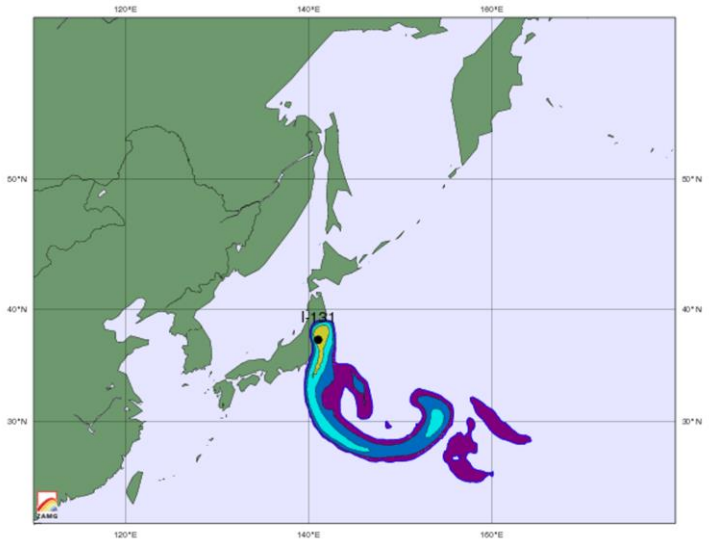
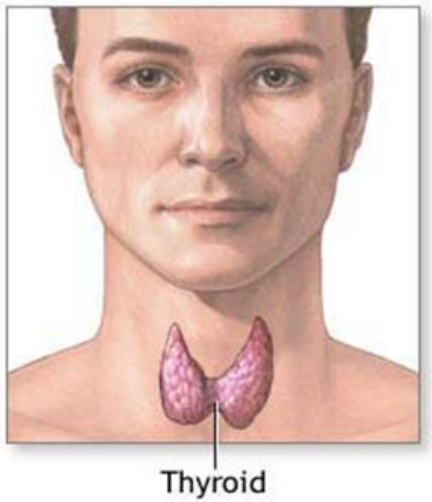
The effect of radioactive iodine on the incidence of thyroid cancer after the Fukushima nuclear accident

Andrzej Wojcik
Centre for Radiation Protection Research
Stockholm University

andrzej.wojcik@su.se

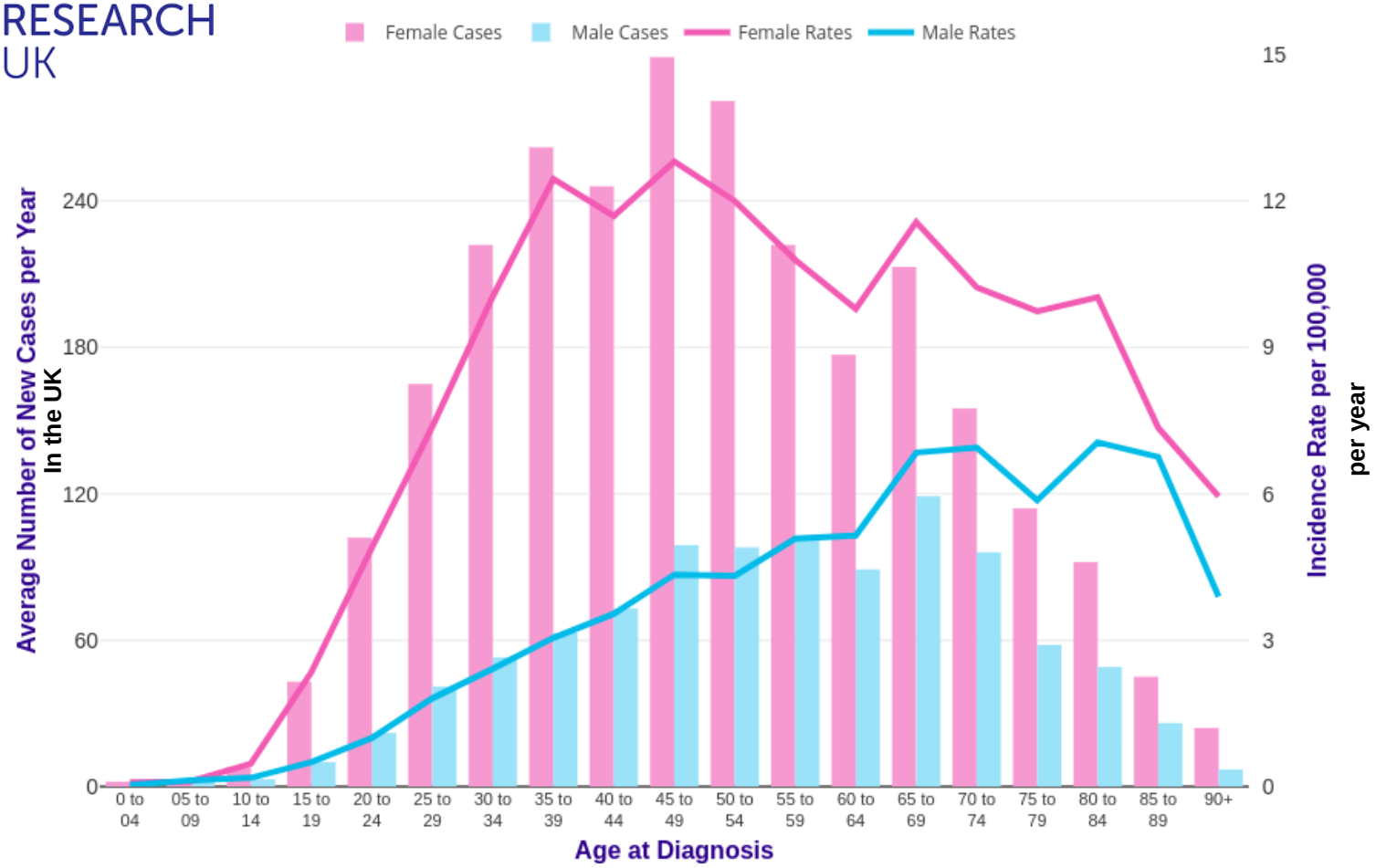
11 March 2011
Fukushima Daiichi accident



