Analysis of dose–response relationship between Thyroid cancer Detection rate and external effective dose in Fukushima prefecture

Hidehiko Yamamoto M.D.
Iryoumondai Kenkyuukai

Background and Purpose

- Thyroid cancer screening ultrasonography for all residents by the age of 18 living in Fukushima prefecture started in October 2011.
- Thyroid cancer of 186 cases were found in the first and second round screening examination by June 2017 .
- This prevalence is about 60 times by the age of 18 in Fukushima Prefecture (According to the National Cancer Research Center)
- As for these excess of thyroid cancers, there is a discussion between it is due to radiation exposure or result of intense screening and over diagnosis of a large population
- We attempted to examine whether numerous cases of thyroid cancers were caused by radioactive contamination

Method(1) Radiation dose assessment

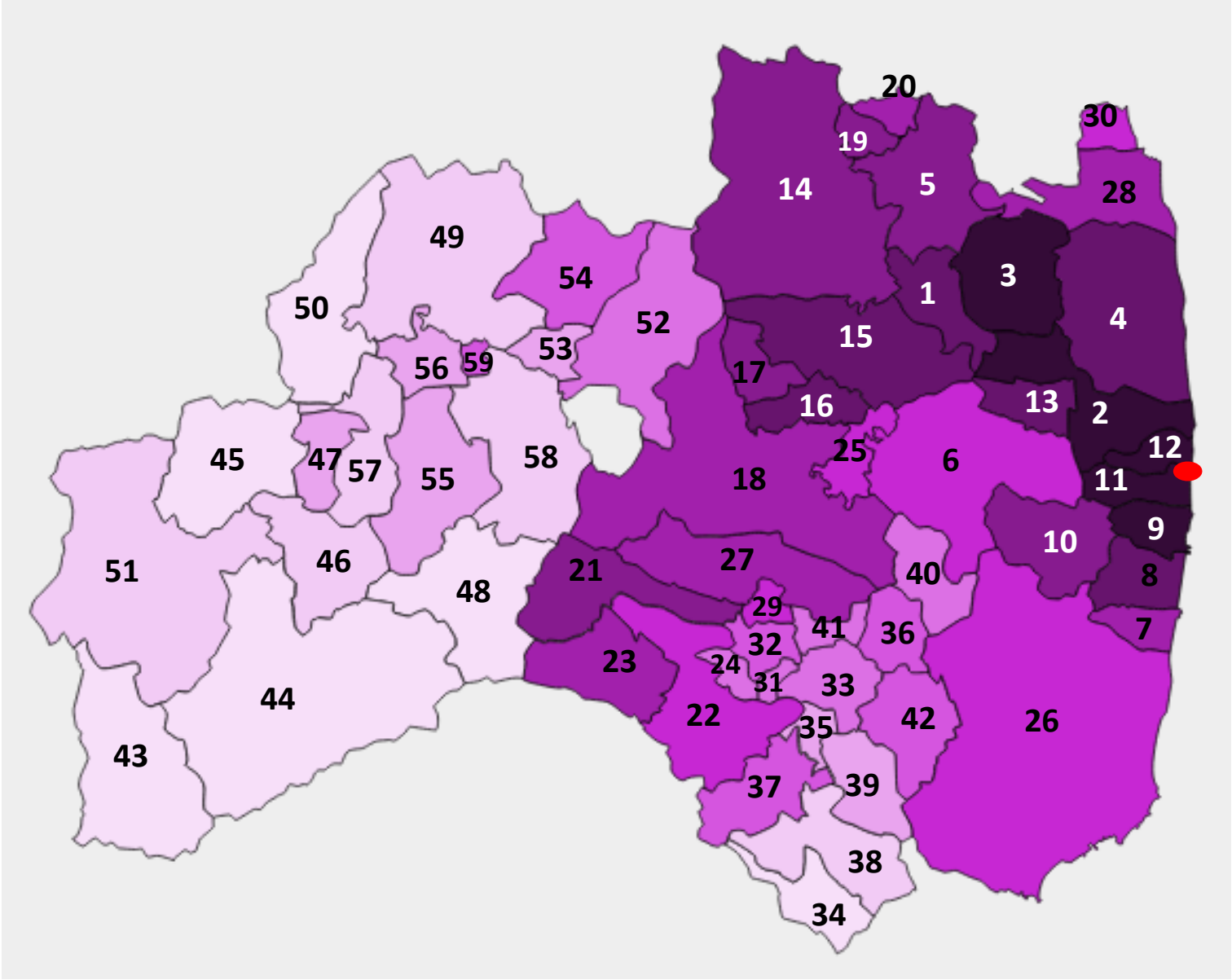
- Experiences of Chernobyl suggest the air dose and external effective dose may be considered a valid surrogate for the internal dose of the thyroid gland.
- We calculated the average air dose and external effective dose of each 59municipalities from the dataset of air and soil radiation dose published by MEXT in UNSCEAR 2013 report(Attachment C-7).

