A Possible Warning from Fukushima III

An Analysis of Radiation Dose and Prevalence of Thyroid Nodules Using City- and Village-level Data

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Research Purpose

- Background
  - "*The number of infants who may have received thyroid doses of 100 mGy is not known with confidence; cases exceeding the norm are estimated by model calculations only, and in practice they are difficult to verify by measurement.*" (UNSCEAR 2013, paragraph 40)
  - However, substantial thyroid anomalies have been identified in Fukushima through thyroid screening and fine needle aspiration cytology.
  - We found a significantly positive relationship between the prevalence of nodules identified through *screening* and the radiation levels (Hamaoka 2013, 2014).
- Research Purpose
  - To examine the relationships between the prevalence of thyroid nodules and cancer based on the results of *confirmatory thyroid examinations* and radiation levels by using publicly available data.

Related Studies

- Studies that have examined radiation exposure in relation to thyroid nodules are few. However, some have confirmed positive and significant relationships.

Table 1. Studies Examining Radiation, Thyroid Nodules, and Cancers

	Research	Exposure		Diagnose			Total (Male/Fenale) (%) Risk Paremeter (p-value)			
		Year	Dose	Age	Year	N	Mean Age	Thyroid Nodule	Solid Nodule	Cancer	Cyst
Semi-palatinsk	Land et al. (2008)	1949–62	External dose 0.04 Gy (range 0–0.65) Iintemal dose 0.31 Gy (range 0–9.6)		1998	2,994	56.0	30.6 (18.0/39.0) Ext. Dose EOR=2.26/Gy (p<0.05) Int. Dose EOR=0.60/Gy (p<0.05)	19.8 (11.3/25.5)	2.0 (0.6/2.9)(*1)	0.9 (0.8/1.1)
A-bomb	Nagataki et al. (1994)	1945	0.488 Sv (*2)	18.7	1984-87	2,857		6.8 (4.0/9.8)	3.2 (1.5/4.7) EOR=?(p<0.01)	0.8 (0.3/1.1) EOR=?(p=0.09)	4.1 (2.5/5.0)
	Imaizumi et al. (2005)	1945	0.488 Sv (*2)	18.7	1984-87	2,637	59.0			Solid nodule Group 7.3 HR=23.6(p<0.05)	
	Imaizumi et al. (2006)	1945	0.490Sv (Median=0.087Sv)		2000-2003	4,091	70.0	20.7 (12.3/24.8)	14.4 (8.0/17.6) EOR=2.01/Sv (p<0.001)	2.1 (0.8/2.8) EOR=1.95/Sv (p<0.001)	7.9 (4.7/9.5) EOR=0.89/Sv (p<0.001)
	Imaizumi et al. (2015)	1945	0.182Gy (Median=0.018Sv)		2007-2011	2,668	68.2	17.6 (12.6/21.8) EOR=1.65/Gy(p<0.001) Diameter <1cm 25.0 (18.5/30.4) EOR=-0.08/Gy(p=0.44)	16.0 (11.2/20.0) EOR=1.72/Gy(p<0.001) Diameter<1 18.0 (12.9/22.3) EOR=-0.09/Gy (ns)	1.8 (0.7/2.6) EOR=4.4/Gy (p<0.001)	1.8 (1.5/2.1) EOR=1.11/Gy(p=0.01)
Medi-cal	Schneider et al. (1993)	1939-62	58.6cGy (Min=45.8,max=71.5)	~16	1974-90	2,634		-	39.6 (34.4/47.2) ERR=0.091/cGy (p<0.05)	11.7 (10.3/13.8) ERR=0.03/cGy (p<0.05)	

Data

Table 2. Results of Fukushima Thyroid Examination (As of Dec. 2014) 1) Thyroid Screening

Analyzed(Hamaoka 2013)