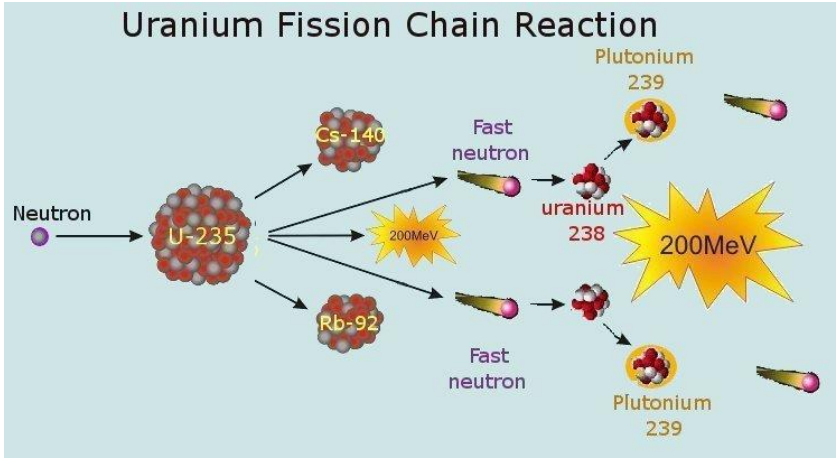


Incidence of thyroid cancer as a function of age and sex

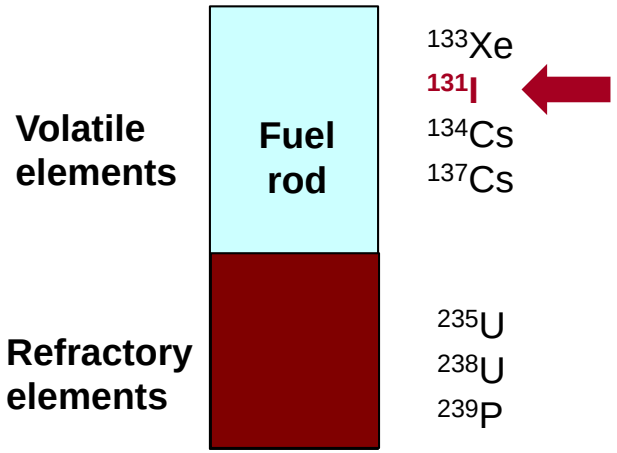
CANCER RESEARCH UK



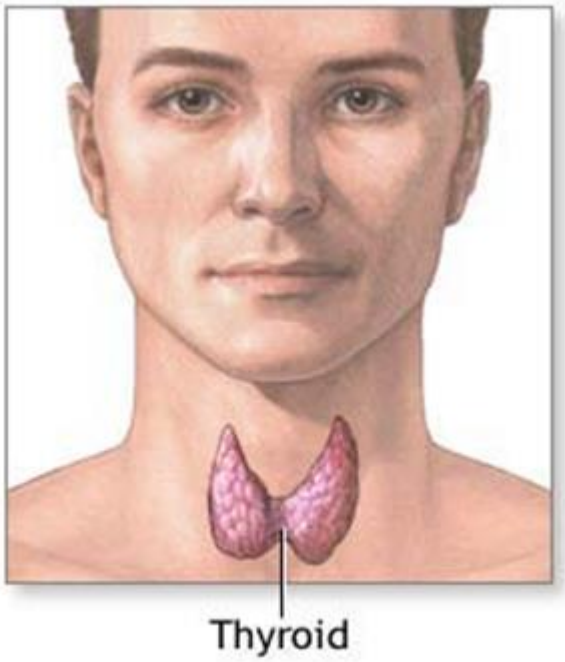
Why is radioactive iodine released in a nucler accident?



In case of a reactor core meltdown, volatile elements will be released from fuel rods



^{131}I can accumulate in the thyroid gland



- The thyroid gland uses iodine to synthetize the hormone thyroxine.
- ^{131}I is taken up by the thyroid gland in people who suffer from iodine deficiency.
- ^{131}I uptake in children increases the risk of thyroid cancer in a dose-dependent manner.

A lot of ^{131}I was released after the Chernobyl accident on 26 April 1987

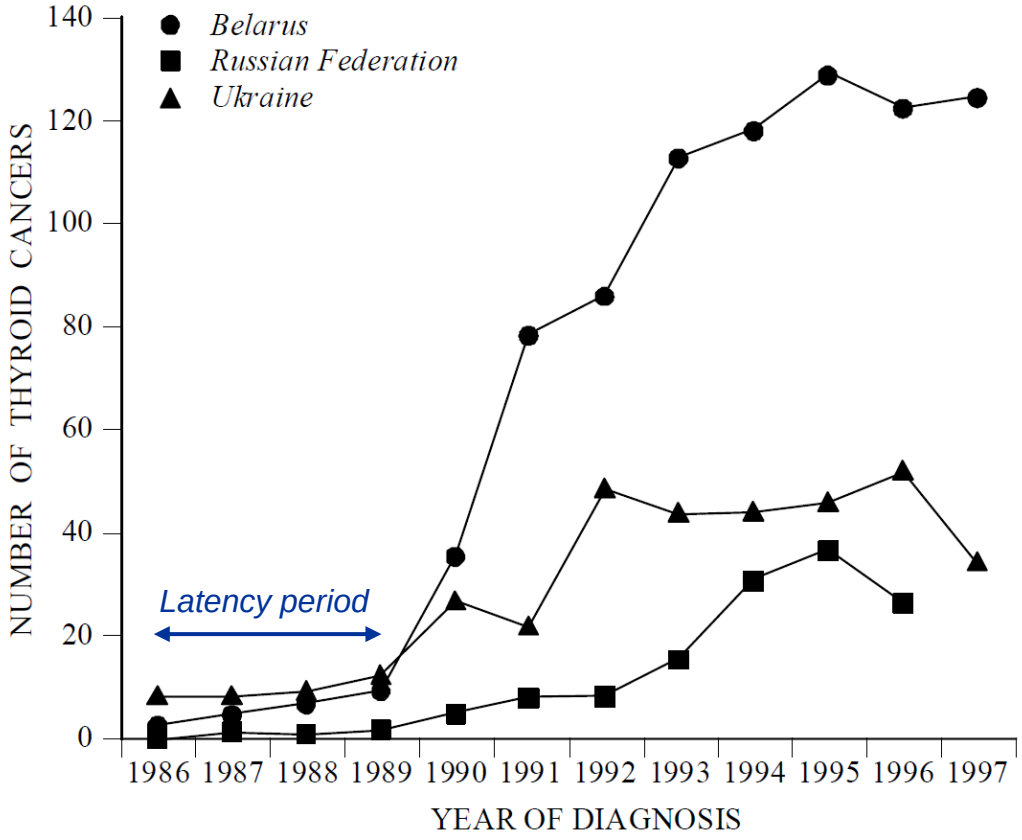
^{131}I activity released:

1760 PBq = 1.76 x 10^{18} Bq

- 1 Bq: 1 radioactive decay per second
- ^{131}I has a half-life of ca 8 days and disintegrates into Xe emitting beta radiation
- After ca 10 half-times (80 days) all ^{131}I has decayed

Incidence of thyroid cancer after the Chernobyl accident

Number of thyroid cancers <u>in children</u> exposed before the age of 14 years as a result of the Chernobyl accident



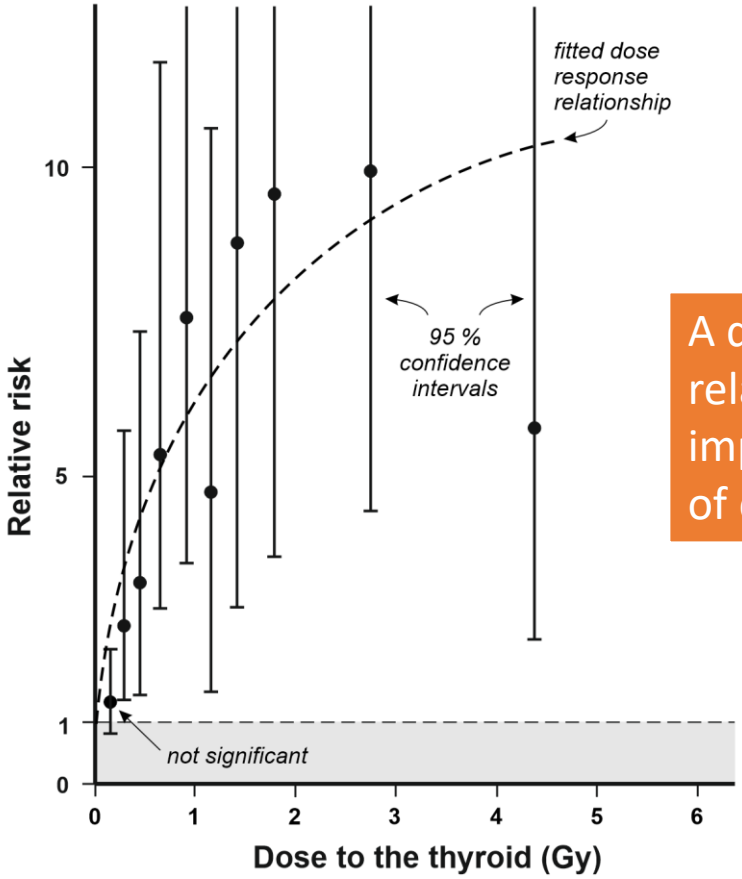
UNSCEAR 2000 Report Annex J: Exposures and effects of the Chernobyl accident

Doses to the thyroid gland and thyroid cancer dose response among the population of Russia, Ukraine and Belarus exposed to ^{131}I

Dosimetric measurements were carried out on a large scale

E. Cardis et al. Risk of Thyroid Cancer After Exposure to ^{131}I in Childhood. J Natl Cancer Inst 97:724 – 32, 2005

Dose response for risk of thyroid cancer could be established thanks to measurements



A dose response relationship is an important indicator of causality

Relative risk

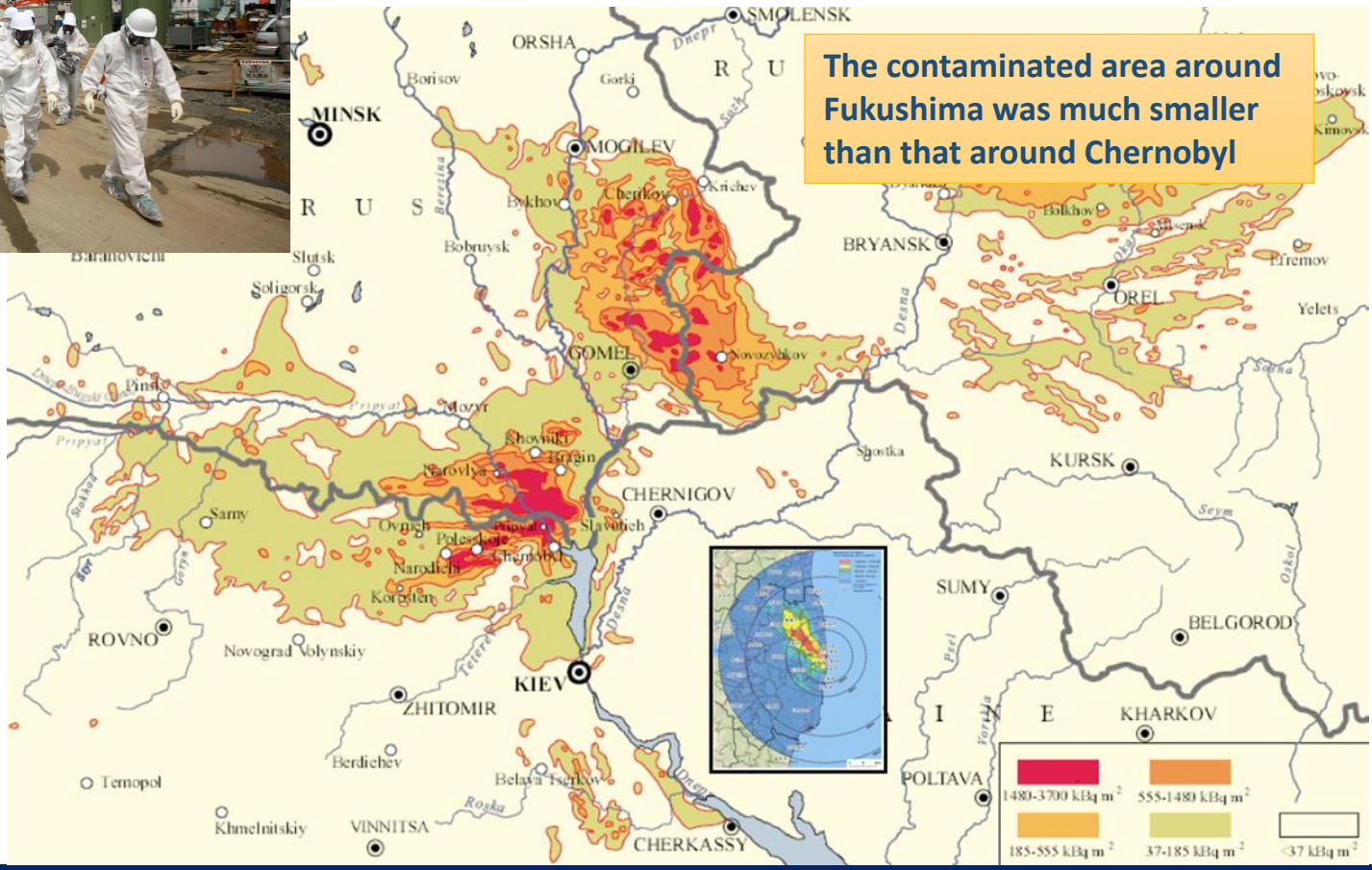
$$\frac{\text{Cases in exposed group}}{\text{Cases in control group}} \pm 95\%\ \text{CI}$$

