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EpiRadBio

Expected influence of the accident on thyroid cancers

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EU Scientific Seminar 2014: Fukushima – Lessons learned and issues
Luxembourg, 18 November 2014

SEVENTH FRAMEWORK PROGRAMME

HELMHOLTZ ASSOCIATION

Questions addressed

Fukushima Prefecture

Under the condition of on-going ultrasonographic screening in Fukushima Prefecture, what are the expectations concerning thyroid cancer in the screened population?

1. Prevalence during first screening
2. Incidence during subsequent screenings
3. Detectability of radiation effect

1. Prevalence in Fukushima Prefecture

1.1 Prevalence in screened cohort and country-specific incidence rate

Fukushima Prefecture and UkrAm cohort

If screening protocol would be the same, assume:

$$P_{FP} / \lambda_{Japan} = P_{UkrAm} / \lambda_{Ukraine}$$

P prevalence in screened population

λ incidence rate in country

1. Prevalence in Fukushima Prefecture

1.2 Differences in screening protocol

UkrAm cohort: nodule > 10 mm => FNA

Fukushima Prefecture: nodule > 5 mm => FNA

Size distributions in Hong-Kong study similar for nodules and tumors:

nodules > 5 mm / # nodules > 10 mm = 398 / 169 = 2.4

tumors > 5 mm / # tumors > 10 mm = 11 / 5 = 2.2

Yuen et al. Head Neck 2011

1. Prevalence in Fukushima Prefecture

1.3 Correction factor for differences in screening protocol

$$P_{FP} / \lambda_{Japan} = f_{sp} P_{UkrAm} / \lambda_{Ukraine}$$

nodules > 5 mm / # nodules > 10 mm = 2218 / 647 = 3.4[a]

[a] based on data as of 30 June 2014

Fukushima Medical University (2014)

http://www.fmu.ac.jp/radiationhealth/results/media/16-2_Thyroid_Ultrasound_Examination.pdf

f_{sp} = triangular distribution [1; 3.2][b]

[b] based on data as of 31 July 2013

Jacob et al. Radiat Environ Biophys 2014

1. Prevalence in Fukushima Prefecture

1.4 UkrAm prevalence and country-specific incidence rates

$$P_{FP} / \lambda_{Japan} = f_{sp} P_{UkrAm} / \lambda_{Ukraine}$$

UkrAm cohort, first screening: 13 127 participants, average age: 22 years

11.2 (95%CI: 3.2; 22.5) cases not associated with radiation

P_{UkrAm} =0.09% (95%CI: 0.02%; 0.17%)

Tronko et al. J Natl Cancer Inst 2006

λ_{Japan} = 0.3 cases per 10^5 person-years*

$\lambda_{Ukraine}$ = 1.8 cases per 10^5 person-years*

* for age-sex distribution during the first screening in Fukushima Prefecture / UkrAm cohort

National Cancer Center; http://ganjoko.jp/pro/statistics/en/table download.html

Federenko et al. Bull. National Cancer Registry of Ukraine 2002

1. Prevalence in Fukushima Prefecture

1.5 Results on prevalence for 295,689 persons*

Data source	Number of cases	Prevalence, P_{FP} (%)
Derived from UkrAm cohort	101 (29; 247)[a]	0.035 (0.010, 0.086)[a]
Observed in Fukushima Prefecture	103[b] (125[c])	0.035[b] (0.042[c])

[a] arithmetic mean and 95% confidence interval
[b] identified by cytology of fine needle aspiration biopsies and not disproved after surgery
[c] assuming that frequency among those denying FNA and among those, for whom cytology results are not yet available, is the same as among those with cytology results

Jacob et al. Radiat Environ Biophys 2014

Fukushima Medical University (2014)
http://www.fmu.ac.jp/radiationhealth/results/media/16-2_Thyroid_Ultrasound_Examination.pdf

