International IPPNW Congress
5 years living with Fukushima
30 years living with Chernobyl
Berlin, February 27th , 2016
9.00 am – 10.30 am

Thyroid Cancer under Age 19 in Fukushima

-As of 57 months after the accident-

(Analysis of data up to December 31, 2015, released on February 15, 2016 by Fukushima Prefecture)

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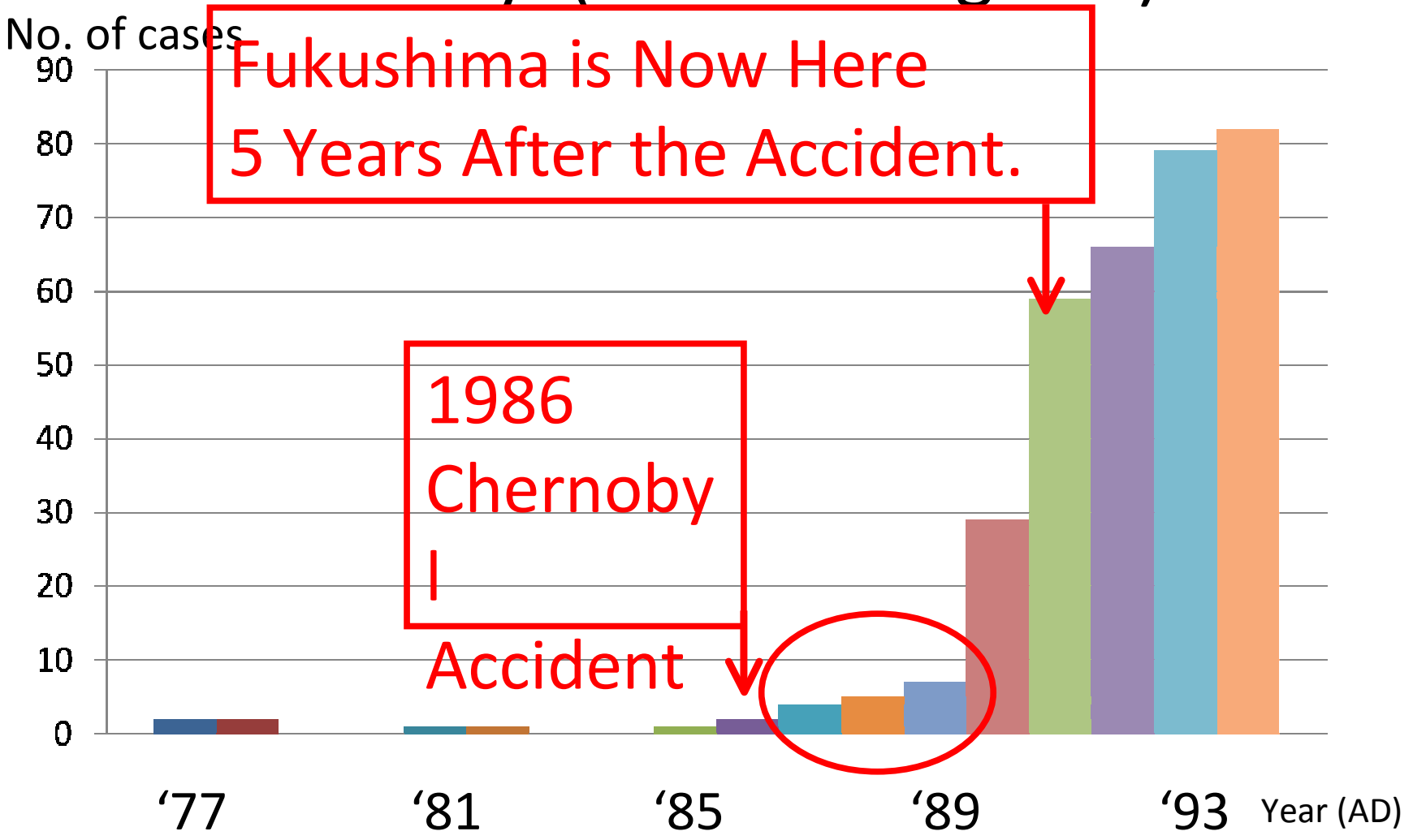
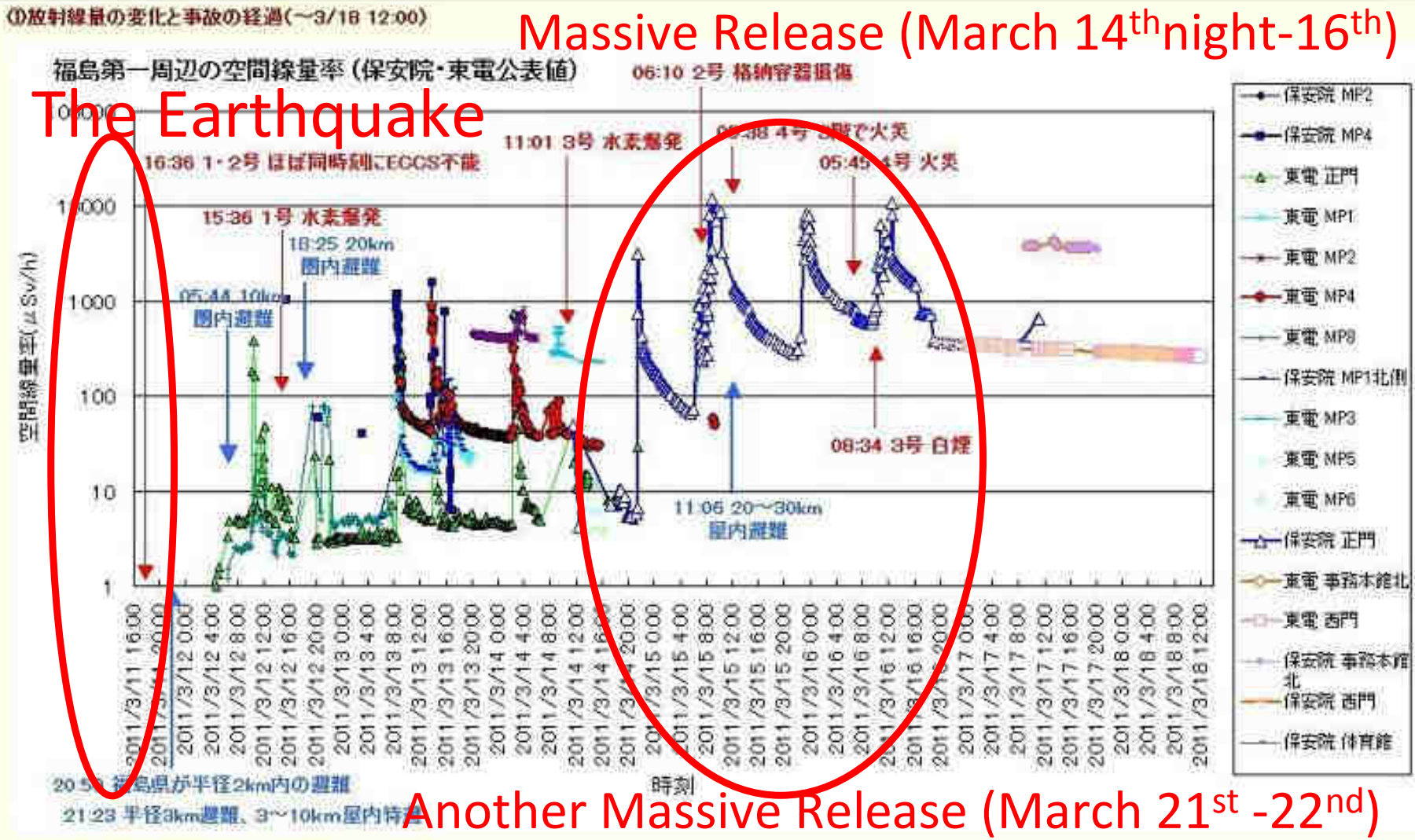
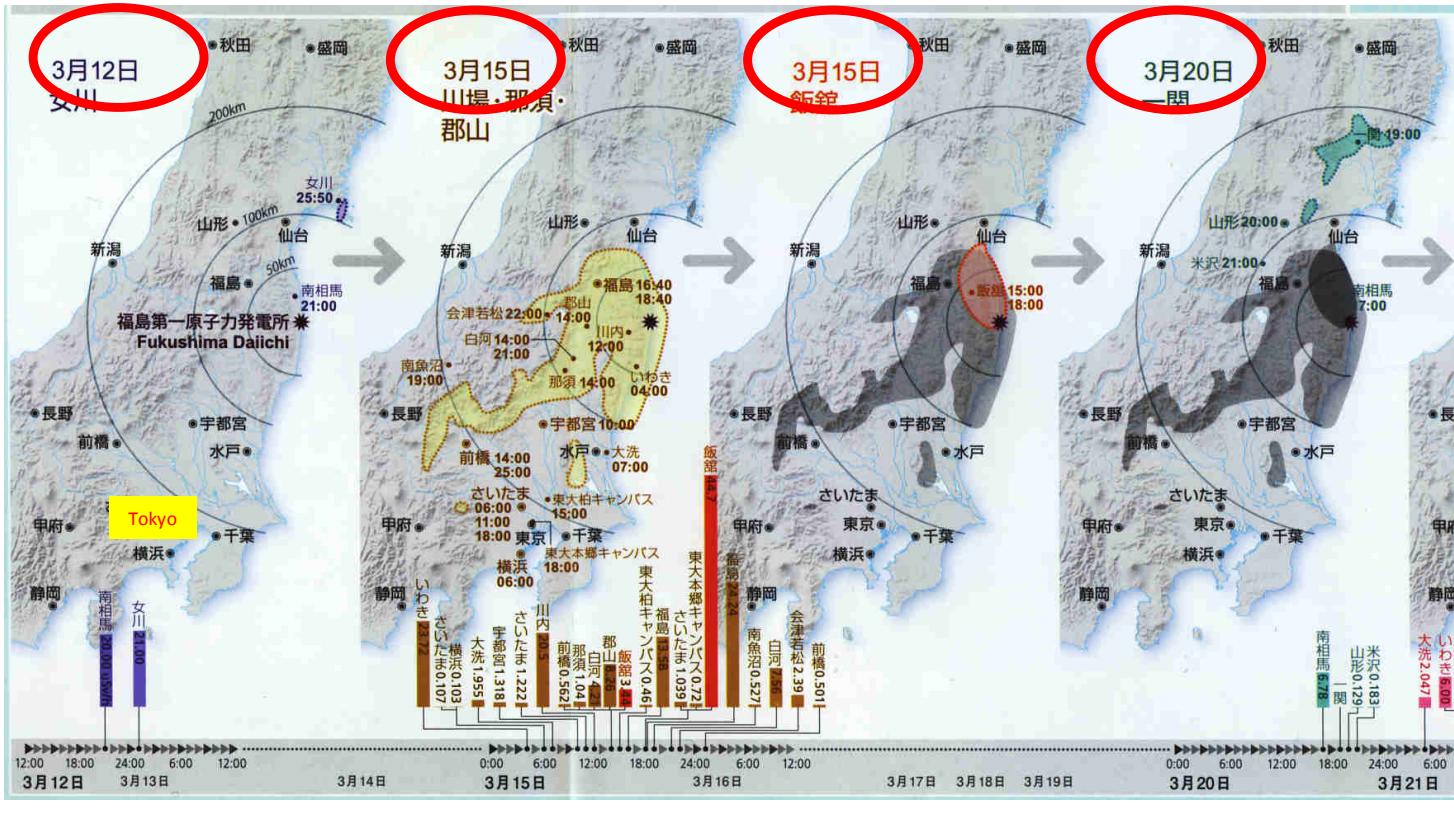
Epidemic Curve of Thyroid Cancer in Chernobyl (Belarus ≤ age 14)



