

Radiation and Children's Health

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Since the Tokyo Electric Power Co.'s Fukushima Daiichi Nuclear Power Plant disaster triggered by the Great East Japan Earthquake, the citizens of Fukushima Prefecture have lived with anxiety and rumors caused by the considerably confusing information regarding the health effects of the radiation exposure. The real nature of this anxiety can be summed up in two points: (1) the future being unclear and (2) not knowing what can be trusted. It is thought that most of the causes of such are due to having believed false information regarding the radiation and because of not being able to understand the right information correctly.

For the healthy growth of children in Fukushima Prefecture, it is indispensable that we, the adults, properly understand the correct information about the radiation, and we need to have the strength to raise our children in this place with resolute minds and confidence so as to not be defeated by anxiety and rumors. The author feels, based on the interactions with parents, that the misunderstandings and anxieties regarding radiation still remain and summarizes the kinds of ideas that are important in order to solve this issue.

I. Past Developments

Just after the nuclear power plant accident, the government's expression, "No immediate health effects" gave rise to negative speculation. The interpretation, "There must be some kinds of effects, which are not immediate, in the future" was spread as if it was true. The emergency measure, "Exposure to radiation that does not exceed 20 mSv per year" also created a misunderstanding that people were forced to be exposed to radiation at that dosage. There were also conflicting opinions. One was that of the experts that there would be few long-term human health influence. The other, espoused by those who considered themselves to be knowledgeable, was that the health effects would certainly appear eventually, and that all children in Fukushima Prefecture should be evacuated. Furthermore, in the opinions of most in the media and on the Internet, the web of false information was confusing, and the experts, who advocated that there were little health effects, were criticized as being government-patronized scholars. The author has the impression that such criticism made many

doctors in Fukushima Prefecture stay quiet. Moreover, the appropriateness of the use of nuclear energy and the human health influence of the radiation exposure because of this accident were discussed in the same context in some instances, and the general population in Fukushima Prefecture has lived in anxiety, making it unclear who or what to trust.

II. Misunderstandings Regarding Radiation

The author has been holding lectures regarding “Radiation and Children’s Health” in various venues in Fukushima City since October 2011, with the aim of alleviating the anxiety of child-rearing parents, in cooperation with the Department of Health Promotion in Fukushima City and the Committee on Mother and Child Health of the Medical Association of Fukushima City. It was found, based on the questions received during those lectures and from daily outpatients, that there were several misunderstandings regarding the radiation.

1. Does the Radiation Received Accumulate in the Body and Result in Health Damage?

Understanding the cumulative amount of radiation received is important to understand the effects of radiation on the body. However, it has been found that more than a few people thought that they were exposed to radiation because this cumulative amount remained in the body or, in other words, because the external dosage remained in the body upon exposure. This misunderstanding was particularly common among elderly people. It is thought that the information about the dosage of 20 mSv and such created this misunderstanding, “It is dangerous when it stays in the body.” Internal exposure was confused with external exposure.

2. Does Low-Dose Exposure have an Influence on Children in Fukushima?

We can still find blog posts and tweets claiming that there are abnormalities in children in Fukushima due to the low-dose exposure. “Nose bleeding comics” caused controversy recently, and the magnitude of the misunderstanding was re-experienced. It is a clear misunderstanding that the number of children who experience nosebleeds increased in Fukushima Prefecture after the accident due to radiation exposure. Radiation exposure causes nose bleeding when one is exposed to high doses (500–2,000 mSv), which inhibits the hematopoietic functions of bone marrow. In other words, it is the manifestation of a deterministic effect (**Figure 1**). Such high doses of radiation could not occur in the areas in Fukushima where the general public lives, even during the time of the accident, and nose bleeds due to radiation exposure are medically inconceivable.

The health effects that one should be concerned with regarding the radiation exposure caused by this nuclear power plant accident are the existence of an increase in cancer and leukemia cases due to long-term low-dose exposure. This is a stochastic effect (**Figure 2**). It is becoming more and more clear that the possibility is extremely low based on past health surveys of citizens of the prefecture. Nevertheless, the deterministic effects and the stochastic effects are often confused. In fact, we can find such false information on the Internet regarding the health effects covered in Fukushima.