* Number of persons for whom screening results were known as of 30 June 2014

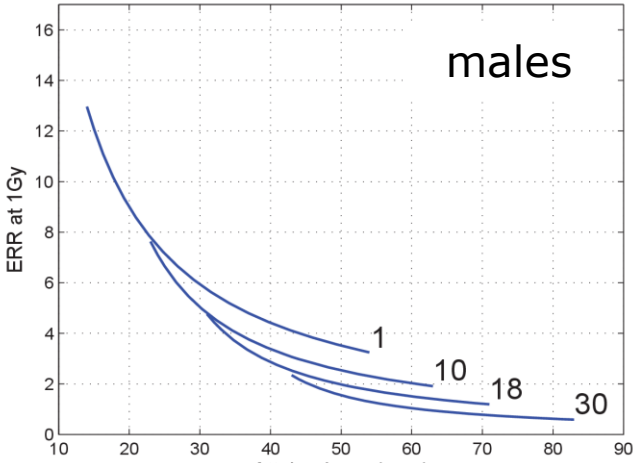
2. Incidence in Fukushima Prefecture

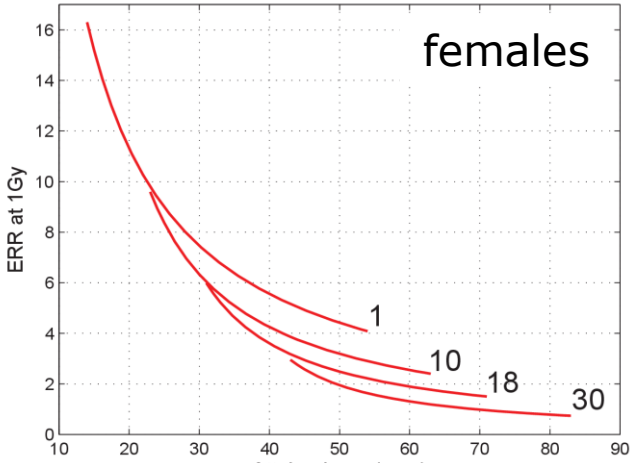
2.1 Risk model for LSS members not participating in AHS

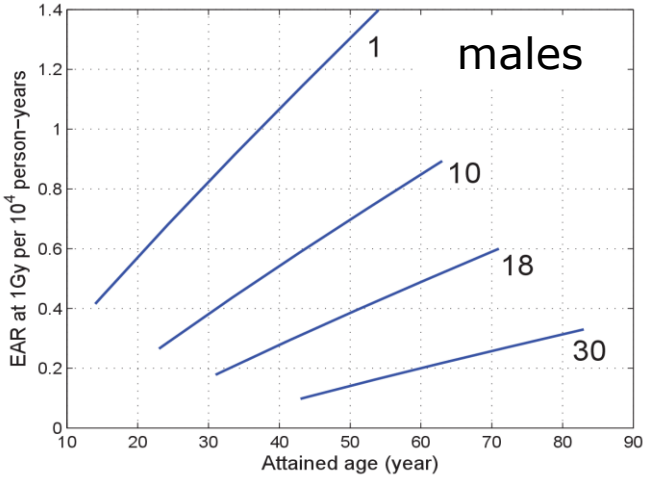
Relative risk decreases with increasing age at exposure and age attained

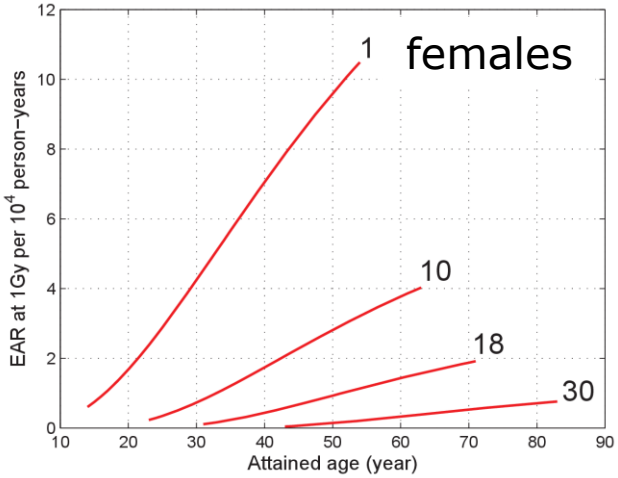
Excess rate decreases with increasing age at exposure and increases with increasing time since exposure