^{131}I was also released after the Fukushima Daiichi accident on 11 March 2011

^{131}I activity released:

124 PBq = 1.24 x 10^{17} Bq

- This is 7% of the activity released by Chernobyl



Sources: UNSCEAR 2000 J (Chernobyl), WHO 2012 (Fukushima)

Experts predicted that the thyroid cancer incidence attributable to the ^{131}I uptake would be very low

2013 World Health Organization

"The values presented in the report should be regarded as inferences of the magnitude of the health risks, rather than as precise predictions"

Doses to the thyroids were not measured because the Japanese government did not want to spread fear…

Estimated thyroid doses for children and infants were calculated based on the contamination of land with Cs-137

High contaminated area: ca 5-100 mGy

Middle contaminated area: ca 3-5 mGy

Low contaminated area: < ca 3 mGy

The population of the whole Fukushima prefecture is ca 2 million.
Thyroid cancers attributed to ^{131}I will not be detectable.

But people were scared…

To calm people, the Fukushima government started the Fukushima Health Management Survey in late 2011

The survey started in late 2011 and is conducted by the Fukushima Medical University.

Its primary purpose is monitoring the long-term health of residents, promoting their future wellbeing and determining whether long-term low-dose radiation exposure has health effects.

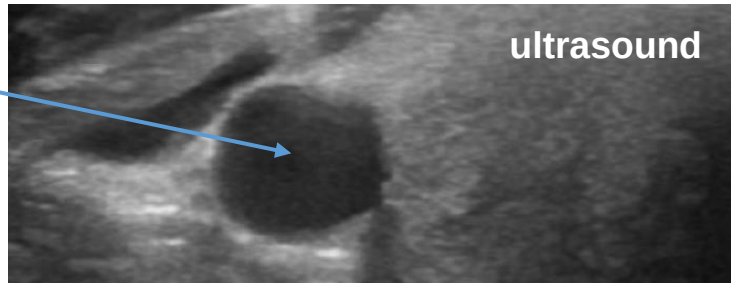
The survey includes a thyroid ultrasound screening examination (residents between 0 and 18 years).
The chronology:

- 2011-2013 base line measurements
- Thereafter every 2 years until age 20
- Thereafter every 5 years

Thyroid screening has never been conducted in Japan before so no reference results existed

The screening for thyroid cancer in the Fukushima prefecture – diagnostic criteria

cyst



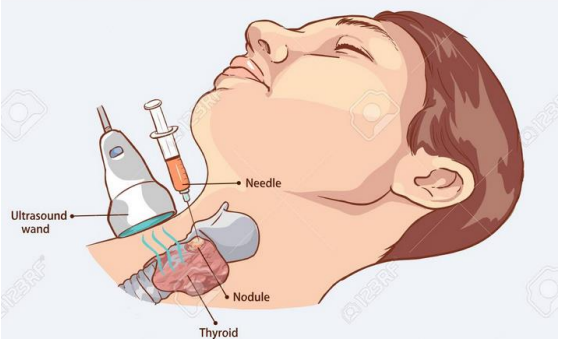
Category	Diagnosis
A1	no nodules or cysts
A2	nodules smaller than 5.0 mm and/or cysts smaller than 20 mm
B	nodules larger than 5.1 mm and/or cysts larger than 20.1 mm
C	large or suspicious thyroid tumour/lymph node

Normal thyroid

Thyroid abnormalities that may lead to cancer development

Indication of existing cancer

Fine needle aspiration



Fine needle aspiration cytology (FNAC)

Positive FNAC

Surgical treatment

S. Suzuki. Childhood and Adolescent Thyroid Cancer in Fukushima after the Fukushima Daiichi Nuclear Power Plant Accident: 5 Years On. Clinical Oncology 28:263-271, 2016.