Air dose rate after March 11, 2011 in the Fukushima Daiichi Plant

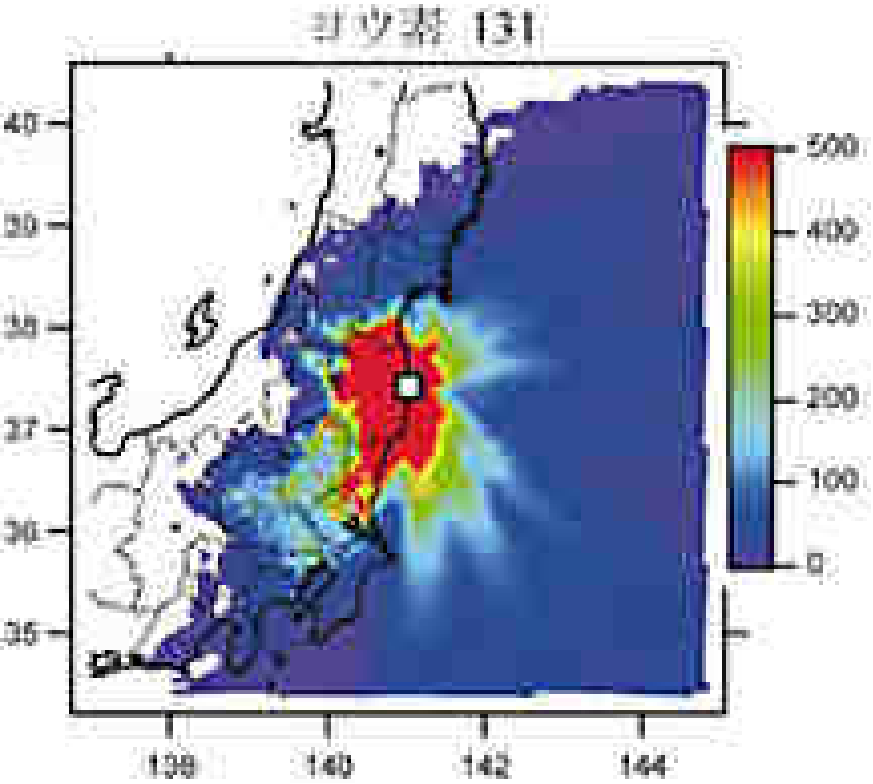


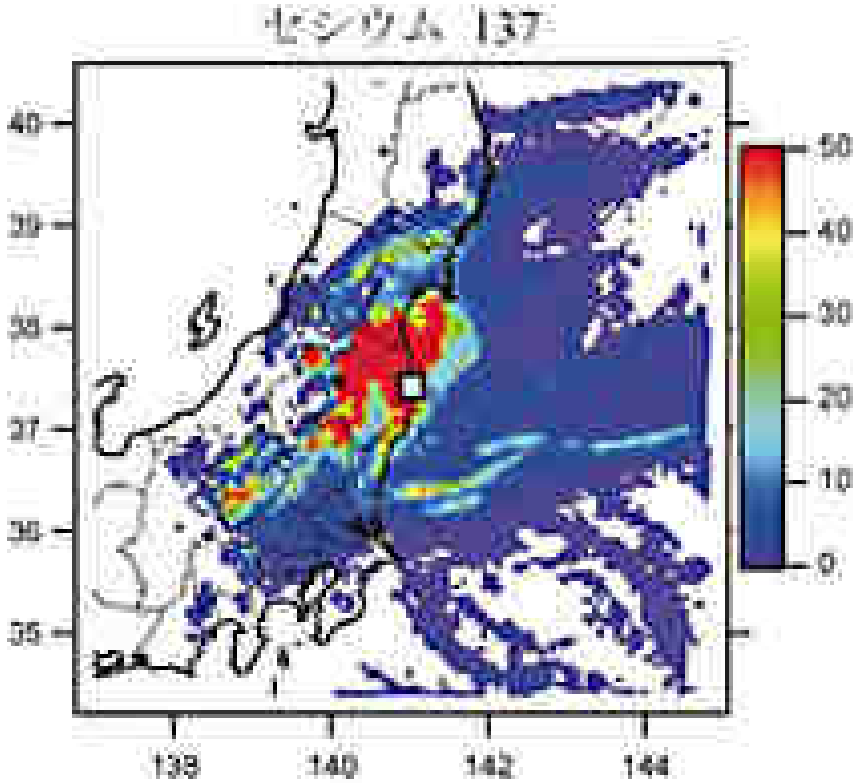
Plume after March 11, 2011



By Prof. Y. Hayakawa
Gunma University

Different distributions of ^{131}I and ^{137}Cs





Cumulative deposition dose (kBq/m^2) of ^{131}I and ^{137}Cs from March 11 to March 29, 2011, which estimated by Ohara T and Morino Y (National Institute for Environmental Studies) :「福島第一原子力発電所から放出された放射性物質の大気シミュレーション－東日本大震災復旧･復興への取組－」(October 31, 2011)

