ICRU Symposium
Revitalization of Fukushima and Radiation Measurement
19th April 2023 in Iwaki, Fukushima

Lessons learned from Fukushima Nuclear Power Plant Accident;
Limitation of public health emergency response and recovery

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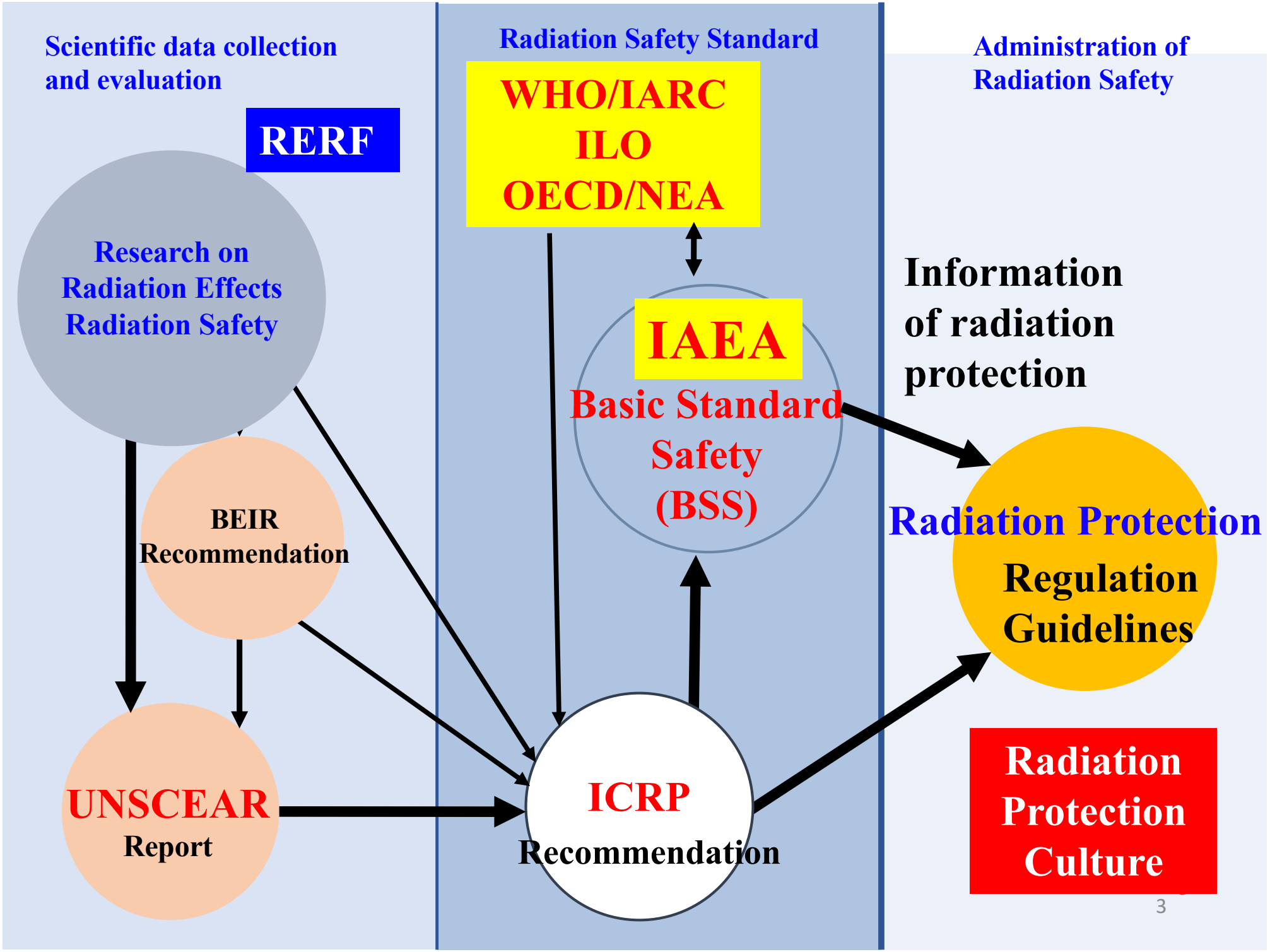
Rationales and Background

- **In response to any nuclear accident or disaster, medical & health experts/responders are expected to provide *rapid countermeasures at on-site and off-site*, consistent with approved guidelines, manuals, and action plans prepared in advance.**
- **Action plans and their implementation should comport with *international standards of radiation protection*, especially when addressing the potentially complicated and long-term health risks that may follow.**
- **However, difficulties with *crisis health risk communication* became apparent just after the Fukushima NPP accident, as radiation medical & health experts encountered an anxious public with insufficient knowledge of radiation and its risk, who were furthermore subjected to the ebb and flow of dubious information and conflicting value systems.**


Scientific data collection and evaluation
Radiation Safety Standard
Administration of Radiation Safety
RERF
WHO/IARC
ILO
OECD/NEA
Research on Radiation Effects Radiation Safety
IAEA
Basic Standard Safety (BSS)
Information of radiation protection
BEIR Recommendation
Radiation Protection
Regulation Guidelines
UNSCEAR Report
ICRP Recommendation
Radiation Protection Culture

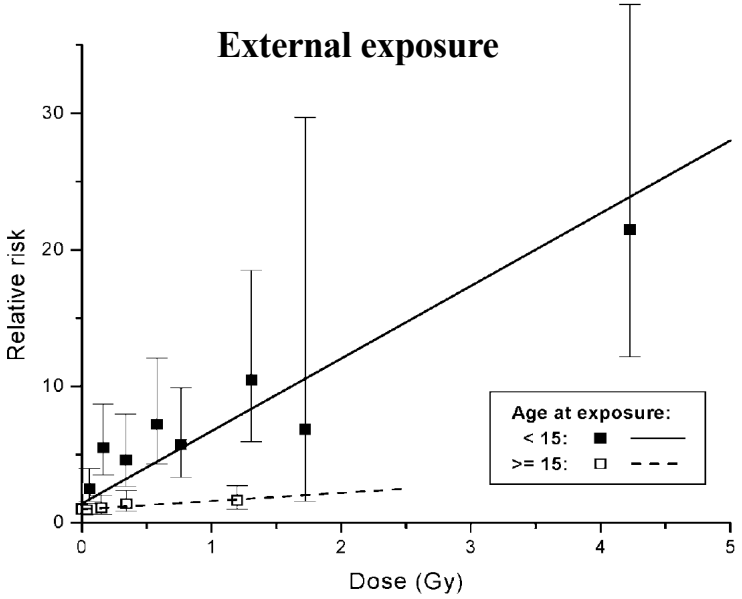
Radiation Epidemiology

Dose dependent increase **of radiation-induced thyroid cancer risk after exposure** ***at younger age*** **but high detection rate of latent and asymptomatic thyroid cancer by US examination.**