MEXT; Ministry of Education , Culture, Sports, Science and Technology in JAPAN

Method(2) detection rate and dose-response relationship

- We calculated the municipality-specific numbers of thyroid cancers found in the first and second round screening in the corresponding municipality-specific exposed person-year observed.
- We collected and summarized data from the 1st to 28th Fukushima Management Survey Committee Meetings .
- A possible association between the radiation exposure and the thyroid detection rate was analyzed with single regression method.

Classify 59 municipalities into 10 groups according to dose



Location

Location No.	Location	Location No.	Location	Location No.	Location	Location No.	Location
1	Kawamata	16	Motomiya	31	Nakajima	46	Showa
2	Namie	17	Otama	32	Yabuki	47	Mishima
3	Iitate	18	Koriyama	33	Ishikawa	48	Shimogo
4	Minamisoma	19	Koori	34	Yamatsuri	49	Kitakata
5	Date	20	Kunimi	35	Asakawa	50	Nishiaizu
6	Tamura	21	Ten-ei	36	Hirata	51	Tadami
7	Hirono	22	Shirakawa	37	Tanagura	52	Inawashiro
8	Naraha	23	Nishigo	38	Hanawa	53	Bandai
9	Tomioka	24	Izumizaki	39	Samegawa	54	Kitashiobara
10	Kawauchi	25	Miharu	40	Ono	55	Aizumisato
11	Okuma	26	Iwaki	41	Tamakawa	56	Aizubange
12	Futaba	27	Sukagawa	42	Furudono	57	Yanaizu
13	Katsurao	28	Soma	43	Hinoemata	58	Aizuwakamatsu
14	Fukushima	29	Kagamiishi	44	Minamiaizu	59	Yugawa
15	Nihonmatsu	30	Shinchi	45	Kaneyama		

Results(1)

The number of thyroid cancer by 1st and 2nd round screening examination for each category

category (count of municipalities)	Municipality No.	mean effective dose (mSv)	1st screened Thyroid cancer	2nd screened Thyroid cancer	total Thyroid cancer
G1 (5)	43,44,45,48,50	0.05	1	0	1
G2 (6)	34,46,49,51,57,58	0.07	7	5	12
G3 (6)	35,38,39,47,53,55	0.10	2	0	2
G4 (6)	24,31,33,40,52,56	0.11	4	1	5
G5 (6)	32,36,41,42,54,59	0.15	3	0	3
G6 (6)	6,22,26,29,30,37	0.20	34	14	48
G7 (6)	7,18,23,25,27,28	0.36	31	21	52
G8 (6)	5,10,14,17,20,21	0.51	17	17	34
G9 (6)	1,4,8,15,16,19	0.64	12	9	21
G10 (6)	2,3,9,11,12,13	4.44	4	4	8

Result(2)
Municipalities divided into 10 by air dose and external effective dose

category (count of municipalities)	1st Screening Examinee	2nd Screening Examinee	mean air dose (μSv/h)	mean effective dose (mSv) within first months	Ln effective dose
G1 (5)	3431	3217	0.09	0.05	-3.08
G2 (6)	22925	21985	0.15	0.07	-2.61
G3 (6)	6036	5751	0.20	0.10	-2.25
G4 (6)	9687	8835	0.27	0.11	-2.24
G5 (6)	6184	5918	0.30	0.15	-1.90
G6 (6)	72065	65116	0.45	0.20	-1.62
G7 (6)	78539	70492	0.76	0.36	-1.03
G8 (6)	61880	55327	1.08	0.51	-0.67
G9 (6)	30127	26005	1.51	0.64	-0.44
G10 (6)	9599	7870	10.94	4.44	1.49
Total	300476	270489	1.58	0.67	-0.40

