

Estimation on Lifetime Attributable Risks for Thyroid Cancer Incidence of Korean Population due to a Hypothetical Nuclear Accident in China

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Introduction

- In case of a nuclear accident, internal exposure of thyroid is considered as one of important issues.
- Supposing that a hypothetical accident occurred at Hongyanhe nuclear power plant (NPP) closest to Korean peninsula among operational NPPs in China, thyroid cancer incidence risk for the Korean population was assessed using BEIR VII (2006) and U.S. EPA (2011) cancer risk models.
 - Evaluation of an accumulated thyroid exposure dose after an accident above took place [1]
 - Calculation of the excessive relative risk (ERR) for thyroid by age and gender
 - Estimate on lifetime attributable risk (LAR) per 100,000 persons

Calculation of Excessive Relative Risk (ERR)

- In a previous study, an accumulated thyroid exposure dose was evaluated as 2.44E-03 mSv.
 - Supposing that Station Blackout (SBO) took place at Hongyanhe NPP
 - Applying seven days after accident above took place as evaluation period
 - Using NANAS (Northeast Asia Nuclear Accident Simulator) code with GDAS 1 degree meteorological data on fourth week of March 2015 that there was direct inflow of air current into South Korea
- We calculated the ERR for thyroid by age and gender using BEIR VII and U.S. EPA 2011 thyroid cancer risk model in accordance with exposure dose (D) derived from the previous study.

- BEIR VII ERR Model [2]

$$ERR_{male} = 0.53D \times \exp[-0.083(e - 30)]$$
$$ERR_{female} = 1.05D \times \exp[-0.083(e - 30)]$$

- U.S. EPA 2011 ERR Model [3]

$$ERR = 10.7D \times A(e) \times T(t)$$

A(e) : effect modifiers for age at exposure
T(t) : effect modifiers time since exposure

Table 1. Effective modifiers for age at exposure and time since exposure in U.S. EPA 2011 model

Modifier	Range of Age at Exposure	Value
A(e)	e<5	1.0
	5≤e≤9	0.6
	10≤e≤14	0.2
	e≥15	0.2 · exp[-0.083(e-15)]
T(t)	e<5	0
	5≤e≤14	1.15
	15≤e≤19	1.9
	20≤e≤24	1.2
	25≤e≤29	1.6
	e≥30	0.47

Estimate on Lifetime Attributable Risk (LAR)

- We estimated lifetime attributable risk (LAR) per 100,000 persons in accordance with exposure dose above (2.44E-03 mSv). Korean demographics and 1.5 of dose and dose rate effectiveness factor (DDREF) were applied.

Table 2. Estimates on lifetime attributable risk (LAR) of radiation-induced thyroid cancer incidence for the Koreans with BEIR VII and U.S. EPA 2011 models

Model	Gender	LAR by age at exposure											
		0	1	5	10	15	20	30	40	50	60	70	80
BEIR VII	Male	1.45E-01	1.34E-02	9.60E-03	6.34E-03	4.17E-03	2.72E-03	1.02E-03	3.14E-04	8.76E-05	1.96E-05	3.23E-06	5.70E-07
	Female	1.05E-01	9.73E-02	6.99E-02	4.61E-02	3.02E-02	1.95E-02	7.33E-03	2.38E-03	6.46E-04	1.31E-04	1.76E-05	1.86E-06
U.S. EPA 2011	Male	1.33E-02	1.38E-02	9.32E-03	3.70E-03	4.32E-03	3.11E-03	1.31E-03	4.48E-04	1.30E-04	2.87E-05	4.81E-06	8.00E-07
	Female	5.00E-02	5.17E-02	3.47E-02	1.35E-02	1.54E-02	1.09E-02	4.82E-03	1.74E-03	4.88E-04	9.69E-05	1.29E-05	1.34E-06

Conclusion

- The estimated lifetime baseline risk (LBR) per 100,000 persons for male, female, and whole Korean population is 951, 3291, and 2117, respectively.
 - The LARs estimated by BEIR VII and U.S. EPA models are as follows; 1.8E-03 and 2.0E-03 for male, and 1.2E-02 and 7.1E-03 for female.
 - Ratios of LARs calculated by two models as above to LBR are as follows; 1.9E-04 % and 2.2E-04 % for male, and 3.8E-04 % and 2.1E-04 % for female.
 - For the Korean population, the LAR assessed by BEIR VII and U.S. EPA 2011 is 7.1E-03 and 4.5E-03, respectively.
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- From these results, it could be expected that 2.44E-06 Gy of thyroid exposure dose due to a hypothetical SBO at Hongyanhe NPP resulted in approximately 2.0E-04%~3.5E-04% increase of thyroid cancer incidence for the Korean population.

Reference

- [1] FNC Technology Co., Ltd., Development of Training System for Emergency Response to a Nuclear Accident in Neighboring Country, 2017.
- [2] National Academy of Sciences (NAS), 2006. Health risks from exposure to low levels of ionizing radiation: BEIR VII–Phase 2.
- [3] U.S. Environmental Protection Agency (US EPA), 2011. EPA radiogenic cancer risk models and projections for the U.S. population, EPA Report 402-R-11-001.

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