External Exposure（effective dose）

- **A-bomb survivors**
- **Marshall Islanders (fall-out)**
- **Children exposed to EBT**

ERR/Gy~7.7 [1.1 – 32]

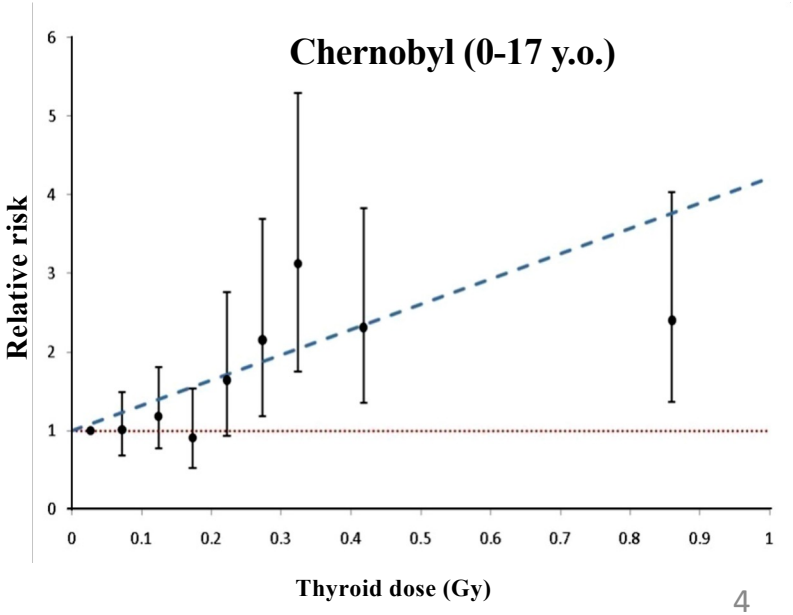


E.Ron 2002

Internal Exposure（equivalent dose）

- **Therapeutic radioiodine**
- **Hanford (fall-out)**
- **Chernobyl**

OR at 1 Gy~5.5 – 8.4 [ERR/Gy 1.9 – 19]



V.Ivanov 2010

From Chernobyl to Fukushima
at the standpoint of radiation health risk management

- ***Atomic Bomb survivors' data*** **and radiation risk analysis with other exposure groups have proved the *dose- and age- dependent* cancer risk after *external* irradiation for all their life with unlimited latency *but no PTSD risk approaches before1995*.**
- ***Chernobyl data*** **suggest a dramatic increase of *childhood thyroid cancers* associated by short-lived radioactive iodines by its *internal* exposure just after the accident and also a *psychosocial impact*.**
- ***Fukushima data*** **suggests the necessity of public health response and of improvement of *radiation risk communication beyond the model of LNT*.**

Similarity between Chernobyl and Fukushima

Information Disaster and Radiation Fear

Difference between Chernobyl and Fukushima

Epidemic of Fear against the Second Coming Chernobyl Thyroid Cancer

- **The most important lesson learned from Chernobyl NPP accident is *how to protect the public from unnecessary exposure of internal as well as external radiation*, and also especially from the *fear/anxiety/mistrust/anger* of any possibility of increased risk of *radiation-induced thyroid cancer*.**
- **How to overcome the difficulty of understanding of *LNT model for population/group risk* depends on logical thinking way at the individual level but emotional reaction cannot be avoided.**
- **It is essentially needed to understand *a stochastic effect of radiation and uncertainty of health effects* interacting various confounding factors.**

To Fukushima from Nagasaki

We have been concentrating on supporting;

① *crisis communication at first* and then

② *post-crisis radiation risk communication*, and now

③ *comprehensive health risk management* based on established regulatory sciences as well as the establishment and maintenance of emergency radiation medicine through the achievement of the *Japanese Radiation Emergency Medicine (REM) Expert Network*.

⇨ Re-establishment of Advanced REM Supporting Centers in Japan

Crisis communication started on 18th March 2011 in Fukushima Medical University

“Accept the disaster as inevitable"," Dig in this situation”

Estimation of the Amount of Radionuclides Released from the Damaged Nuclear Power Plant

- **Estimation by NSC based on the data of environmental monitoring and air diffusion (March 11 to April 5)**

  ^{131}I : 1.5×10^{17}Bq

  ^{137}Cs : 1.2×10^{16}Bq

- **Estimation by NISA and JNES based on the plant data immediately after the accident**