Result(3)
Person year

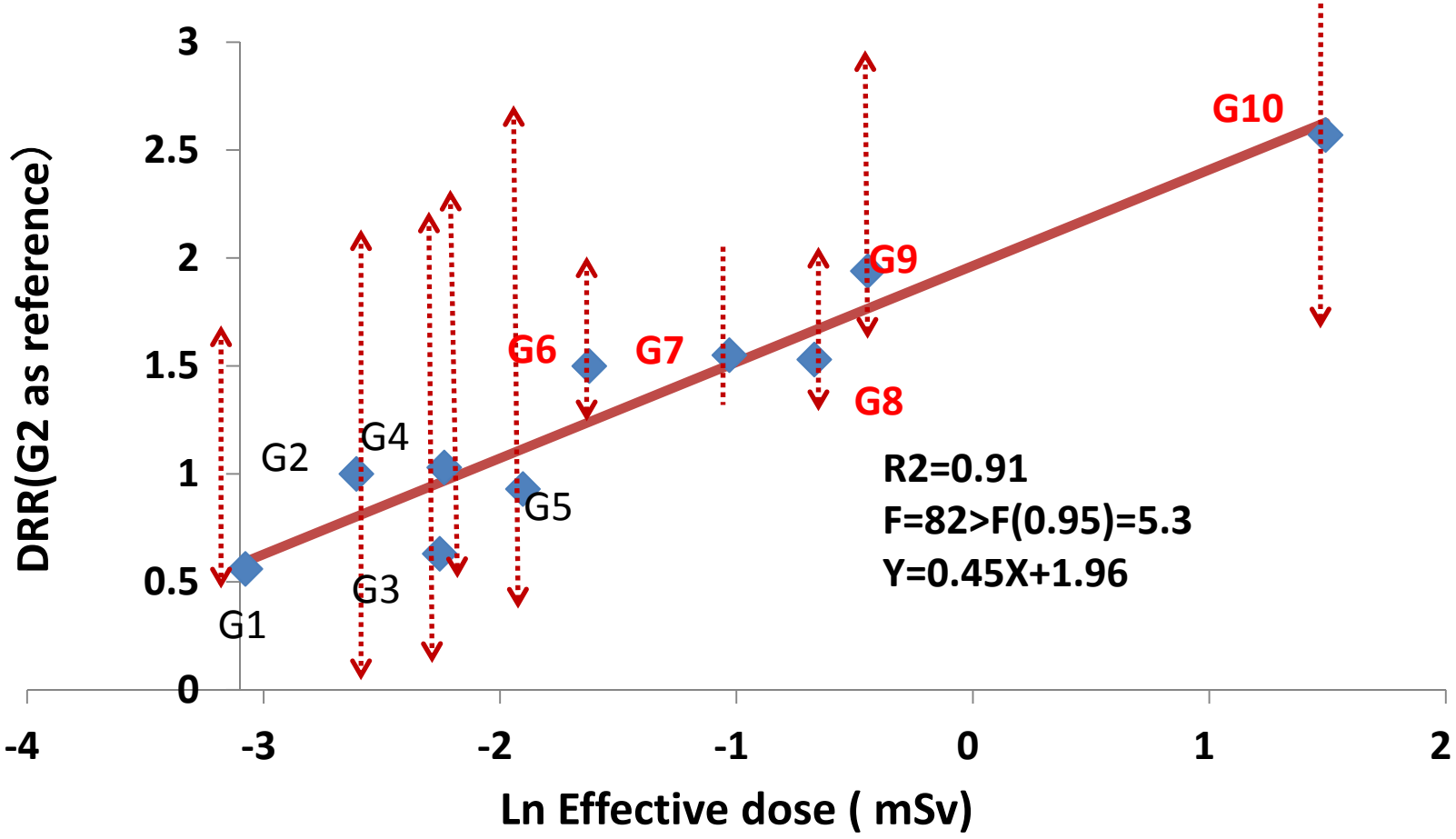
Group	1st Examinee PY	2nd Examinee PY	combined PY	Duration from accident to1st screening (year)	Duration from accident to 2nd screening(year)
G1	9289	14602	15181	2.71	4.54
G2	61984	99791	102331	2.70	4.54
G3	16095	26103	26859	2.67	4.54
G4	24390	39192	41280	2.52	4.44
G5	16452	26860	27565	2.66	4.54
G6	141993	259427	272159	1.97	3.98
G7	140900	271546	285648	1.79	3.85
G8	72394	182448	189986	1.17	3.30
G9	36879	87684	92242	1.22	3.37
G10	7353	25264	26546	0.77	3.21
Total	527730	1032916	1079797	1.76	3.82

