ 11 years	-	4.5 (1.2; 7.8)
Tronko et al., in print, 2006	^{131}I	13 years	-	5.5 (1.6; 16.3)
Jacob et al., Radiat Res 165, 1-8, 2006	^{131}I	10 years	2.7 (2.2; 3.1)	19 (11; 27)
Jacob et al., Radiat Res 165, 1-8, 2006	^{131}I	15 years	3.2 (2.6; 3.8)	10 (5.9; 14)
Ron et al., Radiat Res 141, 259-277, 1995	external	≈ 15 years	4.4 (1.9; 10)	7.7 (2.1; 29)

6. Cases in Belarus and Ukraine

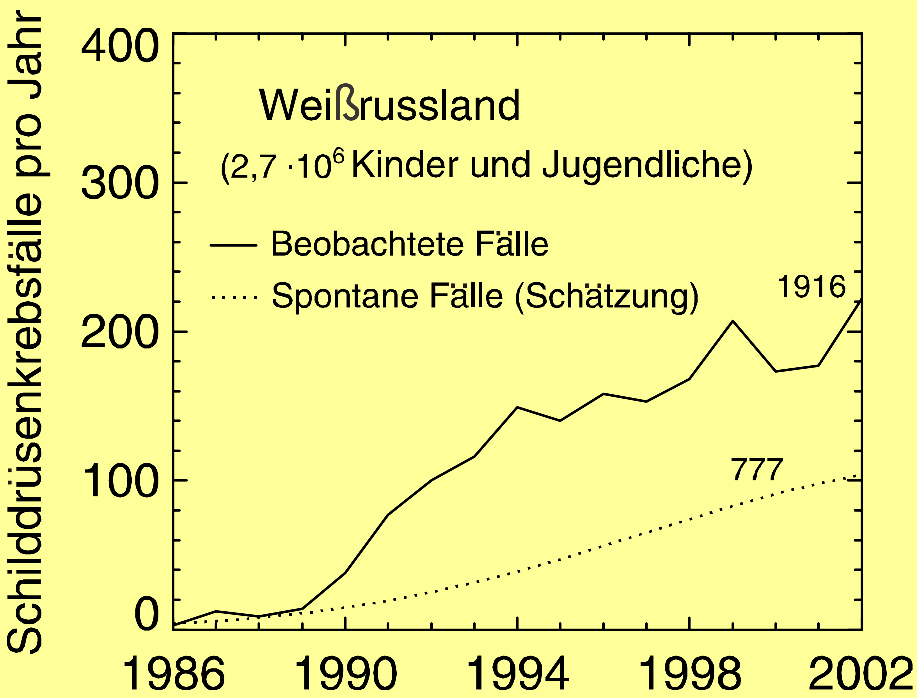
Jacob et al.
J Radiol Prot. 26, 51-67, 2006

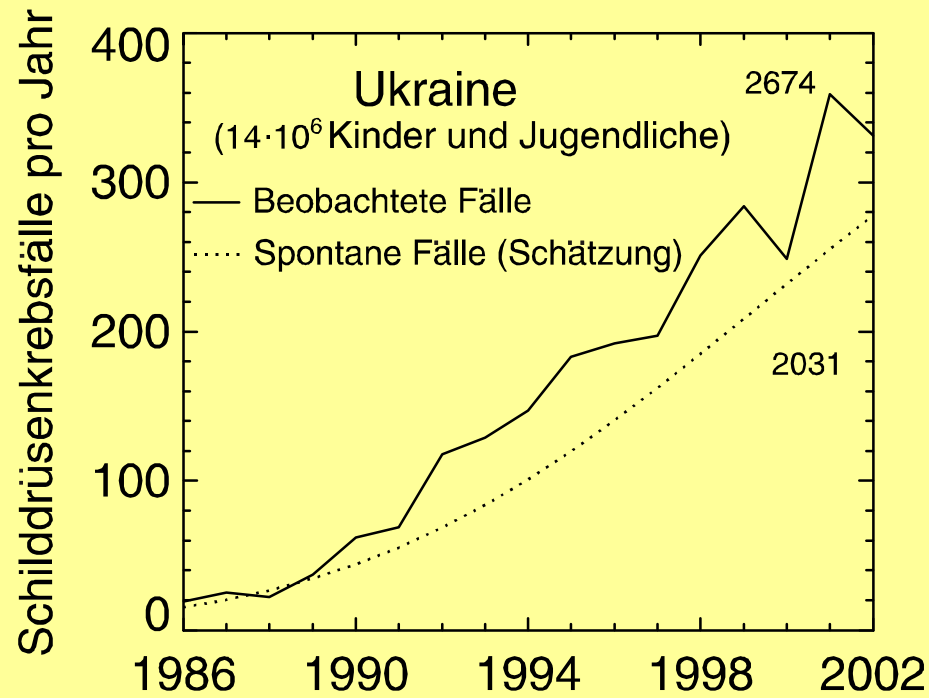




Baseline cases 1993 -1997

Thyroid cancer cases among those, who were 0 – 18 years at the time of the accident





6. Summary (1)

About 100 000 children and adolescents had thyroid doses exceeding 0.3 Gy

Case-control studies demonstrated a significant association between thyroid dose and increase of thyroid cancer risk

Cancer risk per unit dose seems to be higher in areas with poor supply of stable iodine

After a latency period of a few years, the excess relative risk is very high and then decreases with time after exposure

15 years after the accident the excess relative risk per unit dose is about 10 Gy^{-1}

6. Summary (2)

The excess absolute risk per unit dose is especially high for young ages at exposure

At 15 years after exposure the excess absolute risk per unit dose after exposure at age 10 is about 3 cases per 10^4 PY-Gy

The number of excess cases per year increased monotonically in an observation period from 1990 to 2001

Up to 31 December 2002, 4590 thyroid cancer cases have been observed in Ukraine and Belarus among those at age 0-18 at the time of the accident. About 40% of these cases are associated with radiation

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