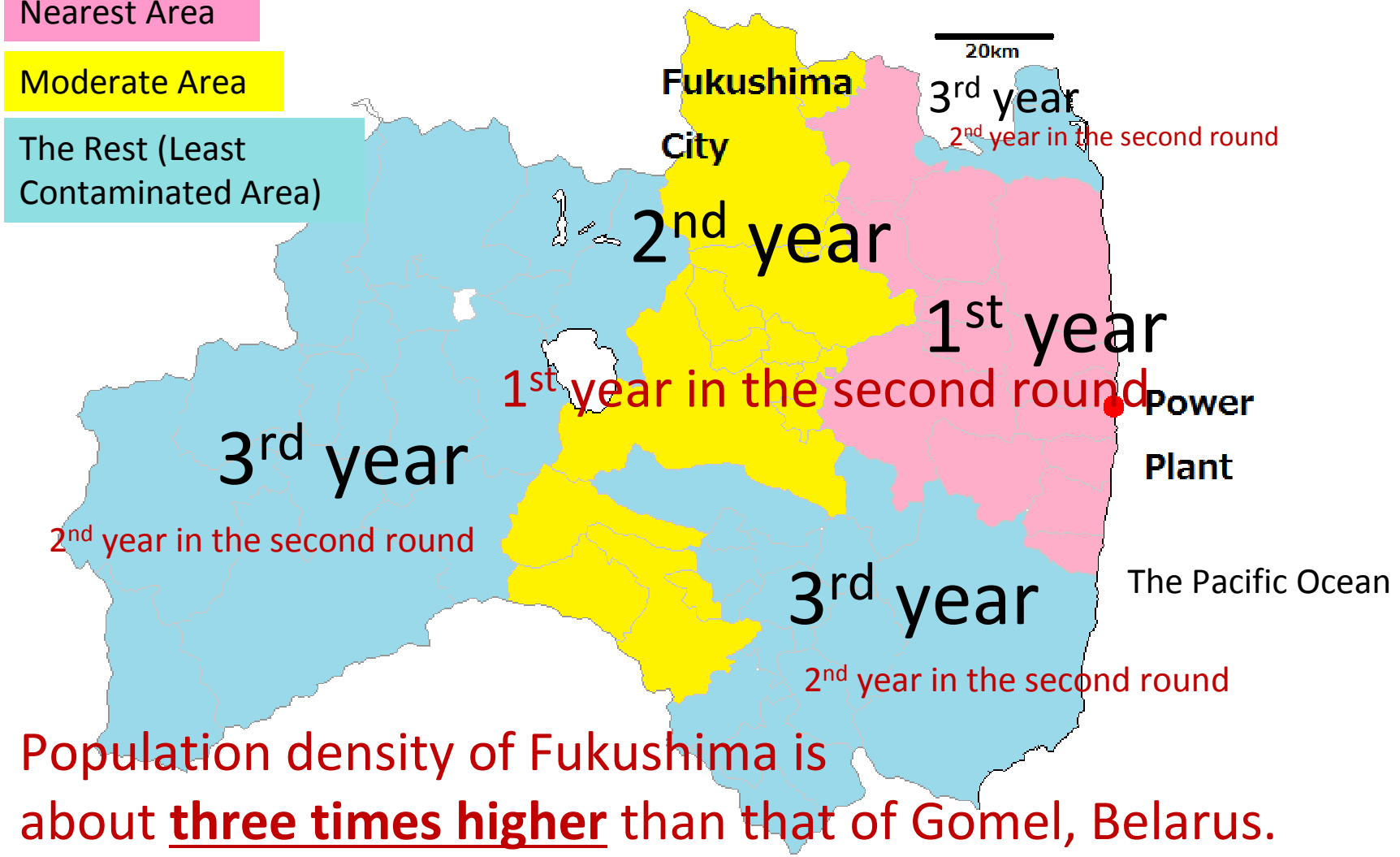
Thyroid Cancer Screening ≤ age 18

- Primary examination: All residents ≤ age 18 in 2011 (born between April 2, 1992 and April 1, 2011)
  - Screened by thyroid ultrasound.
  - Secondary examination when nodules with diameter ≥ 5.1 mm or cysts with diameter ≥ 20.1mm are detected.
- Secondary examination: for positive primary examination
  - More detailed ultrasound, then cytology by fine needle aspiration.
- When cancer cells are detected by cytology
  - Followed with observation, then operated.
  - Cancer confirmed by histological examination of the excised tissues.

Thyroid cancer screening schedule

- The First Round (The Japanese fiscal year is from April 1st to March 31st of the following year).
  - Year 1 (FY 2011, ending on March 31, 2012)
    - The nearest areas to the Fukushima Daiichi NPP
  - Year 2 (FY 2012, ending on March 31, 2013)
    - The moderately near areas including Fukushima City.
  - Year 3 (FY 2013, beginning on April 1, 2013)
    - Remaining areas ("Least Contaminated Area" by WHO 2012).
- The Second Round (from April 1,2014 to March 31, 2016)
  - Year 4 (FY 2014, ending on March 31, 2015)
    - The nearest areas and the moderately near areas
  - Year 5 (FY 2015, ending on March 31, 2016)
    - Remaining areas (corresponding to Year 3 in the first round)