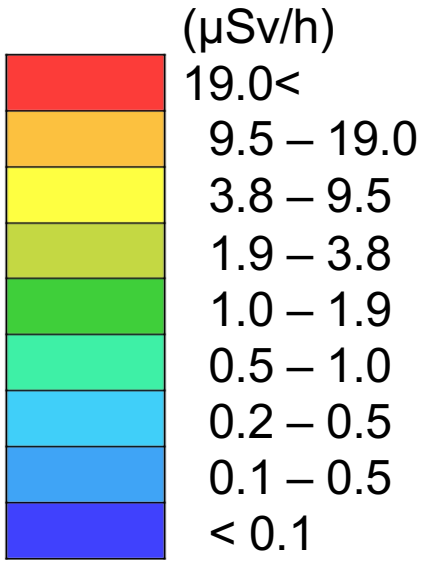
  ^{131}I : 1.6×10^{17}Bq

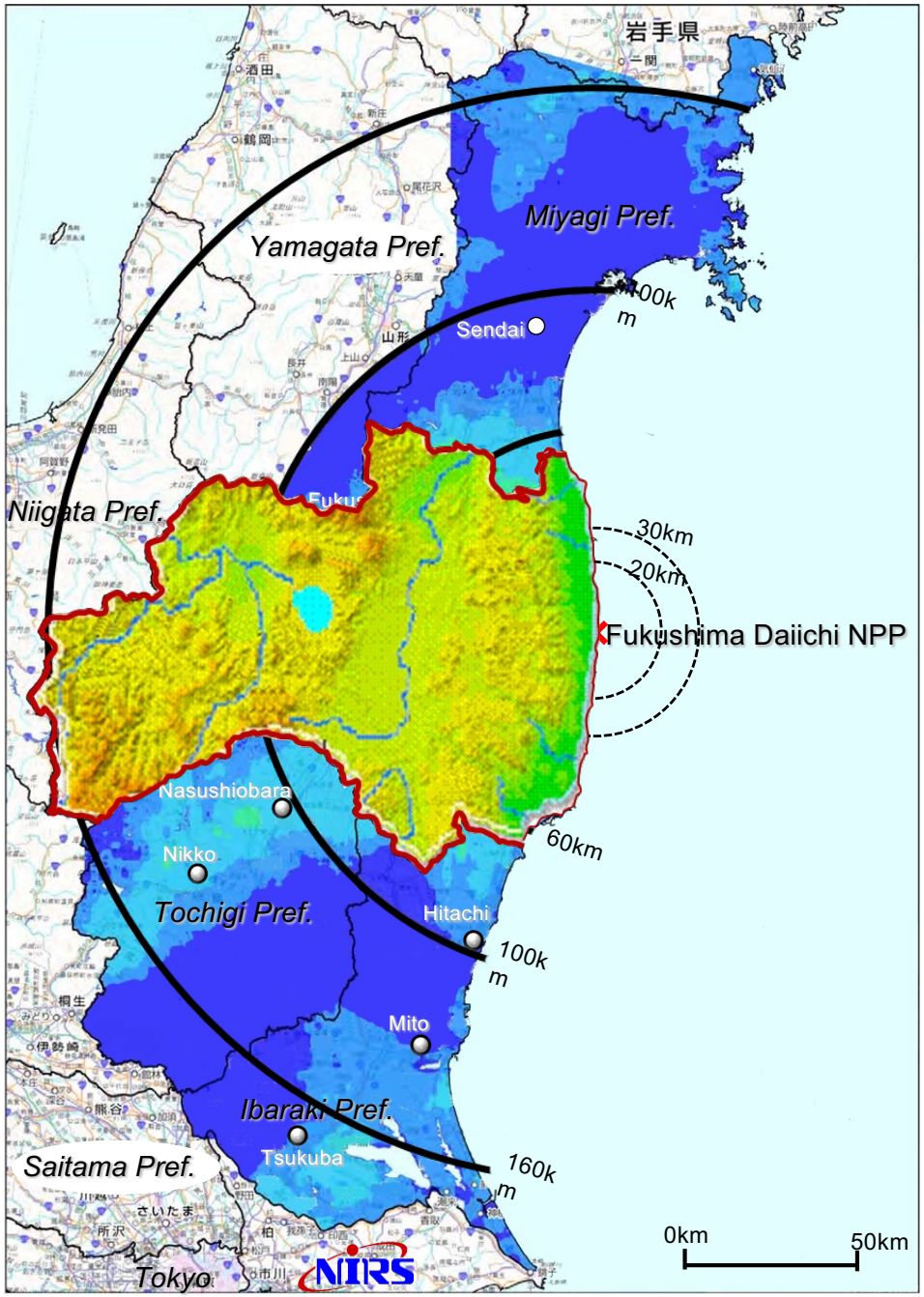
  ^{137}Cs : 1.5×10^{16}Bq

(NSC: Nuclear Safety Commission)
(NISA: Nuclear and Industrial Safety Agency)
(JNES: Japan Nuclear Energy Safety Organization)

Ambient dose rate estimated from aerial survey

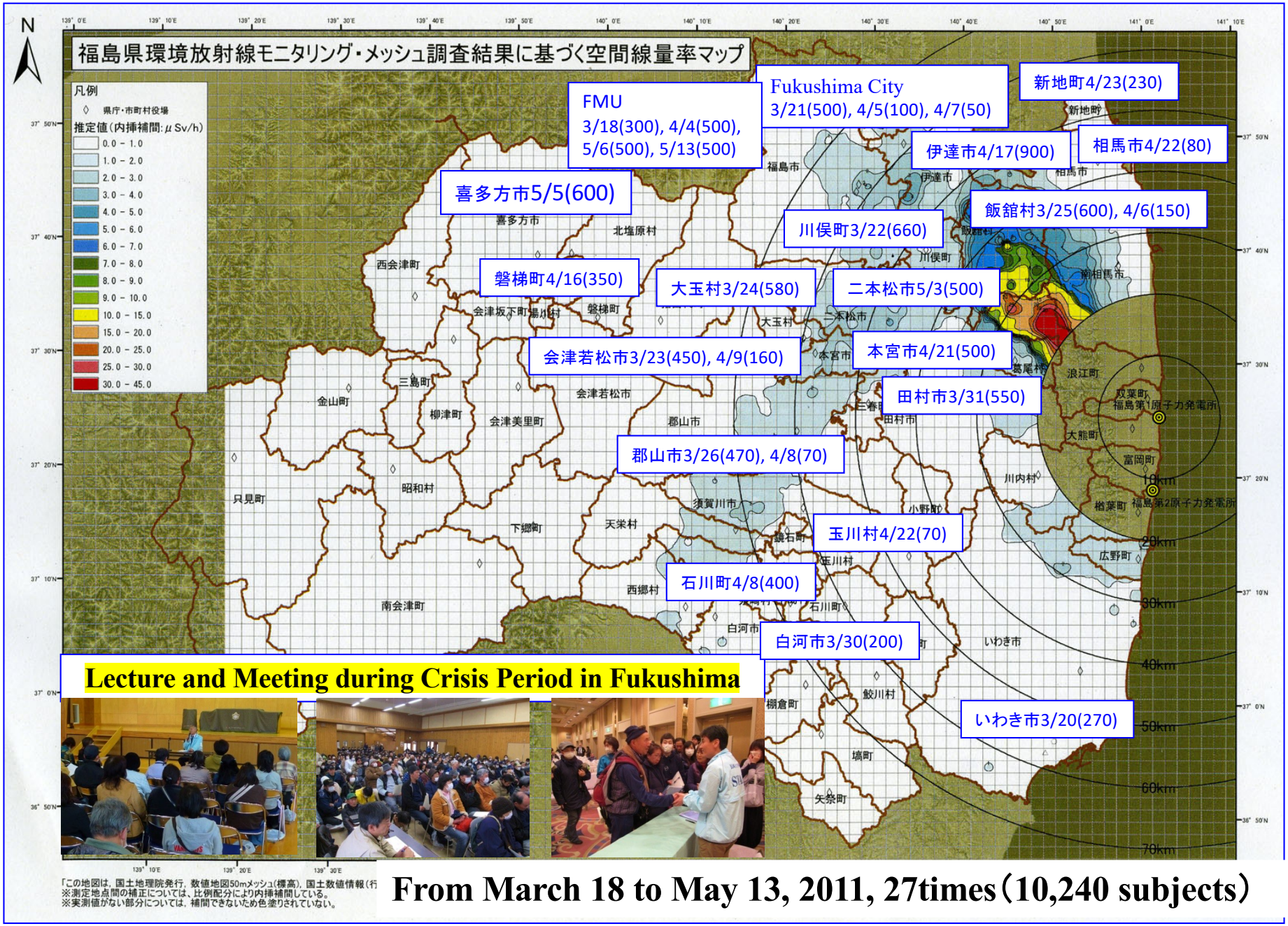
3rd monitoring map within 80 km from NPP 1F by MEXT (presented on 8 July 2011)





