

A Possible Warning from Fukushima

A Preliminary Analysis of Radiation Dose and Occurrence of Thyroid Nodules Using City- and Village-level Data

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Research Purpose

- WHO Health Risk Assessment and Thyroid Screening
 - “For thyroid cancer, the estimated lifetime risk increases by up to around 70% over baseline rates in females exposed as infants.”. “It is important to note that due to the low baseline rates of thyroid cancer, even a large relative increase represents a small absolute increase in risks (WHO 2012, p. 8).”
 - However, through thyroid screening, substantial thyroid anomalies are identified.
- Research Purpose
 - To examine relationships between the number of thyroid nodules with radiation level using publicly available city- and town-level data.

Data

Table 1 Results of Fukushima Thyroid Screening

Year	Number of participants	Number of confirmed test results	Number by class				Nodule		Cyst	Malignancy	
			A1	A2	B	C	≤5.0 mm	≥5.1 mm			
			Specific problems or/and Cyst	≤5.0 mm	Nodule	≥5.1 mm	or/and Cyst	≤20.0 mm	≥20.1 mm	or/and examination	
FY2011	41,296	41,080	26,063 (63.4%)	14,803 (36.0%)	214 (0.5%)	0 (0.0%)	226 (0.6%)	212 (0.5%)	14,727 (35.8%)	1 (0.0%)	14 (0.0%)
FY2012	135,586	135,173	73,961 (54.7%)	60,259 (44.6%)	952 (0.7%)	1 (0.0%)	684 (0.5%)	939 (0.7%)	60,374 (44.7%)	8 (0.0%)	30 (0.0%)
FY2013	39,927	16,633	6,799 (40.9%)	9,721 (58.4%)	113 (0.7%)	0 (0.0%)	77 (0.5%)	112 (0.7%)	9,757 (58.7%)	1 (0.0%)	-
Total	216,809	192,886	106,823 (55.4%)	84,783 (44.0%)	1,279 (0.7%)	1 (0.0%)	987 (0.5%)	1,263 (0.7%)	84,858 (44.0%)	10 (0.0%)	44 (0.0%)

Table 2 Available Dosimetry

	Summary	External	Internal	Data	Data collection date and sample size	Unit of analysis
WHO Thyroid Dose (2012)	Estimate of the first-year thyroid dose for 10 year olds	x	x	Monitoring data on soil and food contamination.	Until September 2011	City and village
NIRS (National Institute of Radiation Science) Thyroid Dose	Estimate of thyroid dose by iodine for 1 year olds		x	WBC measurement of Cs for adults	July 2011 and January 2012. N = 3,128	Individual
Fukushima Prefecture Basic Study External Exposure Dose	Estimate of cumulative external effective dose between 11 March, 2011 and 11 July, 2011	x		Behavior record of individuals and environment contamination map	Since November, 2011 N = 65,582 completed as of June 2013 (ongoing)	Individual
Fukushima Prefecture Internal Exposure Dose	Estimates of committed equivalent dose		x	WBC measurement	Since 27 June, 2011 N = 139,127 as of June 2013 (ongoing)	Individual

Table 3 Doses for Cities and Towns

	WHO Thyroid Dose (mSv)	NIRS Thyroid Dose (mSv)	Fukushima External Dose (mSv)	Fukushima Internal Dose (mSv)
Futaba	43.9*	30	0.739	0.505
Ookuma	32.1*	20	0.849	0.501
Tomioka	20.2*	10	0.692	0.501
litate	52	30	3.584	0.5
Namie	95	20	0.940	0.501
Katsurao	28	20	0.788	0.5
Minami-Soma	25	20	0.775	0.5
Naraha	22	10	0.551	0.503
Kawauchi	22	8**	0.777	0.505
Date	22	8**	1.170	0.5
Fukushima	22	8**	1.280	0.5
Nihon-matsu	22	8**	1.459	0.5
Kawamata	22	10	1.280	0.5
Hirono	18	20	0.533	0.5
Koriyama	18	8**	1.160	0.5
Tamura	18	8**	0.572	0.5
Miharu	15	8**	0.671	0.5
Kunimi	15	8**	0.981	0.5
Ootama	15	8**	1.196	0.5
Tenei	15	8**	1.078	0.5
Motomiya	15	8**	1.386	0.5
Kuwaori	15	8**	1.290	0.5
Senzaki	15	8**	0.517	0.5
Sirakawa	15	8**	0.574	0.5
Saigo	15	8**	0.857	0.5
Iwaki	15	30	0.508	0.5
Shinchi	15	8**	0.509	0.5
Kagami	15	8**	0.522	0.5
Sukagawa	15	8**	0.723	0.5
Soma	18	8**	0.554	0.5