The order of screening according to the level of air dose rate



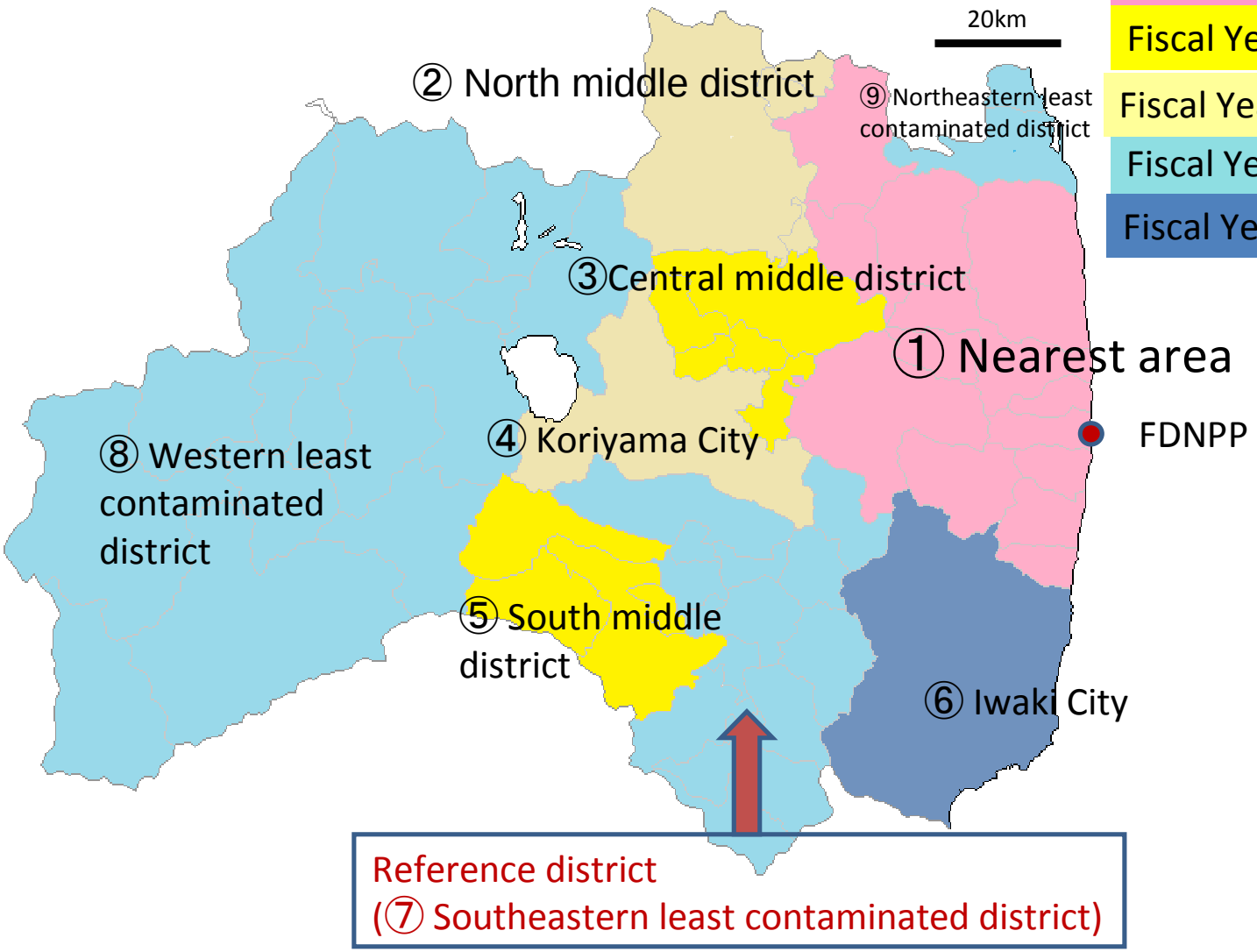
Population density of Fukushima is about **<u>three times higher</u>** than that of Gomel, Belarus.

Methods: Comparison Group

- Fukushima prefectural government releases the screening results about every three months.
  - The present data were released on February 15, 2016 with the results as of December 31, 2015.
- Fukushima Prefecture was divided into 9 districts according to the screening schedule:

  ① Nearest area, ② North middle district, ③ Central middle district, ④ Koriyama City, ⑤ South middle district, ⑥ Iwaki City, ⑦ Southeastern least contaminated district, ⑧ Western least contaminated district, ⑨ Northeastern least contaminated district

Divided into 9 districts



Methods: External Comparison

- Age- and sex-specific incidence estimates of thyroid cancer from the Center for Cancer Control and Information Services, National Cancer Center, Japan (1975-2008).
  - The Japanese mean annual incidence among those aged 0-19 years from 1975 to 2008 (i.e. 3 per 1,000,000) was used in the 1st round data. For the 2nd round data, we used 5 per 1,000,000 taking aging of the subjects into consideration.
- Prevalence $\fallingdotseq$ Incidence $\times$ Average Duration
  - In this case, "duration" is the duration from the date when thyroid cancer became detectable by screening and cytology to the date when it could have been diagnosed in usual clinical settings without screening.
- Poisson distribution was employed to estimate 95% confidence intervals.

Methods: Internal Comparison

- The southeastern least contaminated district was employed as “reference district.”
- We estimated Prevalence Odds Ratio and its 95% Confidence Interval on the remaining 8 districts based on prevalence of the southeastern least contaminated district.
- We employed MLE Odds Ratio (Mid-P) of “StatCalc” in EpiInfo 7 (released by CDC).

Table 1

(1st round data: finalized as of June 30, 2015)

Areas	Population age ≤ 18	Participants in primary examination	Positives in primary examination	Participants in secondary examination	Thyroid Cancer Cases by FNAC (No. operated)
Fiscal Year 2011	47,768	41,810 (87.5%)	221 (0.53%)	199 (90.0%)	15*(15*)
Fiscal Year 2012	161,129	139,338 (86.5%)	988 (0.71%)	920 (93.1%)	56 (52)
FY 2013 (Least Cont.)	158,788	119,328 (75.1%)	1,085 (0.91%)	989 (91.2%)	42 (32)
Total	367,685	300,476 (81.7%)	2,294 (0.76%)	2,108 (91.9%)	113 (99) +3**(+2)**

*Including one benign case

**Additional thyroid cancer cases released later

Table 2 (4 districts in Middle Area)

Districts	Population age ≤ 18	Examinees in primary examination	Positives in primary examination	Examinees in secondary examination	Thyroid Cancer Cases by FNAC（No. operated）
North middle	57,211	50,618 (88.5%)	312 (0.62%)	298 (95.5%)	12 (?)
Central middle	21,052	18,194 (86.4%)	115 (0.63%)	111 (96.5%)	11 (?)
Koriyama City	64,380	54,063 (84.0%)	458 (0.85%)	415 (90.6%)	25 (?)
South middle	18,486	16,463 (89.1%)	103 (0.63%)	96 (93.2%)	8 (?)
Total	161,129	139,338 (86.5%)	988 (0.71%)	920 (93.1%)	56 (52)