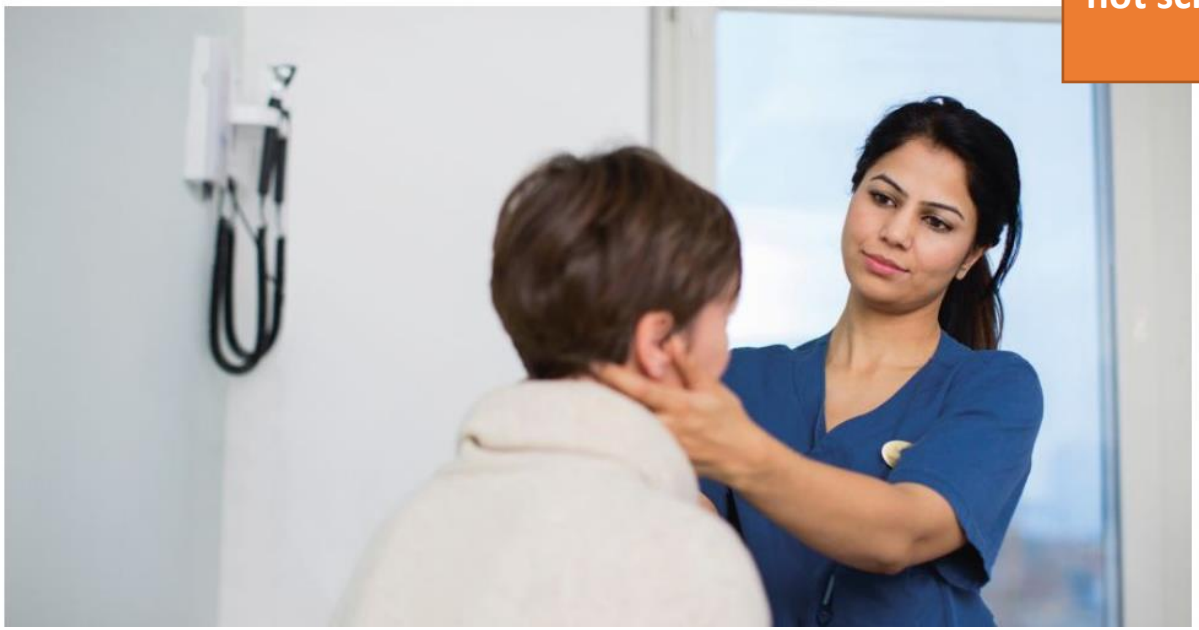
Let us take a break and talk about early cancer diagnosis and treatment success

CANCERFONDEN

Tidig upptäckt räddar liv

8 oktober 2020

Överlevnaden ökar dramatiskt vid många cancerformer om symtomen upptäcks tidigt. Men trots att över 70 procent av cancerdiagnoserna upptäcks på vårdcentralen har forskning och utbildning låg prioritet i primärvården.



If early diagnosis is so important – why not screen the population for early stage cancer?

Early diagnosis and screening

Early diagnosis of cancer

Early diagnosis refers to investigation at first signs of disease.

Screening

Screening refers to the use of simple tests across a healthy population to identify those individuals who have a disease, but do not yet have symptoms.

World Health Organization
REGIONAL OFFICE FOR Europe

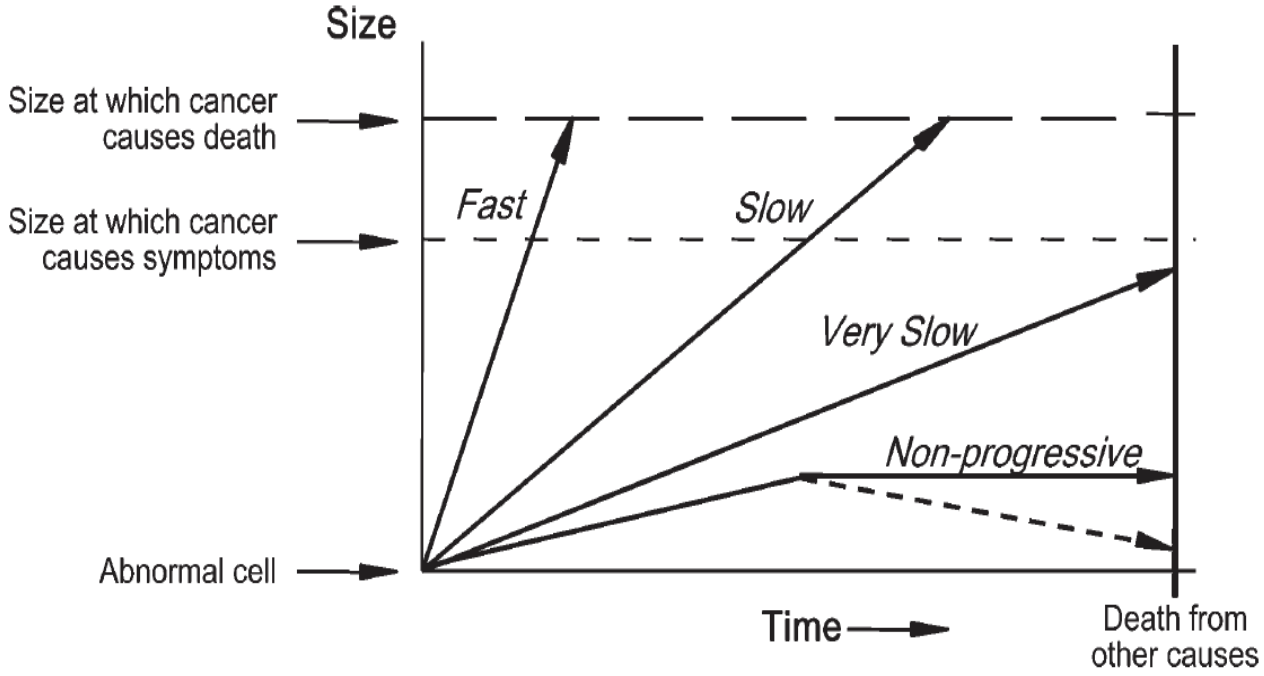
WHO does not recommend general screening programs
Why not?

Overdiagnosis: when finding cancer can do more harm than good

A major problem with screening is that it can lead to overdiagnosis

and unnecessary treatment that injures the patient.