Three targets of radiation-exposed

Object	Situation	Countermeasures
Plant nuclear workers	Increased risk in radiation exposure & contamination, any accident	Radiation Emergency Medicine
Emergency responders	Increased risk in radiation exposure & contamination	Consultation clinic for mental, physical cares (stress&fear)
Residents in Fukushima	Chronic low dose/ low dose rate exposure	Education/ communication/ information

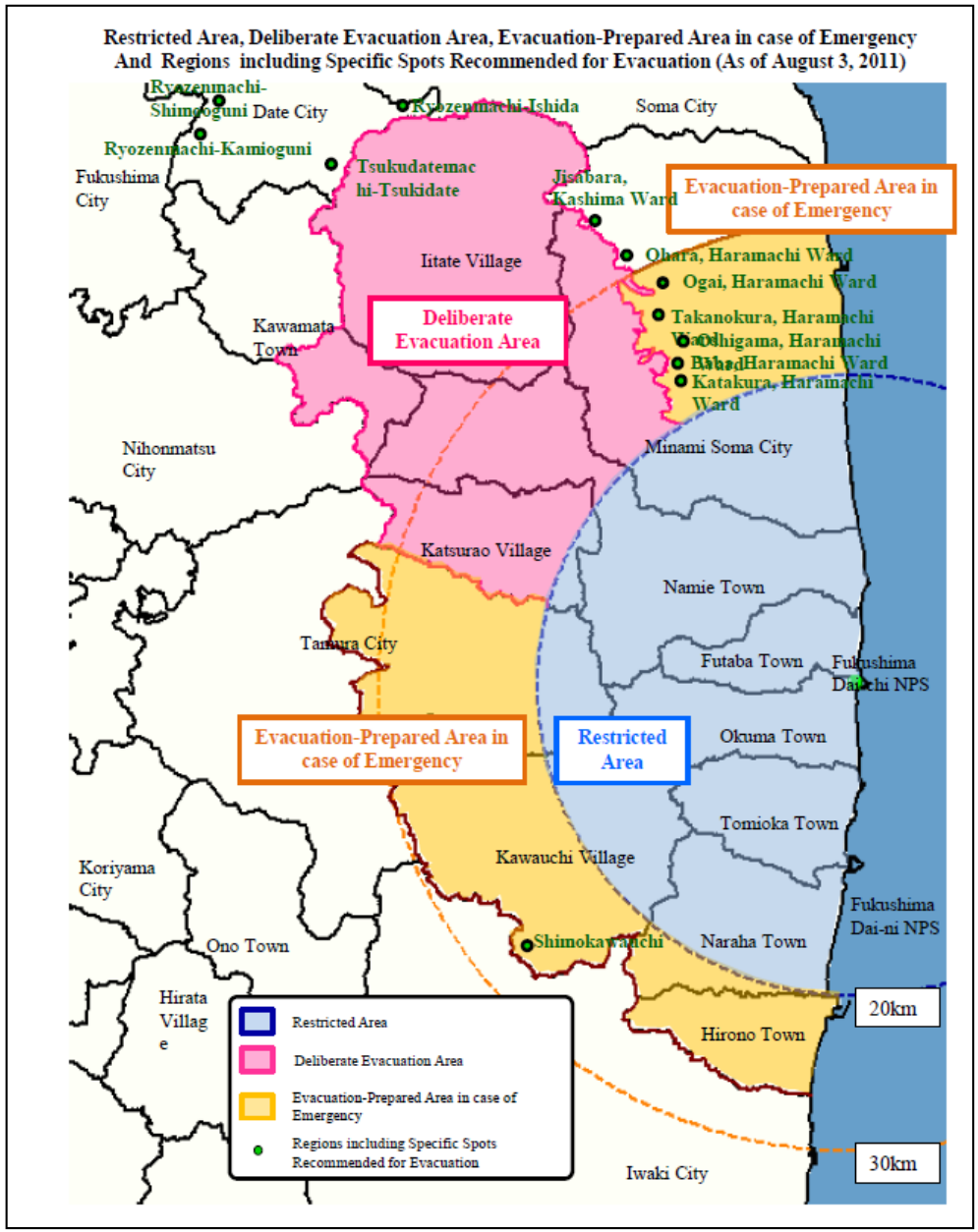


Lecture and Meeting during Crisis Period in Fukushima

「この地図は，国土地理院発行，数値地図50mメッシュ(標高)，国土数値情報(行
※測定地点間の補正については、比例配分により内挿補間している。
※実測値がない部分については、補間できないため色塗りされていない。

From March 18 to May 13, 2011, 27times（10,240 subjects）

Evacuation Status of Residents in Fukushima



Number of evacuees from designated evacuation areas:

- **Restricted Area:**
  about 77,000
- **Deliberate Evacuation Area:**
  about 10,000
- **Evacuation-Prepared Area:**
  about 26,000

Total: about 113,000

(Source: Cabinet Office, Feb 2012)

The Number of Peaks; 164,000 in May 2012
The Number of Disaster-related Death;
2,316 among 4146 in December 2020

Currently about 30,000 residents are still evacuated from their hometown.