Jacob et al.
Radiat Environ Biophys 2014









2. Incidence in Fukushima Prefecture

2.2 Transfer of relative risk from LSS to Fukushima Prefecture

$$EAR_{FP}(s,e,a) = f_{scr}\, f_L(a\text{-}e)\, f_{DDREF}\, ERR_{LSS}(s,e,a)\, \lambda_{Japan}(s,a)$$

f_{DDREF} Uncertainty due to transfer to low dose and low dose rate
Jacob et al. Occup Environ Med 2009

$f_L(a\text{-}e)$ Minimal latency period of 3 years
Heidenreich et al. Radiat Res 1999

f_{scr} Screening factor in Fukushima Prefecture
See next slide

2. Incidence in Fukushima Prefecture

2.3 Screening factor in Fukushima Prefecture, f_{scr}

Screening factor in UkrAm cohort

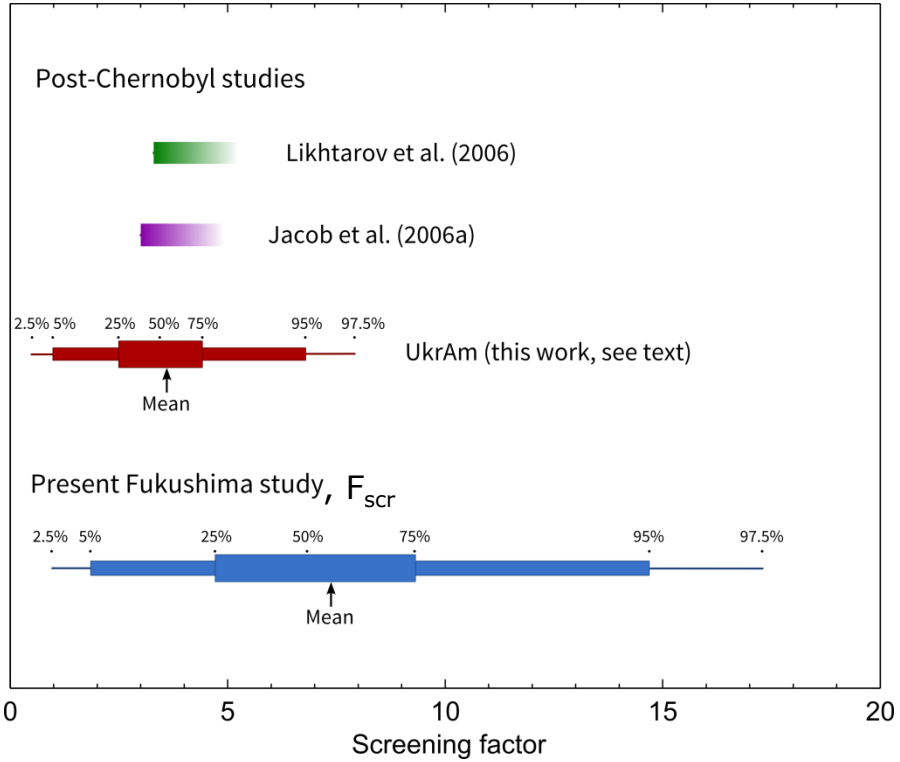
$f_{UkrAm} = (EAR/ERR)/\lambda_{Ukraine}$

Brenner et al. Environ Health Persp 2011

Screening factor Fukushima Prefecture

$f_{UkrAm} * f_{sp} = 7.4$ (95% CI: 0.95; 17.3)

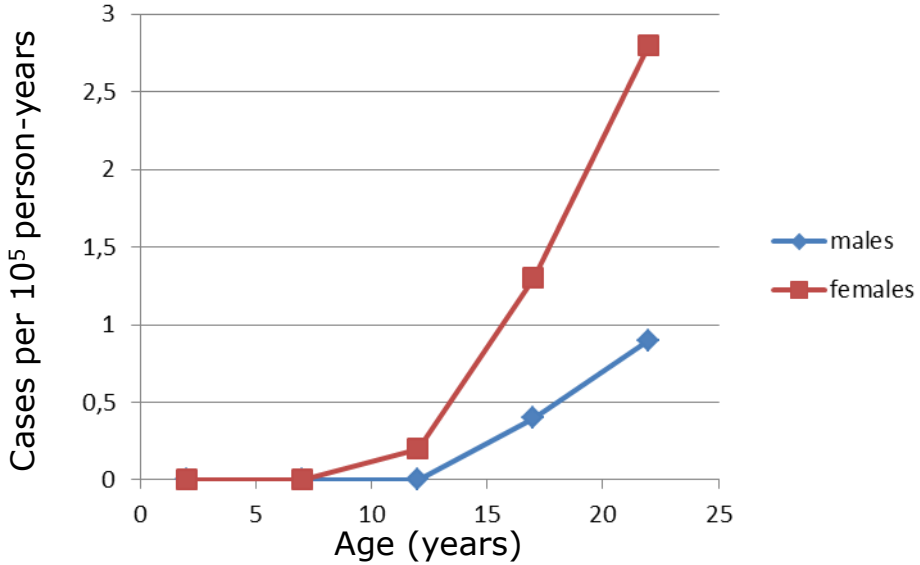
Jacob et al. Radiat Environ Biophys 2014