	Target Population (n)	Participants (n, %)	Mean Age at Exposure (y)	A1 No Specific Finding (n, %)	A2 Nodule ≤5.0 mm or/and Cyst ≤20.0 mm (n, %)	B Nodule ≥5.1 mm or/and Cyst ≥20.1 mm (n, %)	C Needed Further Examination (n, %)	Solid Nodule ≤5 mm (n, %)	Solid Nodule ≥5.1 mm (n, %)	Cyst ≥20 mm (n, %)	Cyst ≥20.1 mm (n, %)
	(a)	(b) (b)/(a)		(c)	(d)=(i)+(k)	(e)=(j)+(l)	(f)	(i)	(j)	(k)	(l)
FY 2011	47,768	41,810 (87.53%)	9.4	26,373 (63.1%)	15,216 (36.4%)	221 (0.53%)	0 (0.00%)	232 (0.55%)	219 (0.52%)	15,140 (36.21%)	1 (0.00%)
FY 2012	161,135	139,339 (86.47%)	9.0	76,183 (54.7%)	62,146 (44.6%)	987 (0.71%)	1 (0.00%)	730 (0.52%)	973 (0.70%)	62,259 (44.68%)	9 (0.01%)
FY 2013	158,784	117,428 (73.95%)	8.6	50,460 (43.0%)	64,415 (54.9%)	1,042 (0.89%)	0 (0.00%)	718 (0.61%)	1,040 (0.89%)	64,704 (55.10%)	2 (0.00%)
Total	367,687	298,577 (81.20%)	8.9	153,016 (51.2%)	141,777 (47.5%)	2,250 (0.75%)	1 (0.00%)	1,680 (0.56%)	2,232 (0.75%)	142,103 (47.59%)	12 (0.00%)

2) Confirmatory Testing

	Target Participants (n)	Participants for Examination (n, %)	Mean Age at Exposure	Confirmed Results of Examination (n, %)	Reclassified to A1 (n, %)	Reclassified to A2 (n, %)
		(m)=(j)+(l) =(e)+(f)	(n)	(o) (n)/(m)	(p) (p)/(n)	(q) (q)/(n)
FY 2011	221	199 (90.0%)	14.5	197 (99.0%)	12 (6.1%)	44 (22.3%)
FY 2012	988	919 (93.0%)	15.0	899 (97.8%)	54 (6.0%)	246 (27.4%)
FY 2013	1,042	949 (91.1%)	14.9	914 (96.3%)	51 (5.6%)	274 (30.0%)
Total	2,251	2,067 (91.8%)	14.8	2,010 (97.2%)	117 (5.8%)	564 (28.1%)

3) Total

Present Study

Confirmed Results (n, %)	A1 (n, %)	A2 (n, %)	Follow-up Advised (n, %)	Cytology (n, %)	Malignancy (Including Suspected) (n, %)	Solid Nodules ≤5 mm (n, %)	Solid Nodules ≥5.1 mm (n, %)
(r)=(s)+(t)+(u)	(s)=(c)+(p)	(t)=(d)+(q)	(u)=(o)-(p)-(q)	(v)	(w)	(x)=(i)+(t)	(y)=(u)-(w)
				Percentage in (r)			
41,786	26,385	15,260	141 (0.34%)	91 (0.22%)	14 (0.03%)	276 (0.66%)	127 (0.30%)
139,228	76,237	62,392	599 (0.43%)	262 (0.19%)	56 (0.04%)	976 (0.70%)	543 (0.39%)
115,789	50,511	64,689	589 (0.51%)	170 (0.15%)	39 (0.03%)	992 (0.86%)	550 (0.48%)
296,803	153,133	142,341	1,329 (0.45%)	523 (0.18%)	109 (0.04%)	2,244 (0.76%)	1,220 (0.41%)

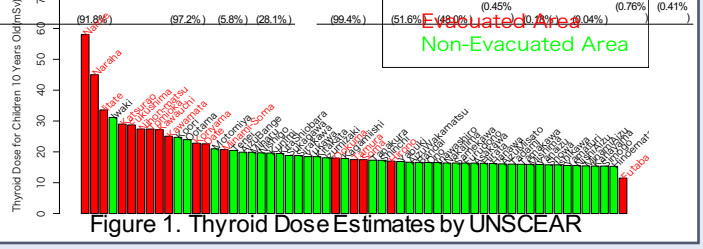


Figure 1. Thyroid Dose Estimates by UNSCEAR

Analysis

- Sample
  - Cities and villages that completed screening between 2011 and 2013 (N=59)
- Poisson regression
  - # of confirmed test results were considered as the offset
- Dependent variables
  - # of nodules with diameter ≤5 mm, ≥5.1 mm, and thyroid cancer (including suspicious cases)
- Explanatory variables (Expected sign)
  - Thyroid Dose (+)
  - Mean age at exposure (−)
  - Mean age at screening (+)