Fukushima Health Management Survey

Objectives: *from June 2011*

- To monitor long-term health condition of resident in Fukushima and to promote their health
- To investigate whether a long-term low-dose radiation exposure has a consequence on their health

Fukushima Medical University

Contents: *(https://fhms.jp/en/fhms/)*

1. Basic survey (subjects: 2 million all residents in Fukushima)
2. Detailed survey (target population)
   - *Thyroid examination by ultrasonography (380,000; 0-18 y/o)*
   - Comprehensive medical checkups (210,000 ; Evacuees)
   - Mental health and lifestyle survey (210,000 ; Evacuees)
   - Survey on pregnant women and nursing mothers (16,000)

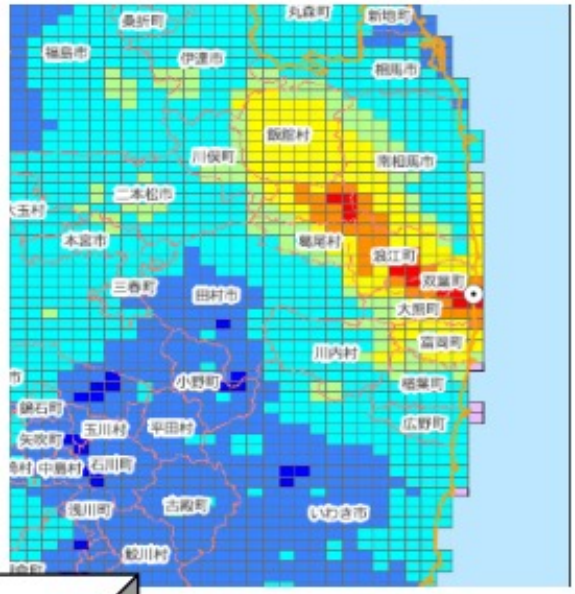
The results of the survey program are valuable and useful not only for public health promotion but also for sound health risk communication between experts and the residents in Fukushima.

How to analyze external radiation dose

Questionnaire

Movement & behavior 調査

Time-course of air dose map



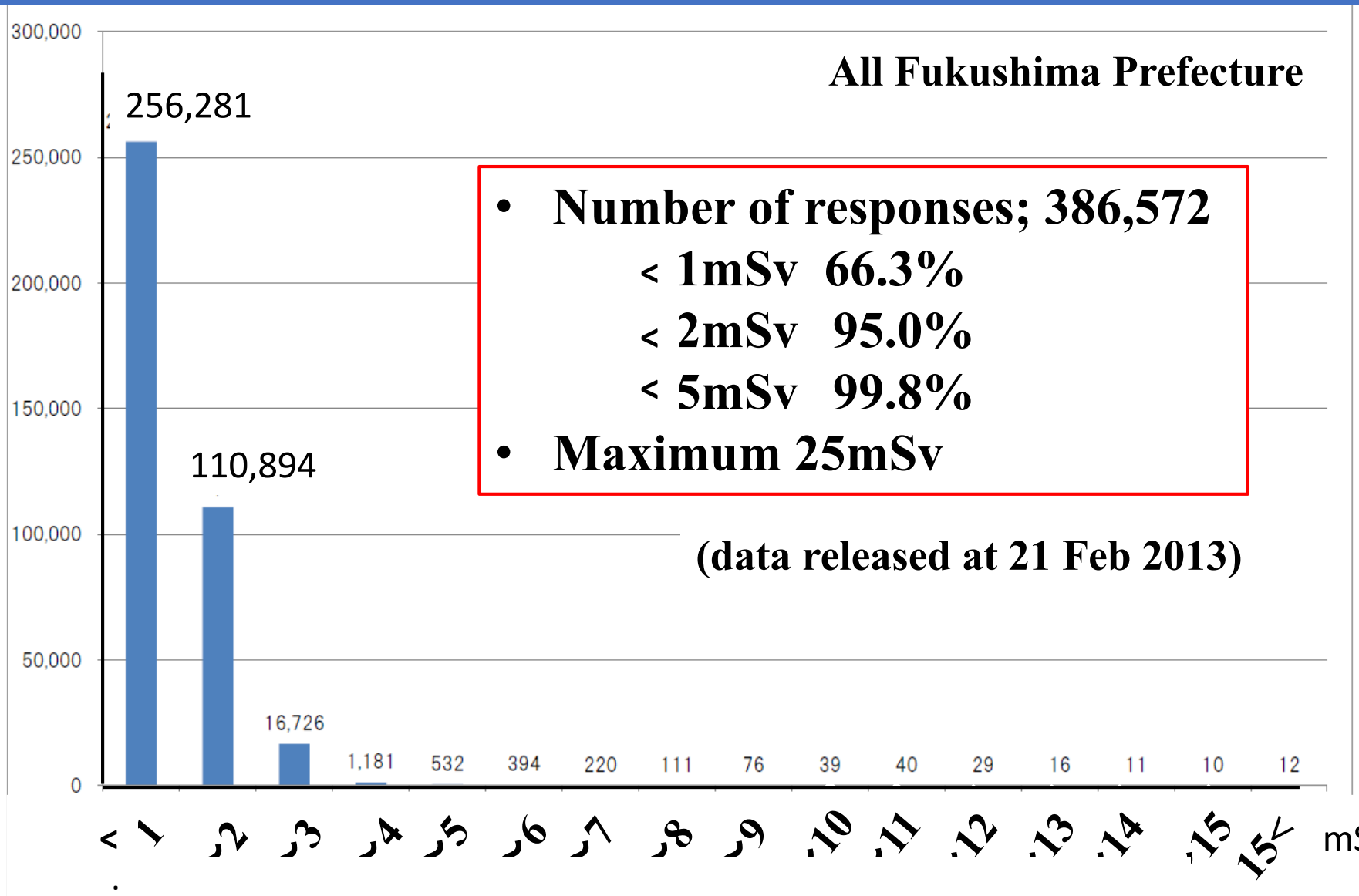
Estimation dose calculating combined above two information by NIRS

To help understanding of individual first 4M dose

To help understanding of radiation-related health risk

To establish database for long-term health management

Distribution of External Exposure Dose (mSv)
(Estimated Cumulative effective dose from March 11 to July 11)



- Number of responses; 386,572
  - < 1mSv 66.3%
  - < 2mSv 95.0%
  - < 5mSv 99.8%
- Maximum 25mSv

(data released at 21 Feb 2013)

Estimated from location and time course on questionnaire

【International Expert Symposium in Fukushima, ***Sept 11 and 12, 2011***】

How to solve uncertainty of low dose radiation health effects;
Necessity of Social Medicine and Regulatory Science
based on common understanding and sound policy-making

The expert group endorsed the Fukushima Health Management Survey program.