2. Incidence in Fukushima Prefecture

2.4 Transfer of relative risk predicts zero risk for male children

$$EAR_{FP}(s,e,a) = f_{scr}\, F_L(a\text{-}e)\, F_{DDREF}\, ERR_{LSS}(s,e,a)\, \lambda_{Japan}(s,a)$$



National Cancer Center
http://ganjoho.jp/pro/statistcs/en/table download.html

=> mixed transfer more plausible

2. Incidence in Fukushima Prefecture

2.5 Predicted incidence of females after exposure during infancy

Incidence rates integrated over two periods of time after the accident

Baseline and attributable to ***assumed*** thyroid dose of 20 mGy

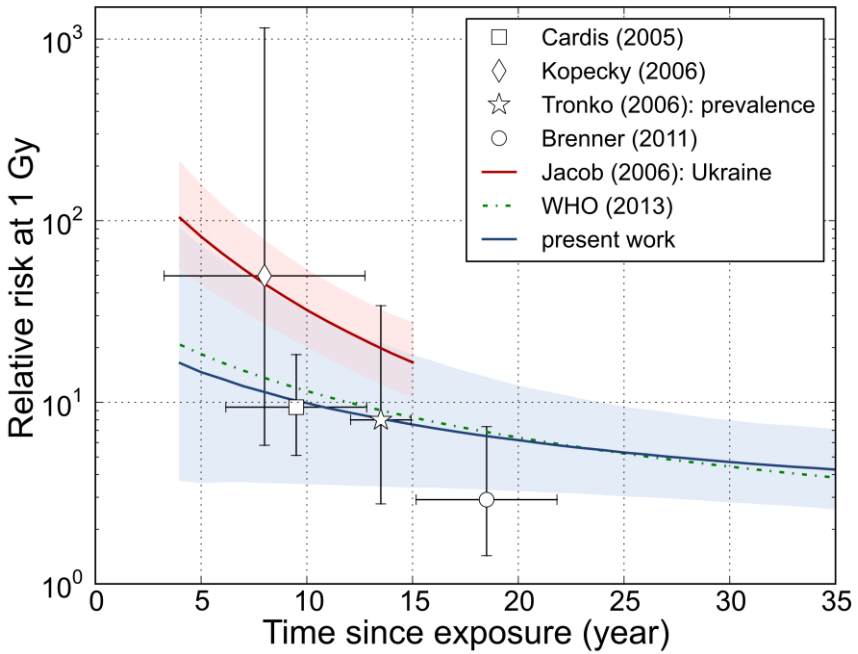
Thyroid cancer	Incidence (%)	
	10 years	50 years
Baseline	0.003 (2 10^{-4}; 0.009)	2.3 (0.3; 5.5)
Excess	0.003 (6 10^{-5}; 0.01)	0.3 (0.02; 0.9)