Heterogeneity of cancer progression.
Some cancer may never become manifest

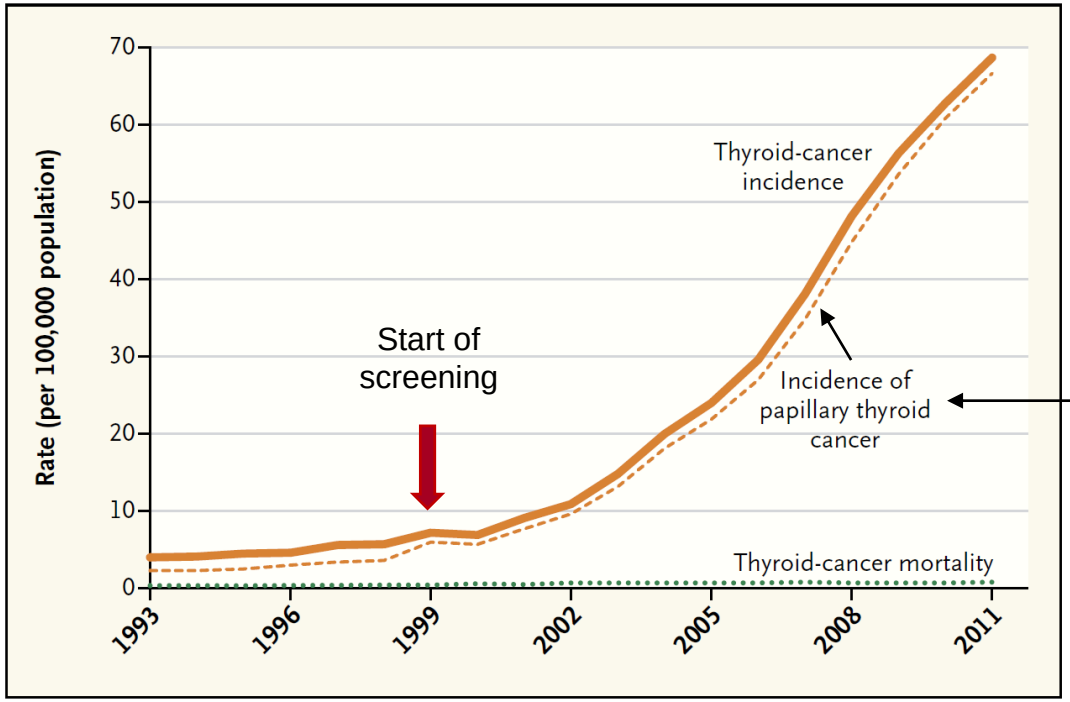


Source: H.G. Welch et al. Overdiagnosis in Cancer. JNCI 102(9), 2010.

The national screening program in South Korea: cancer incidence and mortality

In 1999, the Korean government initiated a national screening program for cancer and other common diseases. This program provides screening for breast, cervical, colon, gastric, hepatic and thyroid cancer.

Thyroid-Cancer Incidence and Related Mortality in South Korea, 1993–2011



By 2014 thyroid cancer was the most common cancer diagnosed in South Korea leading to a surge of surgery.

The most common type

Source: H.S. Ahn et al. Korea's Thyroid-Cancer "Epidemic" — Screening and Overdiagnosis. N Eng J Med 371, 2014.

The screening for thyroid cancer in the Fukushima prefecture: the 2011-2013 baseline results

Baseline screening carried out in **ca 300 000** youths

Category	Baseline investigation
A1	51%
A2	48%
B	1%
C	< 1%
FNAC positive	113

Normal thyroid ←

Thyroid abnormalities that may lead to cancer development ←

Indication of existing cancer ←

→ **386 cancer cases per 1 million = prevalence**

Prevalence: number of people ill at a given moment

Incidence: number of new disease cases per time (e.g. year)

The screening for thyroid cancer in the Fukushima prefecture – the 2011-2014 baseline results and interpretation by Tsuda et al.

Category	Baseline investigation
A1	51%
A2	48%
B	1%
C	< 1%
FNAC positive	113

Thyroid Cancer Detection by Ultrasound Among Residents Ages 18 Years and Younger in Fukushima, Japan: 2011 to 2014

Toshihide Tsuda,[a] Akiko Tokinobu,[b] Eiji Yamamoto,[c] and Etsuji Suzuki[b]

(*Epidemiology* 2016;27: 316–322)

→ **386 cancer cases per 1 million = prevalence in the year 2013**

In overall Japan the **incidence** (number of diseased per year) of thyroid cancer in youths is ca 3 per million. Prevalence is not calculated because thyroid cancer is quickly treated.

Because radiation-induced thyroid cancer has a latency period of ca 4 years, Tsuda et al. divided 386 (**prevalence**) by 4 to calculate **incidence** and compare with overall Japan.

$$\frac{386}{4} = 96.5$$ which is ca **30 times higher than 3**

Conclusion of the Tsuda study: ^{131}I is a much stronger inducer of thyroid cancer then previously assumed. The current radiation protection assumptions are wrong.

The reactions to the Tsuda paper were strong

In Iwaki, a town south of the Fukushima nuclear plant, a doctor conducts a thyroid examination on 4-year-old Maria Sakamoto. Scientists are puzzled over a high number of thyroid abnormalities observed so soon after the accident.

Mystery cancers are cropping up in children in aftermath of Fukushima

By Dennis Normile | Mar. 4, 2016 , 10:45 AM

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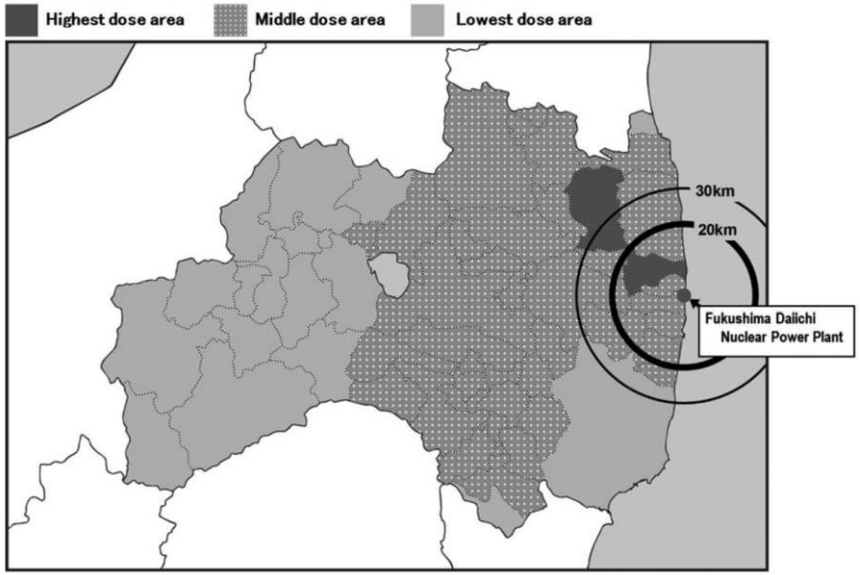
Validation of the Tsuda conclusions
Is there a dose-response relationship for thyroid cancer?