Ethics, Legal and Society

Radiation Exposure Dose : Chernobyl and Fukushima

	Radiation Exposure among Evacuation Groups from the Chernobyl and Fukushima Nuclear Accidents

UNSCEAR 2008 Report

Chernobyl Accident	# of people (x1,000)	Mean effective dose (mSv)		Mean Thyroid Dose (mGy)
		External	Internal	
Belarus	25	30	6	1,100
Russia	0.19	25	10	440
Ukraine	90	20	10	330

UNSCEAR 2020 Report

Fukushima average doses of evacuees(First year total)	Adult	10-year-old	1-year-old
RENGE OF EFFECTIVE DOSE(mGy)	0.046-5.5	0.10-6.5	0.15-7.8
RANGE OF ABSORBED DOSE TO THE THYROID(mGY)	0.79-15	1.6-22	2.2-30

Fukushima Thyroid Ultrasound Examination – Results

As of Mar.31,2020

		Preliminary Baseline (1st Exam)	Full-Scale Survey (2nd Exam)	Full-Scale Survey (3rd Exam)	Full-Scale Survey (4th Exam)	Survey of Age 25
Fiscal Year		2011-2013	2014-2015	2016-2017	2018-2019	2017-
Number of target population		367,637	381,244	336,670	294,240	66,637
Participation rate of primary exam		81.7%	71.0%	64.7%	61.5%	8.4%
Target population of confirmatory exam		2,293	2,227	1,501	1,362	244
Participation rate of confirmatory exam		92.9%	84.1%	73.4%	60.1%	68.9%
Malignant or suspicious for malignancy(FNAC)		116	71	31	27	7
Number who received surgery		102	54	27	16	4
Patho-logical diagnosis	Papillary cancer	100	53	27	16	3
	Undifferentiated cancer	1				
	Others	1	1			1

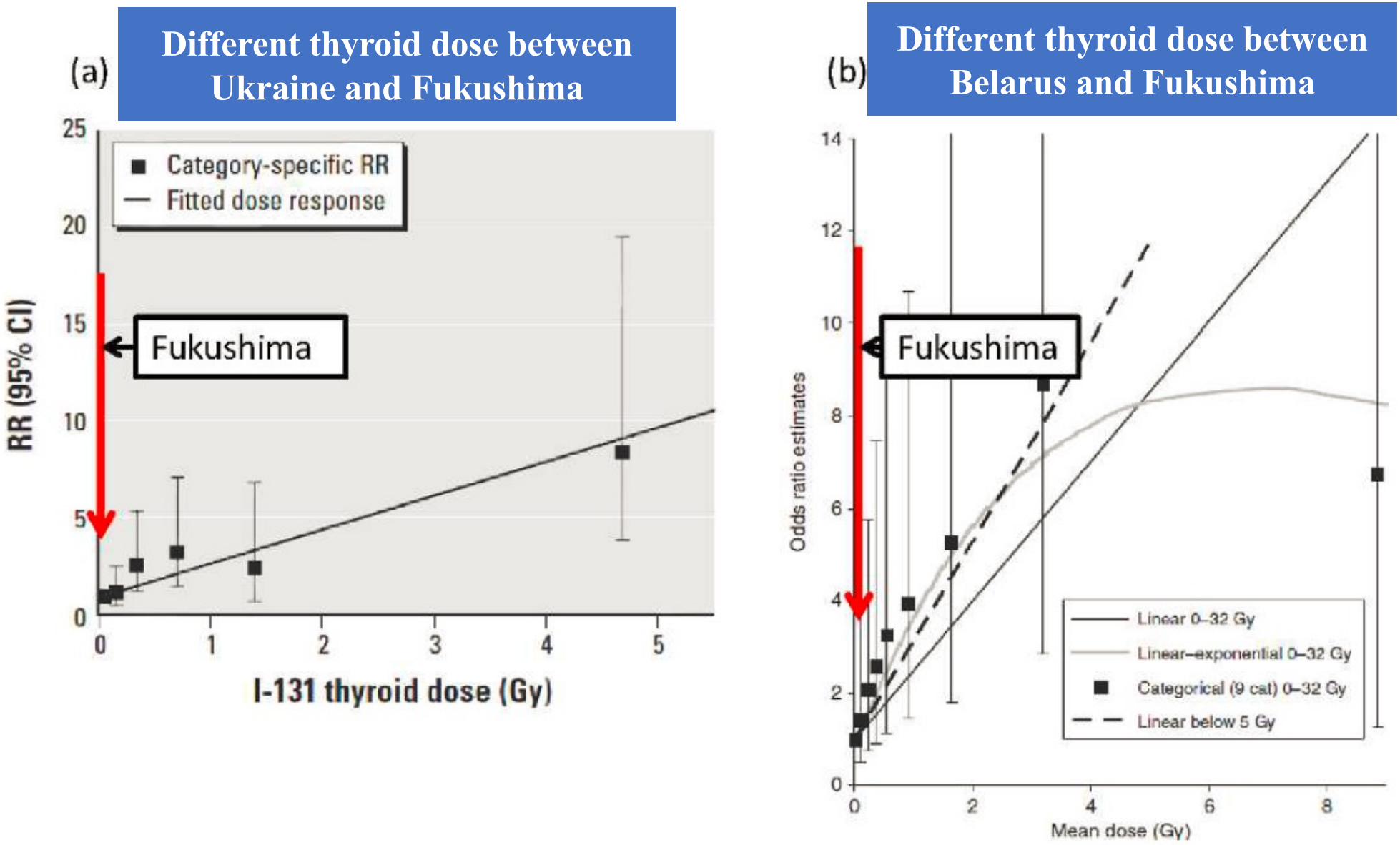


Fig.6. Panel a: Thyroid radiation doses in Fukushima, Ukraine and Belarus in dose-response relationship between thyroid cancer and ^{131}I. Panel b: Dose-response relationship for the incidence of thyroid cancers. Both figures were modified from two articles (republished with permission, Brenner AV, et al. *Environ Health Perspect* 2011; 119: 933-9 and Zablotska LB, et al. *Br J Cancer* 2011; 104: 181-7).