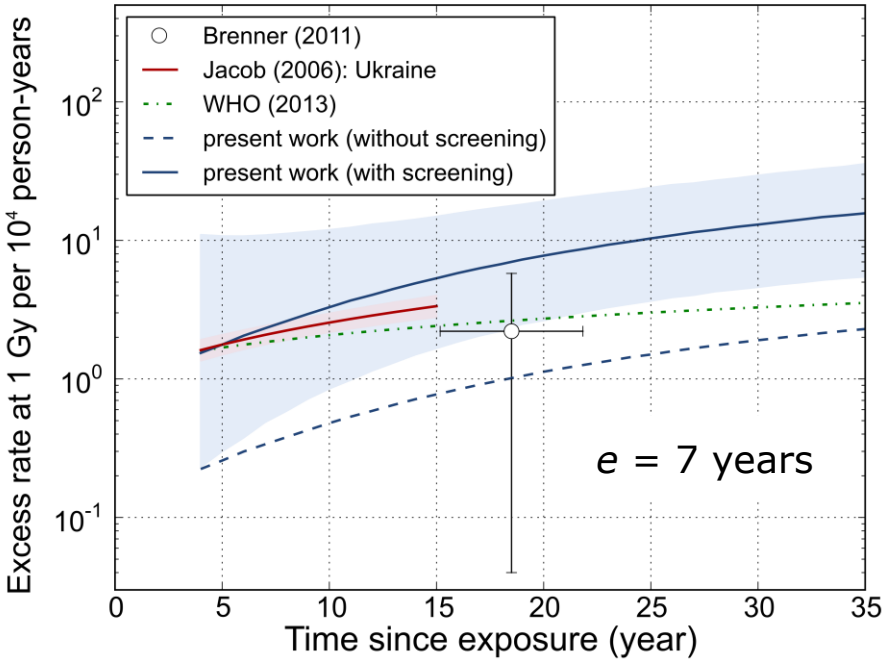
Main sources of uncertainty: f_{scr}, ERR_{LSS}, f_{DDREF}

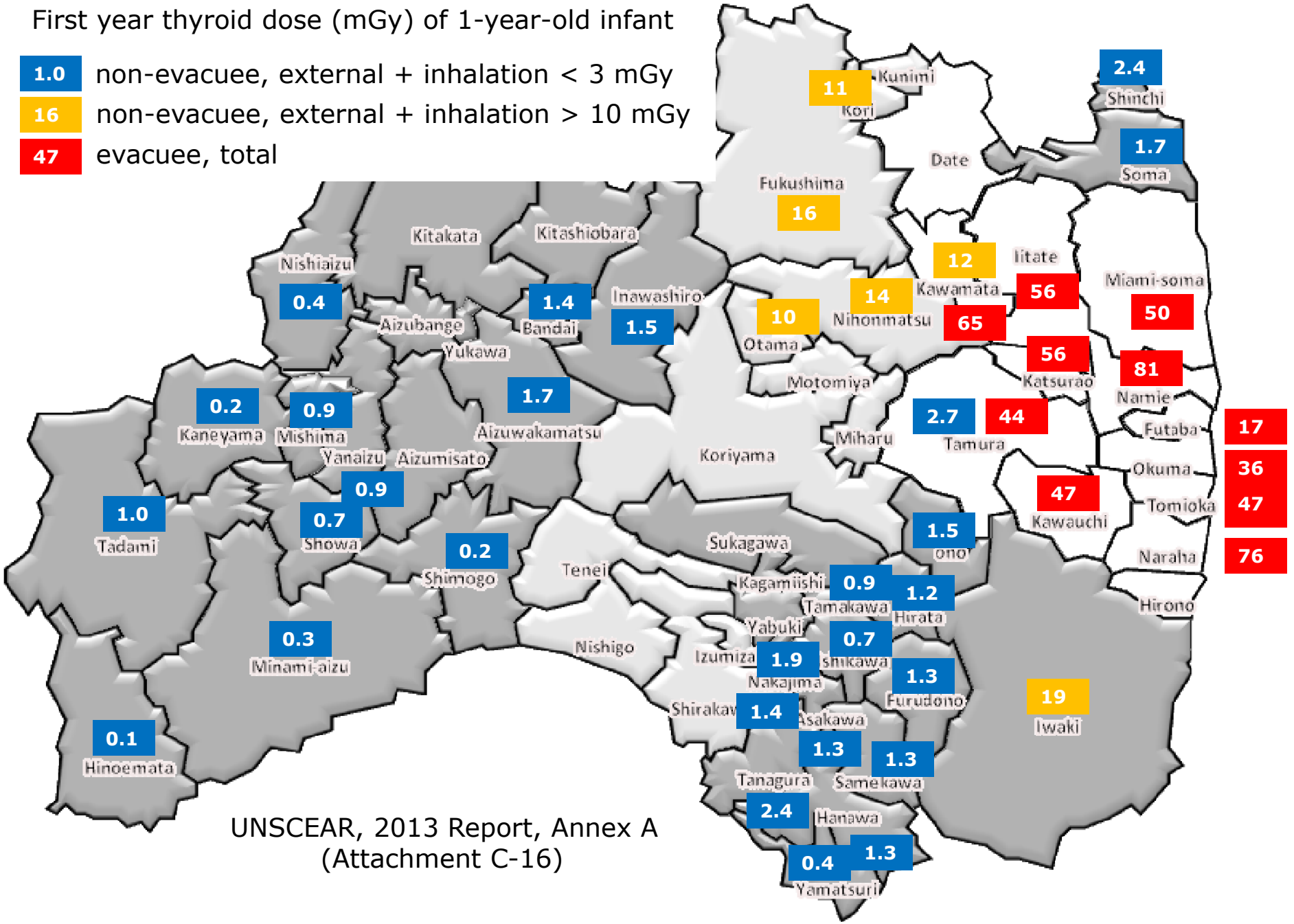
Jacob et al. Radiat Environ Biophys 2014