Results(4)
detection rate ratio and confidence interval

	External effective dose (mSv)	N0. of Thyroid cancer	Observed detection rate 10^5 PY	expected DR 10^5 PY	Detection rate (G2 as reference)	95% C.I. Lower Limits	Upper Limits
G1	0.05	1	6.59	6.89	0.56	0.03	2.11
G2	0.07	12	11.73	9.19	1.00	0.52	1.75
G3	0.10	2	7.45	10.84	0.63	0.11	2.32
G4	0.11	5	12.11	12.24	1.03	0.41	2.44
G5	0.15	3	10.88	12.86	0.93	0.25	2.72
G6	0.20	48	17.64	14.79	1.50	1.11	1.99
G7	0.36	52	18.20	17.47	1.55	1.16	2.04
G8	0.51	34	17.90	19.26	1.53	1.06	2.13
G9	0.64	21	22.77	20.93	1.94	1.20	2.97
G10	4.44	8	30.14	30.93	2.57	1.21	5.08

Results(5)

Simple regression analysis of Effective dose and Thyroid cancer Detection rate ratio



Conclusions

The average external radiation dose-rate in the 59 municipalities of the Fukushima prefecture in June 2011 and the corresponding thyroid cancer detection rates in the period October 2011 to June 2017 showed statistically significant dose-response relationship

Appendix1. Dose data source

- UNSCEAR 2013 Attachment C-7
- DERIVED GROUND DEPOSITION FOR 1 KM GRID CELLS FROM MEXT GROUND SURVEY
- Data were provided by the Government of Japan as described in the report titled "Summarized version of the results of the research on distribution of radioactive substances discharged by the accident at TEPCO's Fukushima Daiichi NPP."

  The Japan Atomic Energy Authority (JAEA) conducted the survey with cooperation of various universities and research institutes.
  The Ministry of Education, Culture, Sports, Science and Technology (MEXT) was responsible for the coordination of the measurement data and assessment of validity.

  The Committee reviewed the dataset submitted and supporting documentation and considered it acceptable and fit for purpose.

A

Appendix2. To assess effective dose from exposure to ground contamination

equation

$$E_{ext} = \dot{H}^{*}_{g} \cdot \frac{\sum_{i=1}^{n} C^{rep}_{g,i} \cdot CF_{4,i}}{\sum_{i=1}^{n} C^{rep}_{g,i} \cdot CF_{3,i}}$$

E_{ext} = Effective dose from deposition for the period of concern [mSv]

$\dot{H}^{*}_{g}$ = Ambient dose rate at 1 m above ground level from ground contamination [mSv/h]

$CF_{3,i}$ = Conversion factor from Table E3; ambient dose rate at 1 m above ground level per unit of deposition for radionuclide *i*

$C^{rep}_{g,i}$ = Representative deposition (ground) concentration of radionuclide *i* [kBq/m^2]

CF4,i = Conversion factor from Table E3; effective dose per unit deposition for radionuclide i; includes external dose and committed effective dose from inhalation
due to resuspension resulting from remaining on contaminated ground for the period
of concern

n = Number of radionuclides

IAEA-TECDOC-1162; p96～