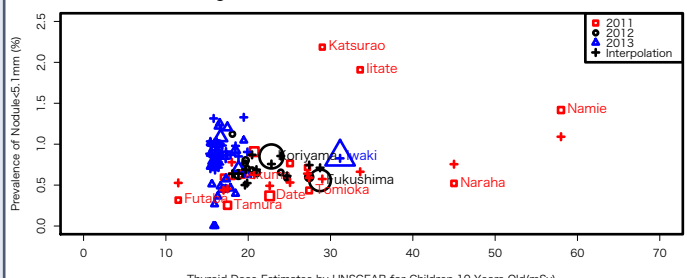
Results

- The UNSCEAR thyroid dose had positive and significant coefficients for both smaller and larger nodules. The t-value was larger for the smaller nodules.
- Age at screening was positive, and age at exposure was negative, as we expected.
- They were insignificant for malignancy, due to sample size is not enough to detect differences at prevalence of malignancy of 0.03%.

Table 4. Results of Poisson Regression

	Coeff.	s.e.	t-value	p-value	95% CI	
(a) Nodule ≤5 mm						
Intercept	-1.55	0.83	-1.88	0.06 *	(-3.17,	0.07)
Age at screening	0.04	0.05	0.74	0.46	(-0.06,	0.13)
Age at exposure	-0.47	0.07	-7.13	0.00 ***	(-0.60,	-0.34)
Thyroid dose (Sv)	18.76	3.79	4.95	0.00 ***	(11.33,	26.18)
(2) Nodule ≥5.1 mm						
	Coeff.	s.e.	t-value	p-value	95% CI	
Intercept	-5.44	1.12	-4.85	0.00 ***	(-7.64,	-3.24)
Age at screening	0.23	0.07	3.36	0.00 ***	(0.09,	0.36)
Age at exposure	-0.31	0.09	-3.53	0.00 ***	(-0.48,	-0.14)
Thyroid dose (Sv)	11.45	5.3	2.16	0.03 **	(1.06,	21.85)
(c) Nodule (Total)						
	Coeff.	s.e.	t-value	p-value	95% CI	
Intercept	-2.27	0.67	-3.41	0.00 ***	(-3.57,	-0.96)
Age at screening	0.1	0.04	2.59	0.01 ***	(0.03,	0.18)
Age at exposure	-0.41	0.05	-7.84	0.00 ***	(-0.52,	-0.31)
Thyroid dose (Sv)	16.26	3.09	5.27	0.00 ***	(10.21,	22.31)
(d) Malignancy (including suspicious)						
	Coeff.	s.e.	t-value	p-value	95% CI	
Intercept	-8.03	3.67	-2.19	0.03 **	(-15.23,	-0.84)
Age at screening	0	0.22	-0.02	0.99	(-0.44,	0.43)
Age at exposure	-0.03	0.29	-0.09	0.93	(-0.58,	0.53)
Thyroid dose (Sv)	15.9	15.7	1.01	0.31	(-15.03,	46.83)

Significance levels: ***1%, **5%, and *10%



Size of circle indicates number of confirmed results from thyroid screening and confirmatory examinations

Figure 2. Observed and Fitted Values (Nodules ≤5 mm)

Conclusions

- We confirmed the results of the study by Hamaoka (2013, 2014), in which the results of screening were analyzed.
- Although this was an ecological study at the municipality level, our results are consistent with previous studies.
- According to follow up studies of a-bomb (Imaizumi et al 2005) and Chernobyl (Hayashida et al. 2012), nodule group has larger risk of thyroid cancer. Our results might indicate an early warning for future incidence of thyroid cancer. Health follow-up for children in Fukushima is necessary.

Additional Remarks

- Insufficient information disclosure caused distrust of the Japanese and local governments. Proper measurement, timely provision of information, and information disclosure are necessary.