Radiation Research 180(5):439-447, 2013

- *The first five years' results demonstrated a high detection rate of thyroid cancer in young individuals revealing 116 and 71 cases*

in the first and second rounds, respectively,

in the same cohort of about 300,000 subjects, aged at the time of accident from 0 to 18.

THYROID
Volume 28, Number 1, 2018
Mary Ann Liebert, Inc.
DOI: 10.1089/thy.2017.0283

Lessons from Fukushima: Latest Findings of Thyroid Cancer After the Fukushima Nuclear Power Plant Accident

Shunichi Yamashita,[1,2,3] Shinichi Suzuki,[4] Satoru Suzuki,[1] Hiroki Shimura,[5] and Vladimir Saenko[3]

The increase in risk for late-onset thyroid cancer due to radiation exposure is a potential health effect after a nuclear power plant accident mainly due to the release of radioiodine in fallout. The risk is particularly elevated in those exposed during infancy and adolescence. To estimate the possibility and extent of thyroid cancer occurrence after exposure, it is of utmost importance to collect and analyze epidemiological information providing the basis for evaluation of radiation risk, and to consider radiobiology and molecular genetics. In this regard, the dose–response of cancer risk, temporal changes in the rates of thyroid cancer, its histopathological types and subtypes, and frequency of underlying genetic abnormalities are important. At present, however, it is difficult or impossible to distinguish radiation-induced thyroid cancer from spontaneous/sporadic thyroid cancer because molecular radiation signatures, biomarkers of radiation exposure, or genetic factors specific to radiation-induced cancer have not yet been identified. The large-scale ultrasound screening in Fukushima Prefecture of Japan demonstrated a high detection rate of thyroid cancer in young individuals, revealing 116 and 71 cases in the first and second rounds, respectively, among the same cohort of approximately 300,000 subjects. These findings raised concerns among residents and the public that it might be due to putative exposure to radiation from the accident at Fukushima Daiichi Nuclear Power Plant. This review summarizes evaluations by international organizations and reviews scientific publications by the authors and others on childhood thyroid cancer, especially those relevant to radiation, including basic studies on molecular mechanisms of thyroid carcinogenesis. Clinical details are also provided on surgical cases in Fukushima Prefecture, and the effect of thyroid ultrasound screening is discussed. Correct understanding of issues relating to radiation and the thyroid are essential for interpretation of thyroid cancer in Fukushima.

Interpretation of Fukushima Data

How to interpret more than 270 cases of childhood/adolescent thyroid cancer detected in Fukushima in the past 10 years (2011-2021)

due to sophisticated US Mass Screening from neonates to young adolescence

Screening Bias/Harvest Effect

Latency and Dose; Fukushima ＜Chernobyl

Unlikely due to radiation exposure

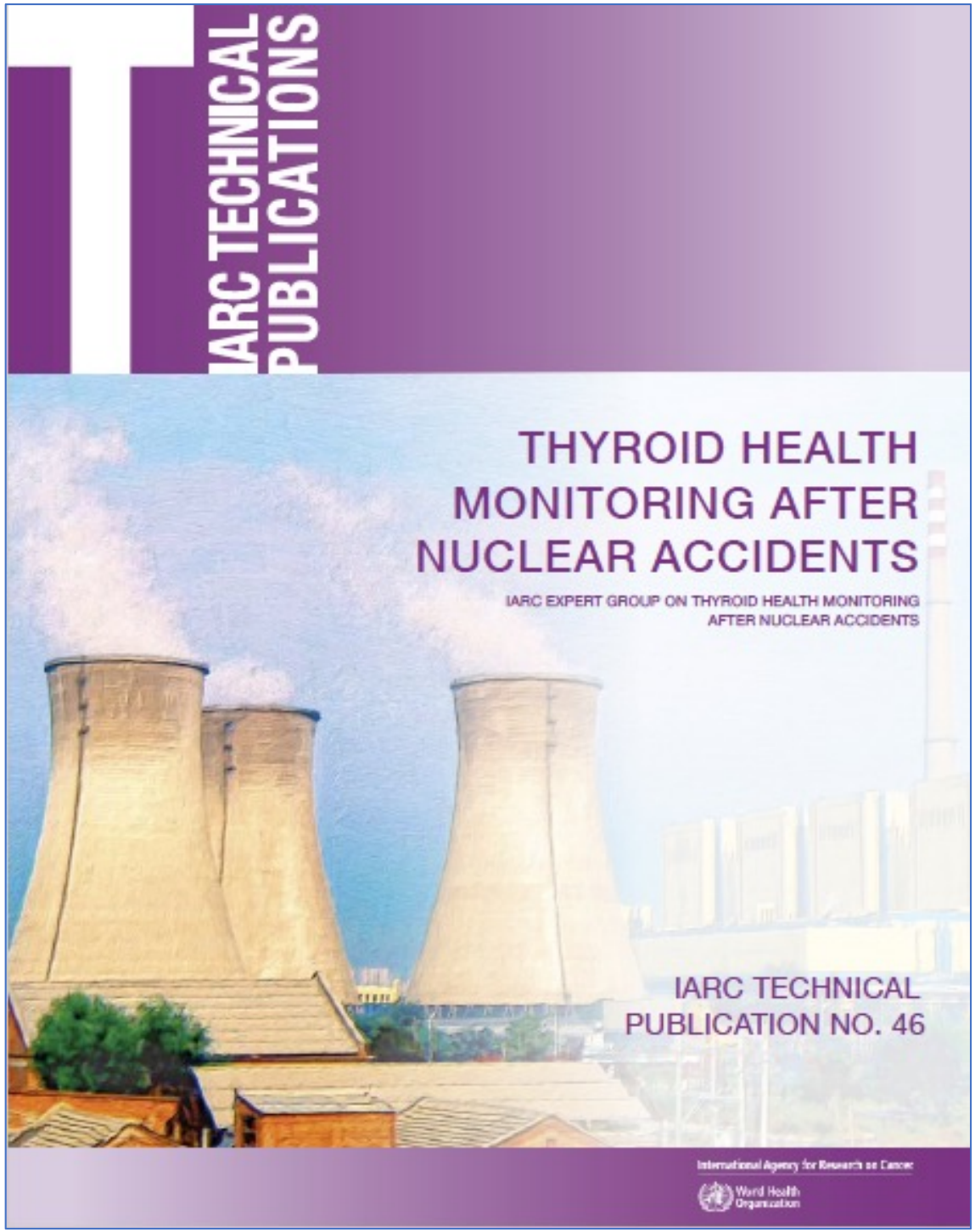
Basal prevalence of thyroid cancer

Overdiagnosis?

unnecessary examination?
indolent tumor?
life-time asymptomatic microcarcinoma PTC?