Geographic details of the highest dose area, middle dose area, lowest dose area, and the Fukushima Daiichi Nuclear Power Plant.



Highest. More than 1% of people received ≥5 mGy
Middle. Less than 1% of people received ≥5 mGy
Lowest. 99.9 % of people received < 1 mGy **= reference**

Comparison of childhood thyroid cancer prevalence among 3 areas based on external radiation dose after the Fukushima Daiichi nuclear power plant accident

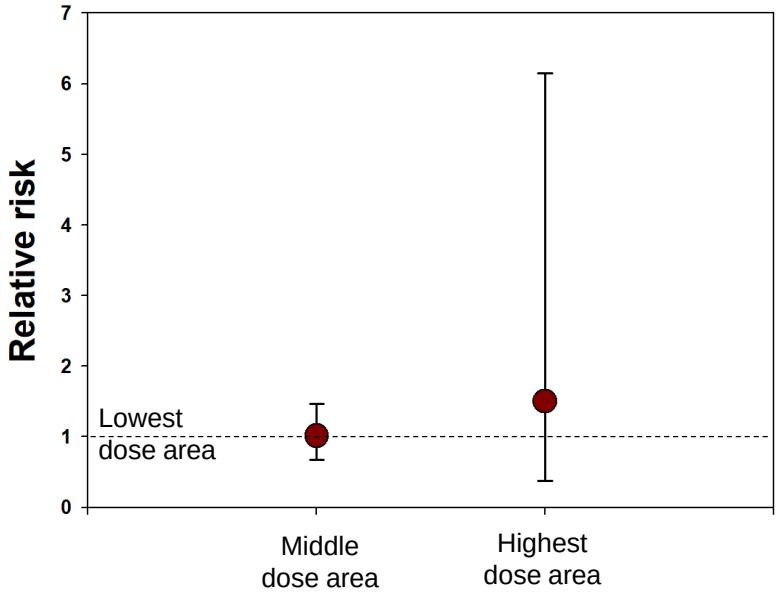
The Fukushima health management survey

Tetsuya Ohira, MD, PhD[a,b,*], Hideto Takahashi, PhD[a], Seiji Yasumura, MD, PhD[a,c], Akira Ohtsuru, MD, PhD[a,d],

Medicine (2016) 95:35(e4472)

Result of the analysis

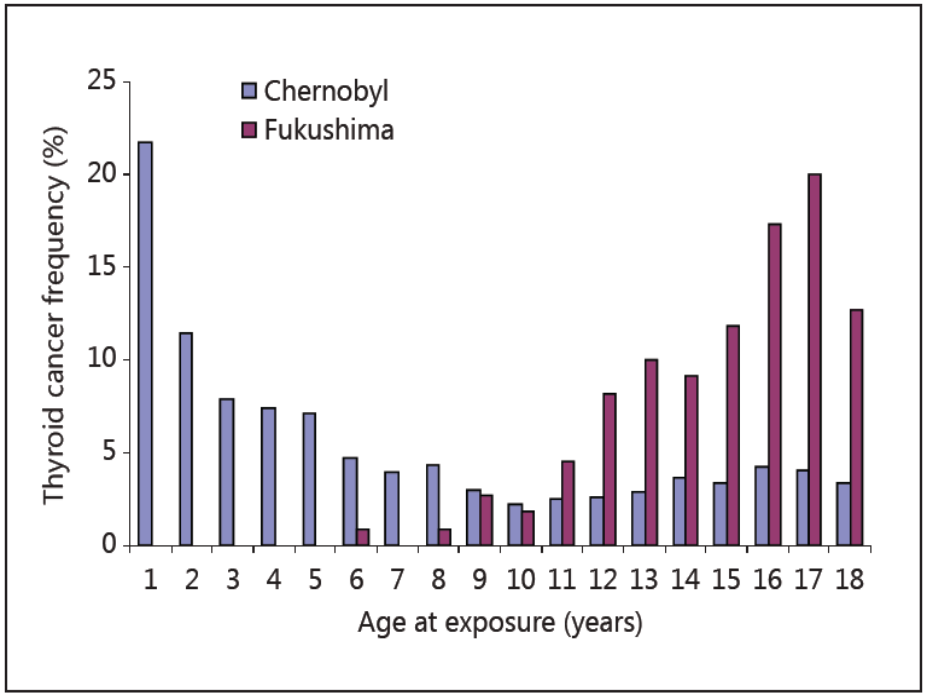
Relative risk and 95% confidence intervals



Conclusion of the Ohira study: there is no dose-response for ^{131}I-induced thyroid cancers, so the results of Tsuda et al. are due to screening.

Validation of the Tsuda conclusions: is there a negative correlation between age at exposure and thyroid cancer incidence?

Thyroid cancer frequency (percentage distribution) by age at exposure to fallout from Chernobyl and in the first 3 years after Fukushima.



Thyroid Growth and Cancer

Dillwyn Williams Eur Thyroid J 2015;4:164–173

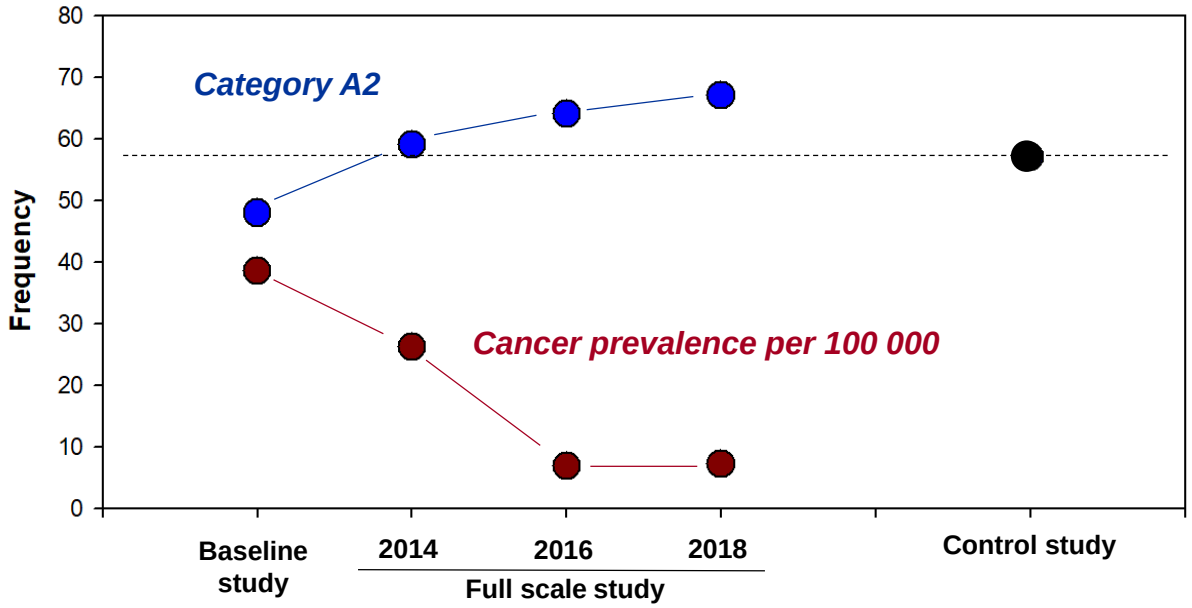
The Chernobyl age distribution shows that the risk of ^{131}I-induced cancers decreases with age at exposure. The Fukushima distribution shows that the risk increases with age at exposure.