Table 3:
4 Districts in the Least Contaminated Area

Districts	Population age ≤ 18	Participants in primary examination	Positives in primary examination	Participants in secondary examination	Thyroid Cancer Cases by FNAC（No. operated）
Northeastern	8,246	6,359 (77.1%)	54 (0.85%)	49 (90.7%)	0 (0)
Iwaki City	62,293	49,429 (79.3%)	455 (0.92%)	422 (92.7%)	24 (?)
Southeastern (Reference)	38,322	29,820 (77.8%)	242 (0.81%)	221 (91.3%)	7 (?)
Western	49,927	33,720 (67.5%)	334 (0.99%)	297 (88.9%)	11 (?)
Total	158,788	119,328 (75.1%)	1,085 (0.91%)	989 (91.2%)	42 (32)

Table 4: External Comparison (1st Round)

	3/1,000,000*		Prevalence	
Areas and Districts	IRR**	(95% C.I.) **	per 10^6	Reciprocal
①Nearest area (FY 2011)	29.90	(16.73-49.31)	359	2,787.3
②North middle district	19.76	(10.21-34.51)	237	4,218.2
③Central middle district	50.38	(25.15-90.15)	605	1,654.0
④Koriyama City	38.54	(24.94-56.89)	462	2,162.5
⑤South middle district	40.49	(17.48-79.79)	486	2,057.9
⑥Iwaki City	40.46	(25.92 -60.20)	486	2,059.5
⑦SE least contaminated district	19.56	(7.86-40.31)	235	4,260.0
⑧Western least contaminated district	27.18	(13.57-48.64)	326	3,024.5
⑨NE least contaminated district	0	(0.00-48.34)	0	-

*Comparison with Japanese mean **Incident Rate Ratio（95% Confidence Interval）

Table 4-2: Internal Comparison and POR (1st round)

	Cancer cases	No. in primary exam.	POR*	(95% C.I.) *
①Nearest area (Fiscal Year 2011)	15**	41,810	1.53	(0.63-4.01)
②North middle district	12	50,618	1.01	(0.40-2.73)
③Central middle district	11	18,194	2.58	(0.99-7.06)
④Koriyama City	25	54,063	1.97	(0.88-4.91)
⑤South middle district	8	16,463	2.07	(0.73-6.00)
⑥Iwaki City	24	49,429	2.07	(0.92-5.17)
⑦SE least contaminated (Reference)	7	29,820	1	
⑧Western least contaminated district	11	33,720	1.39	(0.54-3.81)
⑨NE least contaminated district	0	6,359	0	(0-2.50)

* Prevalence Odds Ratio（95% Confidence Interval） **Including one benign case

Back-Door Path between Areas/Districts and Prevalence of Cancer

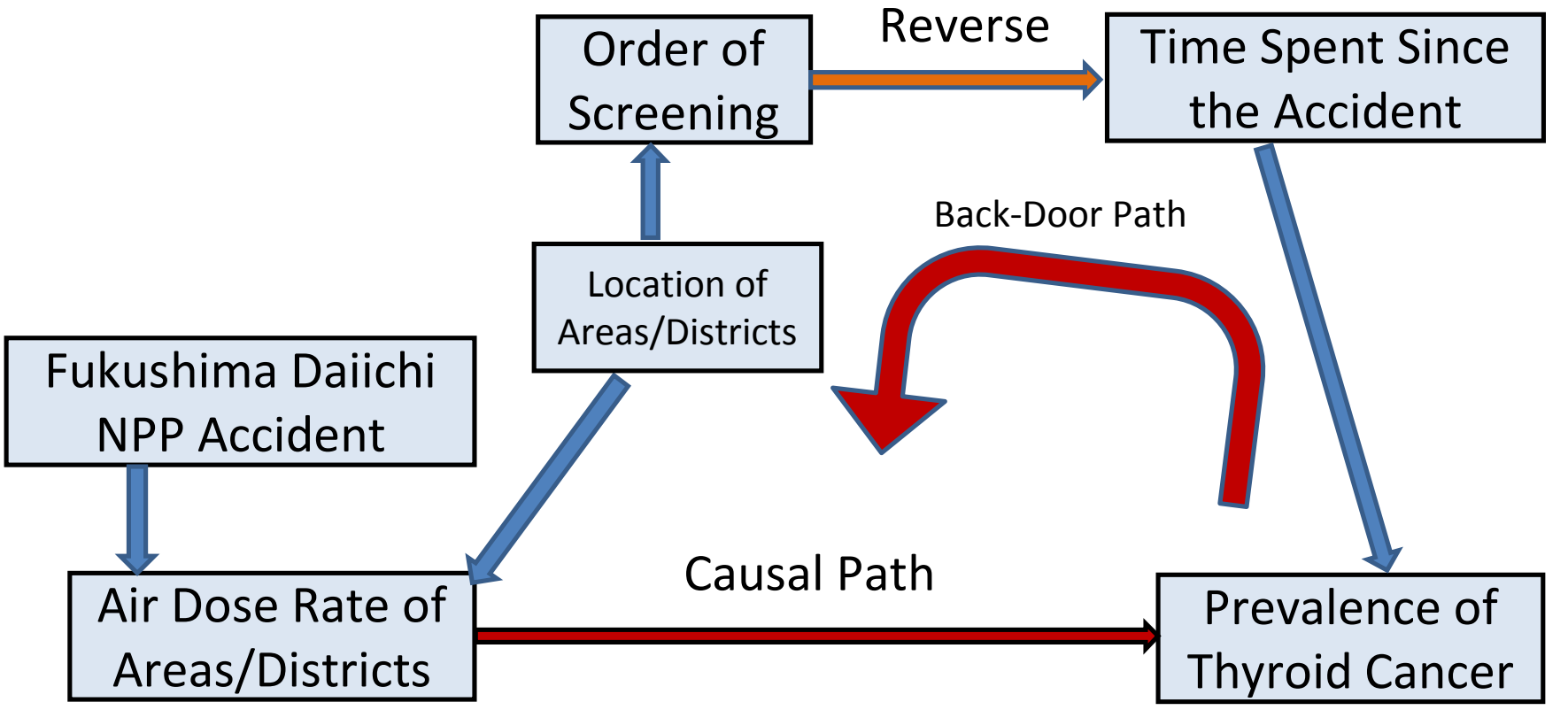


Table 5 Latency Adjusted External (IRR) and Internal Comparison (POR)