- merits and demerits of early diagnosis by US screening-

5~10mm in tumor size;
***indication of FNA cytology**
***watch and wait strategy**



- Recommendation - 2018

1.
The expert group **recommends against population-based thyroid screening after a nuclear accident.**

2.
The expert group **recommends that consideration be given to offering a long-term thyroid monitoring programme for higher-risk individuals* after a nuclear accident.**

higher-risk individuals **are defined as those exposed in utero or during childhood or adolescence with a thyroid dose of 100-500 mSv or more.**

Five Medical Support Centers for Advanced Radiation Emergency Medicine in JAPAN

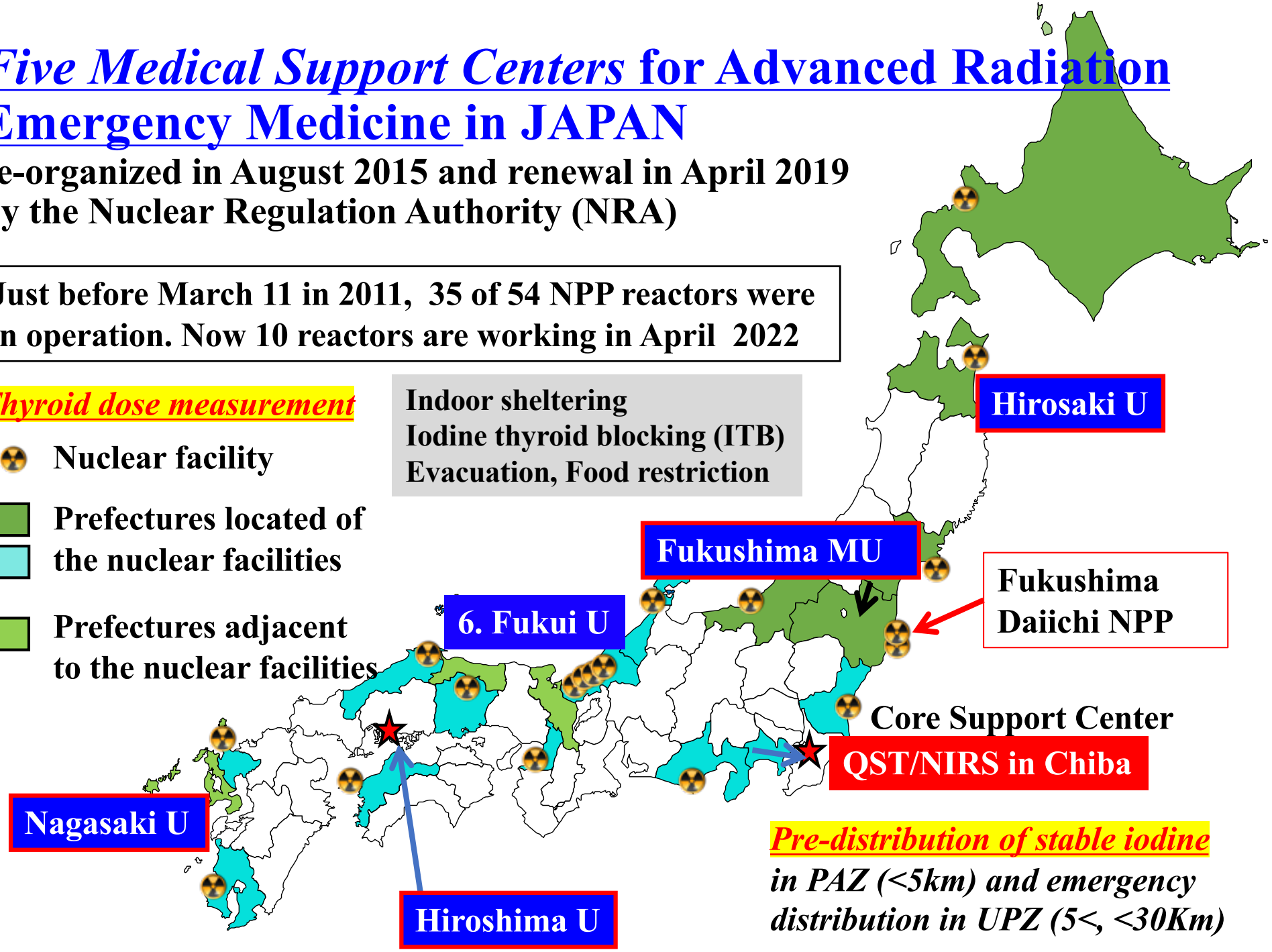
re-organized in August 2015 and renewal in April 2019 by the Nuclear Regulation Authority (NRA)

Just before March 11 in 2011, 35 of 54 NPP reactors were in operation. Now 10 reactors are working in April 2022

Thyroid dose measurement

- Nuclear facility
- Prefectures located of the nuclear facilities
- Prefectures adjacent to the nuclear facilities

Indoor sheltering
Iodine thyroid blocking (ITB)
Evacuation, Food restriction



Pre-distribution of stable iodine

in PAZ (<5km) and emergency distribution in UPZ (5<, <30Km)

Lessons learned from Fukushima NPP accident

(1) Although the risk of radiation-associated health consequences in Fukushima is considerably low and negligible based on the estimated radiation doses individuals received, *a high prevalence of childhood and adolescent thyroid cancers detected by a population-based screening aggravates negatively radiation fear and anxiety, especially by a wrong interpretation of the Fukushima's data and through the fear and anxiety of the second coming Chernobyl.*

(2) It is, therefore, critically important for the medical experts as well as radiation protection members and administrative officers to explain the current prevalence of thyroid cancers in Fukushima to the public correctly *as a screening effect but not as epidemic due to direct linkage of radiation-induced.*

***(3) Sound radiation risk learning and dialogue with the public* is currently challenged during the recovery phase after NPP accident.**