*) WHO did not estimate the dose for three towns. The author estimated the dose for these towns based on regression analysis using the NIRS dose.

**) NIRS estimated less than 10 mSv. The author assumed 8 mSv for these towns.

Shaded towns were excluded from analysis because of ongoing thyroid screening.

Analysis

- Sample
 - Cities and villages that completed screening between 2011 and 2012. N = 25
- Poisson regression
 - # of confirmed test results as offset
- Dependent variables
 - # of nodules with diameter ≤5 mm, ≥5.1 mm, and Total #.
- Explanatory variables
 - Dose
 - FY2001 screening dummy
 - Within 10km dummy
 - Percentage of age groups of participants
 - Fraction of residents evacuated from the affected area before midnight of March 13, 2011
 - Whether stable iodine tablets were distributed or not

Results

- Although the significant covariates varied among the smaller, larger, and summed values, the WHO thyroid dose had positive and significant coefficients.

Table 4 Results of Poisson Regression

	≤5 mm		≥5.1 mm		Total	
	Estimates	z-value	Estimates	z-value	Estimates	z-value
Intercept	3.747	2.380 **	-11.200	-8.500 ***	1.354	1.250
Mean age of participants (Fraction of 6–10 year olds)	-1.031	-5.910 ***	20.500	4.710 ***	-0.657	-5.510 ***
Within 10 km?	-0.906	-2.720 ***			-0.536	-2.550 **
FY2001 screening dummy	0.549	4.040 ***	-0.142	-1.100	0.112	1.160
Fraction of early evacuation	-0.006	-2.330 **	0.002	1.180	-0.001	-0.860
Stable iodine distributed?	0.482	2.170 **	0.000	0.000	0.196	1.300
WHO Thyroid Dose	0.017	5.750 ***	0.009	2.710 ***	0.010	4.860 ***