	Latency 1-3 years		Latency 2-4 years
	IRR (95% CI)	POR(95% CI)	IRR (95% CI)
①2011 FY Combined (Nearest area)	120 (67 - 197)	4.6 (2.1 – 11)	60 (33 - 99)
2012 FY Combined (Middle area)	67 (51 - 87)	2.6 (1.2 – 6.0)	45 (34 - 58)
②North middle district	40 (20 - 69)	1.5 (0.65 – 3.9)	26 (14 - 46)
③Central middle district	101 (50 - 180)	3.9 (1.6 – 10)	67 (34 -120)
④Koriyama City district	77 (50 - 112)	3.0 (1.4 – 7.2)	51 (33 - 76)
⑤South middle district	81 (35 - 160)	3.1 (1.2 – 8.4)	54 (23 -106)
2013 FY Combined (Least contaminated)	37 (26 - 50)		28 (20 - 38)
⑥Iwaki City district	50 (31 - 76)	2.1 (0.92 – 5.2)	38 (24 - 57)
⑦Southeastern least contaminated	26 (11 - 54)	1 (reference)	20 (8 – 41)
⑧Western least contaminated district	34 (16 - 62)	1.4 (0.54 – 3.8)	25 (12 - 47)
⑨Northeastern least contaminated	0 (0 - 66)	0 (0 – 2.5)	0 (0 - 50)

Table 6: Internal Comparison and POR

	Cancer cases	No. in primary exam.	POR*	(95% C.I.) *
①Nearest area (Fiscal Year 2011)	15**	41,810	1.53	(0.63-4.01)
②North middle district	12	50,618	1.01	(0.40-2.73)
③Central middle district	11	18,194	2.58	(0.99-7.06)
④Koriyama City	25	54,063	1.97	(0.88-4.91)
⑤South middle district	8	16,463	2.07	(0.73-6.00)
⑥Iwaki City	24	49,429	2.07	(0.92-5.17)
⑦SE least contaminated (Reference)	7	29,820	1	
⑧Western least contaminated district	11	33,720	1.39	(0.54-3.81)
⑨NE least contaminated district	0	6,359	0	(0-2.50)