Conclusion of the Williams study: The risk of thyroid cancer among the Fukushima youths increased with age at exposure which is to be expected for spontaneous cancers. Therefore, the results of Tsuda et al. are due to screening.

The screening for thyroid cancer in the Fukushima prefecture – the follow-up results

Category	Baseline study	Full scale study			Control study
	2011-2013	2014-2015	2016-2017	2018-2019	
A1	51%	40%	35%	32%	42%
A2	48%	59%	64%	67%	57%
B	1%	1%	1	1%	1%
C	< 1%	< 1%	< 1%	< 1%	< 1%
Cancer prevalence	386	262	69	71	Not carried out

Carried out in non-contaminated area in Japan



It is all about radiation protection…

The screening for thyroid cancer in the Fukushima prefecture – the results

Thyroid Examination - Results As of mar. 31, 2020

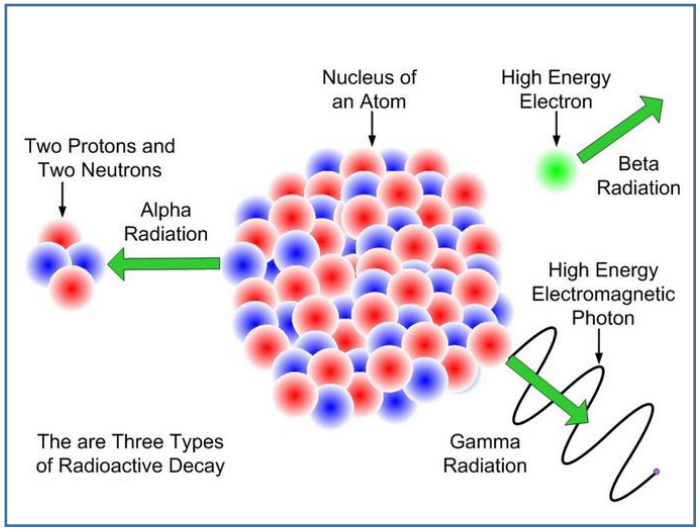
		Preliminary Baseline (1st Exam)	Full-scale Screening (2nd Exam)	Full-scale Screening (3rd Exam)	Full-scale Screening (4th Exam)
Fiscal Year		2011-2013	2014-2015	2016-2017	2018-2019
N0.of target population		367,637	381,244	336,669	294,240
Participation rate of primary exam		81.7%	71.0%	64.7%	61.4%
Target population of confirmatory exam		2,293	2,227	1,501	1,327
Participation rate of confirmatory exam		92.9%	84.1%	73.4%	55.8%
Malignant or suspicious for malignancy (FNAC)		116	71	31	21
No. of people received surgery		102	54	27	13
Pathological Diagnosis	Papillary Cancer	100	53	27	13
	Low-differentiated cancer	1			
	Others	1	1		

From a presentation by Kenji Kamiya – IRPA or ICRP conference)

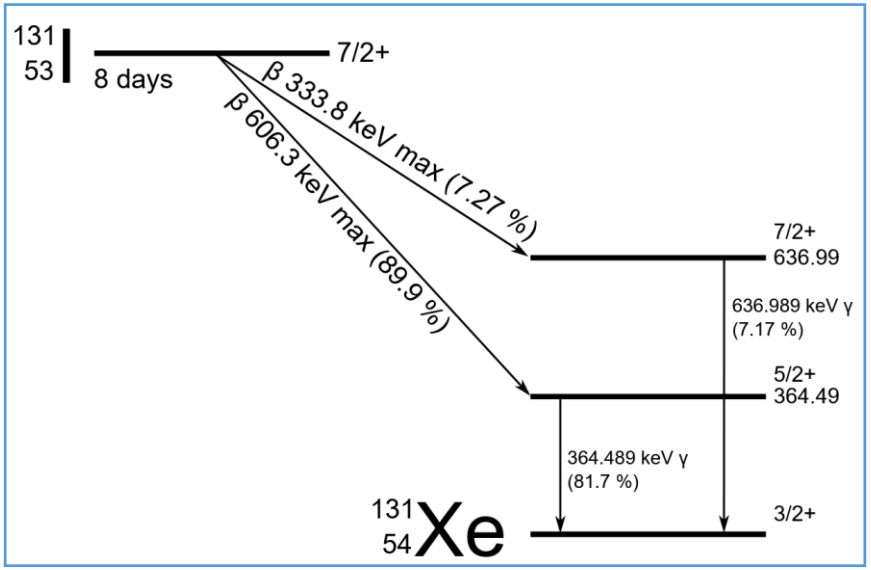
^{131}I radiation and activities released as a consequence of the Chernobyl accident

^{131}I activity released after the Chernobyl accident:
1760 PBq = 1.76 x 10^{18} Bq

1 Bq is 1 radioactive decay per second



^{131}I has a half-life of ca 8 days and disintegrates into Xe emitting beta radiation



After ca 80 days all ^{131}I has decayed

Only a small part of the Fukushima prefecture was contaminated

People in the areas with highest contamination were evacuated