Significance level ***:1% **:5% *:10%

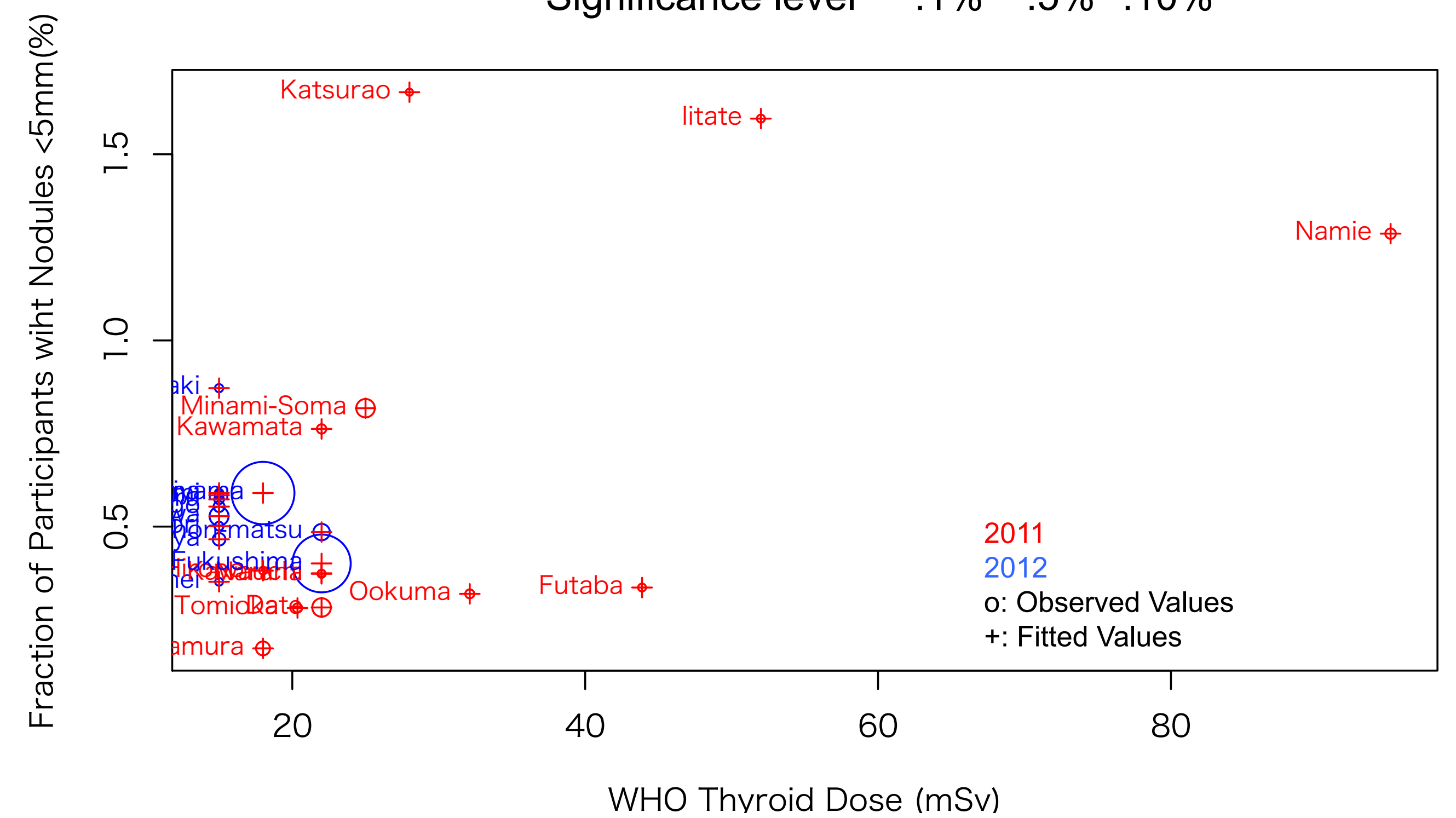


Figure. Observed and Fitted Values (Nodules < 5 mm: WHO Thyroid Dose)

- The NIRS and Fukushima external doses were positive and significant coefficients for smaller and total nodules. This is consistent with the conjecture that “if a nodule was caused by radiation, taking into account the slow growth of thyroid nodules, smaller nodules would correlate with radiation dose.”

Table 5 Estimates of Dose Coefficients

	≤5 mm		≥5.1 mm		Total	
	Estimates	z-value	Estimates	z-value	Estimates	z-value
WHO Thyroid Dose	0.017	5.75 ***	0.009	2.71 ***	0.010	4.86 ***
NIRS Thyroid Dose	0.070	6.23 ***	0.016	1.47	0.035	4.36 ***
Fukushima External Dose	0.267	2.55 **	-0.008	-0.07	0.151	1.94 *
Fukushima Internal Dose	93.80	1.04	74.88	0.97	89.11	1.45

Conclusions

- We found that the WHO thyroid dose, estimated based on early monitoring data, correlated positively with incidence of nodules.
- NIRS thyroid and Fukushima external doses, estimated based on individual-level measurement, correlated positively with smaller nodules but not with larger nodules.
- The sample size was limited; however, the robustness of the results was confirmed through the exclusion of outliers such as “Namie” and “litate”.
- Considering the slow growth rate of thyroid cancer, the results might indicate an early warning for future incidence of thyroid cancer. Follow-up is necessary.

Additional Remarks

- The WHO did not estimate the doses for Futaba, Okuma, and Tomioka. This was because they believed that the residents of these towns were evacuated immediately. However, the NIRS thyroid and Fukushima external doses were substantially high for these towns. The WHO should re-estimate the doses based on the latest information.
- Insufficient information disclosure caused distrust of the Japanese and local governments. Proper measurement, timely information provision, and information disclosure is necessary.