2. Incidence in Fukushima Prefecture

2.6 Comparison with studies post-Chernobyl and WHO Fukushima






First year thyroid dose (mGy) of 1-year-old infant
1.0 non-evacuee, external + inhalation < 3 mGy
16 non-evacuee, external + inhalation > 10 mGy
47 evacuee, total
11
Kunimi
Kori
2.4
Shinchi
1.7
Soma
Date
Fukushima
16
Kitakata
Kitashiobara
Nishiaizu
0.4
1.4
Bandai
Inawashiro
1.5
Aizubange
Yukawa
12
Iitate
Kawamata
14
56
Miami-soma
50
10
Otama
Nihonmatsu
65
56
Katsurao
81
Namie
Motomiya
0.2
Kaneyama
0.9
Mishima
1.7
Aizuwakamatsu
Yanaizu
Aizumisato
Koriyama
2.7
Tamura
44
Miharu
17
Futaba
36
Okuma
47
Kawauchi
47
Tomioka
76
Naraha
0.9
1.0
Tadami
0.7
Showa
0.2
Shimogo
Sukagawa
1.5
ono
Tenei
Kagamiishi
0.9
1.2
Tamakawa
Hirata
Hirono
Yabuki
0.7
Nishigo
Izumiza
1.9
shikawa
1.3
Nakajima
Furudono
0.3
Minami-aizu
Shirakaw
1.4
Asakawa
19
Iwaki
0.1
Hinoemata
1.3
1.3
Tanagura
Samekawa
2.4
Hanawa
0.4
1.3
Yamatsuri
UNSCEAR, 2013 Report, Annex A
(Attachment C-16)

3. Will radiation effect become detectable?

3.1 Assumptions and software

Consider non-evacuated population

Thyroid dose	Population	Screened	Girls < 3 yr
$D_{1yr,ext+inh}$ > 10 mGy	740,000	111,000	11,000
$D_{1yr,ext+inh}$ < 3 mGy	440,000	66,000	6,600
Δd_{total}	-	10 mGy	20 mGy

Calculations for best estimates of risk
and 2.5 times higher risks*
performed with G*Power

* Higher risk per unit dose or higher dose, if, e.g., evacuees are considered

3. Will radiation effect become detectable?

3.2 Statistical power in different scenarios

Population	D_{high}-D_{low} (mGy)	Radiation risk	20 years	50 years
Screened	10	Best estimate	11%	22%
		2.5 * best estimate	28%	70%
Girls < 3 yr	20	Best estimate	11%	31%
		2.5 * best estimate	27%	87%
Girls < 3 yr Unexposed doubled	20	Best estimate	14%	40%

Summary

Results have large uncertainties

Observed prevalence of 103 (125) cases consistent with UkrAm study

Screening factor for incidence rate: 7 (95% CI: 1; 17)

Thyroid cancer incidence over 50 years about 2%

Females exposed as infants with 20 mGy have expected excess of about 0.3%

Excess might become detectable after 50 years of observation,
but is not expected to be detectable after 20 years

Summary

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Thank you for your attention!