* Prevalence Odds Ratio（95% Confidence Interval） **Including one benign case

The order of screening in the 2nd round

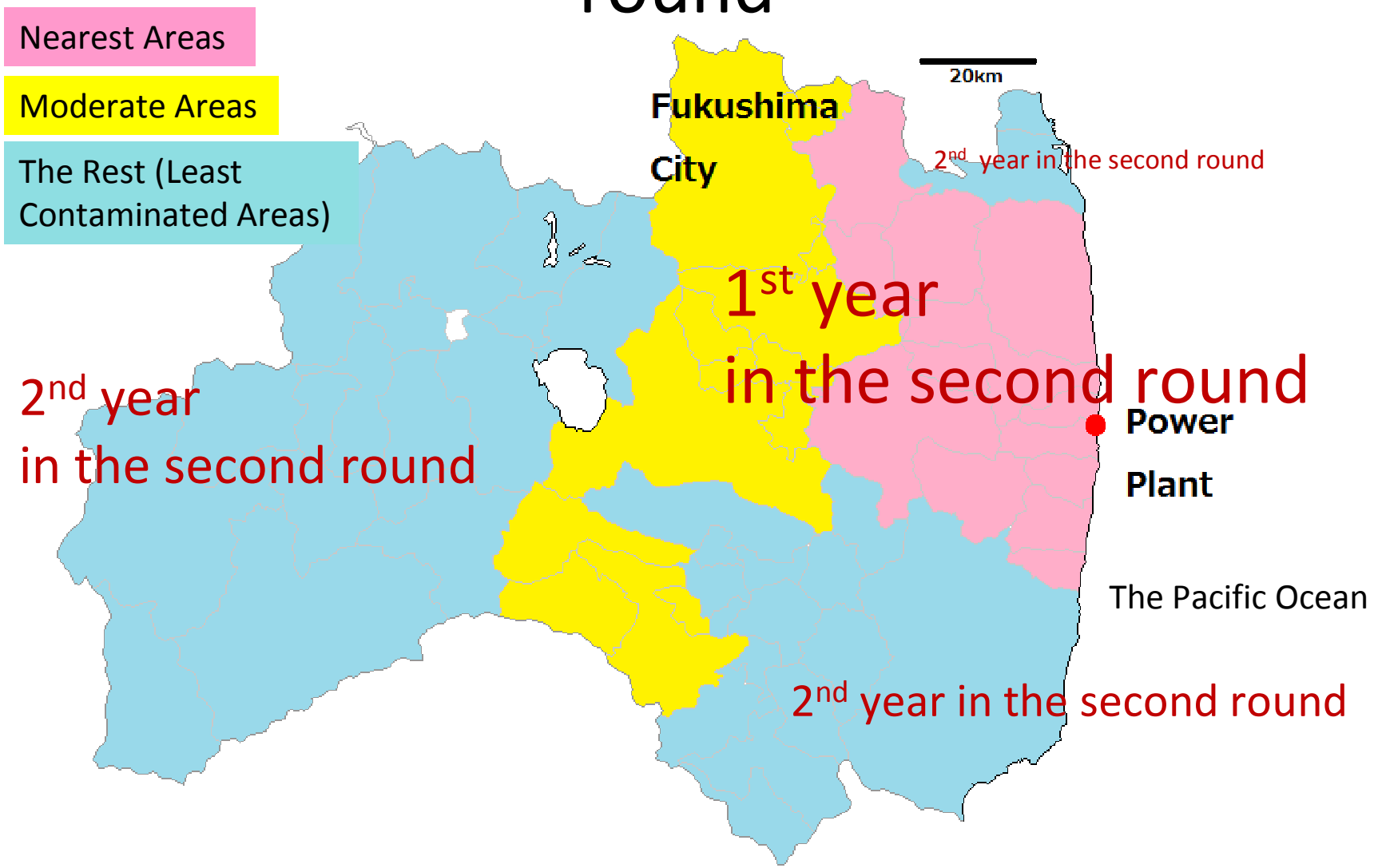


Table 7: Current results of the 2nd round screening（as of December 31, 2015）

Areas	Population age* ≤ 18 (including fetuses)	Participants in primary exam.	Positives in primary exam.	Participants in secondary exam.	No. of FNAC	Thyroid Cancer Cases by FNAC（No. operated）
2014	216,874	155,536 (71.7%)	1,260 (0.8%)	990 (78.6%)	139	45 (?)
2015	164,387	81,059 (49.3%)	559 (0.7%)	182 (32.6%)	18	6 (?)
Total	381,261	236,595 (62.1%)	1,819 (0.8%)	1,172 (64.4%)	157	51 (16)

* Age at the time of the March 2011 accident

Table 8: Results of Fiscal Year 2014 in 2nd Round

（Data as of December 31, 2015）

Districts/Area	Population age ≤ 18	Examinees in primary examination	Positives in primary examination	Examinees in secondary examination	Thyroid Cancer Cases by FNAC（No. operated）
Nearest area	49,457	33,721 (66.6%)	332 (0.98%)	279 (84.0%)	16 (?)
North middle	59,496	45,190 (75.6%)	361 (0.79%)	296 (82.0%)	9 (?)
Central middle	21,809	16,136 (73.9%)	116 (0.72%)	91 (78.4%)	4 (?)
Koriyama City	66,759	45,965 (68.9%)	347 (0.75%)	254 (73.2%)	15 (?)
South middle	19,353	14,524 (75.0%)	104 (0.72%)	70 (67.3%)	1 (?)
Total	216,874	155,536 (71.7%)	1,260 (0.81%)	990 (78.6%)	45 (?)

Table 9: Results of FY 2015 in 2nd Round

4 Districts in the Least Contaminated Area

（Data as of December 31, 2015）

Districts	Population age ≤ 18	Participants in primary examination	Positives in primary examination	Participants in secondary examination	Thyroid Cancer Cases by FNAC（No. operated）
Northeastern	8,563	5,463 (63.8%)	41 (0.75%)	28 (68.3%)	1 (?)
Iwaki City	64,294	32,992 (51.3%)	277 (0.84%)	41 (14.8%)	2 (?)
Southeastern (Reference)	39,772	26,665 (67.0%)	183 (0.69%)	98 (53.6%)	2 (?)
Western	51,758	15,939 (30.8%)	58 (0.36%)	15 (25.9%)	1 (?)
Total	164,387	46,865 (28.5%)	559 (1.19%)	182 (32.6%)	6 (?)

**Incidence Rate Ratio（95%Confidence Interval）

Table 10: External Comparison in the 2nd Round（Latency 2 years）

	5/1,000,000*		Prevalence	
Areas and Districts	IRR**	(95% C.I.) **	per 10^6	Reciprocal
①Nearest area（Latency 2.5 years）	37.96	(21.70-61.64)	474	2,107.6
②North middle district	19.92	(9.11-37.81)	199	5,021.1
③Central middle district	24.79	(6.75-64.46)	248	4,034.0
④Koriyama City	32.63	(18.26-53.82)	326	3,064.3
⑤South middle district	6.89	(0.17-38.36)	68.9	14,524
⑥Iwaki City	6.06	(0.73-21.90)	60.6	16,496
⑦SE least contaminated district	7.50	(0.91-27.09)	75.0	13,332
⑧Western least contaminated district	6.27	(0.16-34.96)	62.7	15,939
⑨NE least contaminated district	18.30	(0.46-101.99)	183.1	5,463

Tentative Conclusion 1

- In Chernobyl, the outbreak of thyroid cancer actually began one year after the accident, rather than the fourth or fifth post-accident year when the marked increase was observed.
- As of 57 months after the accident, the first round screening conducted from October 2011 to March 2014 revealed a 20- to 50-fold excess incidence in thyroid cancer in ages 18 years or younger.
  - A higher rate of thyroid cancer with a dose-response tendency was seen with proximity to FDNPP, especially in the south area.

Tentative Conclusion 2

- Post-operative findings indicate that 92% of the operated cases had lymph node metastasis, distant metastasis and/or extrathyroidal extension.
- In the ongoing 2nd round screening, 20- to 38-fold excesses are already seen even though many results are still pending. Screening effect discussed in the 1st round has no relevance in the 2nd round. About 80% of thyroid cancer cases detected in the 2nd round had no lesions with pre-malignant potential detected in the 1st round: it appears that these cancers grew over 5.0 mm in diameter in only 2 years.
- We must prepare to take measures to deal with not only thyroid cancer but also other cancers and non-cancer diseases.
- Further investigation is needed especially in children in neighboring prefectures as well as in residents older than 18.

What is next ?

- Fukushima thyroid cancer screening data is updated by Fukushima Prefecture every three months.

- Acknowledgement: We are grateful to Colin L. Soskolne, PhD, Martin Tondel, MD, PhD, Erik R. Svendsen, PhD, Gaston Meskens, MSc, and Wael Al-Delaimy, MD, PhD, for their thoughtful suggestions and constructive discussions on cancer-related issues relating to the 2011 nuclear accident in Fukushima, Japan. The authors also thank Tetsuji Imanaka, MSc, Keiji Hayashi, MD, and Okujou Iwami MD, PhD, for providing important references. We are also grateful to Professor Toshiro Ogura (Health Service Center of Okayama University) for providing their data, and Dr. Yuri Hiranuma for her thoughtful suggestions.

- Vielen Dank!