One of the reasons that there is no end to such a misunderstanding is because, “radiation damages genes.” Therefore, it creates the perception that radiation is terrible, that the slightest

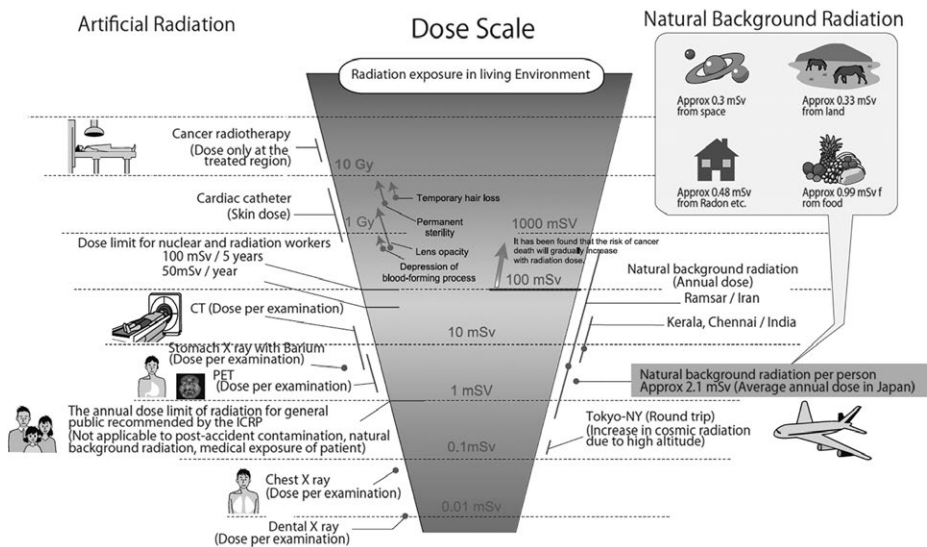


Figure 1 Comparison of Exposure Doses (Simplified Chart)

Retrieved from National Institute of Radiological Sciences web site.

Deterministic effect: Eliminate the effect by limiting the dose below the threshold

Stochastic effect: Assume that there is no threshold and lower the dose as much as possible to make the probability that the effect appears to be at an acceptable level

* Threshold: The value at the boundary regarding whether a certain action induces a response

Deterministic effect (alopecia, cataract, etc.)

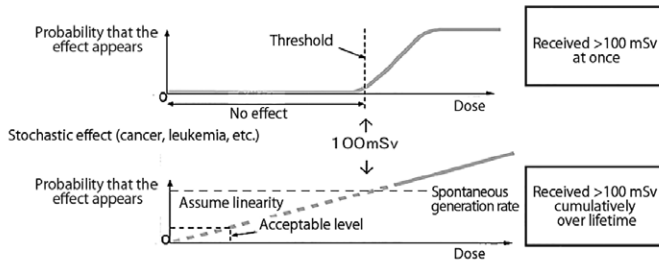


Figure 2 Thought process on radiation protection

Retrieved from "Committee on answering questions regarding radiation", Japan Atomic Energy Agency.

exposure can damage genes, and that the cells will become cancerous in the future. Speaking of the gene damage caused by radiation, radiation itself breaks down genes in around one-third of cases. Genes are more likely to be damaged by the activated oxygen generated by the radiation in the cell. Moreover, the factor that generates the activated oxygen is not limited to the radiation. It is known that the activated oxygen increases due to one's lifestyle, such as due to smoking, stress, etc., and the effects of one's mental condition. In this manner, genes in all cells are not only damaged by radiation. It is not widely known that approximately 70,000 genes in the cells are spontaneously damaged every day due to the activated oxygen generated in the body and repaired each time.

3. Are the Japanese Provisional Standards for Food too High?

The provisional standards of radioactive cesium set by the government in fiscal year (FY) 2011 were: 200 Bq/kg for drinking water, milk, and dairy products; and 500 Bq/kg for vegetables, grains, meat, eggs, fish, etc., and food products exceeding these criteria were not allowed to be shipped. However, since not all bags of rice were inspected when they were shipped in this FY, rice having >500 Bq/kg was shipped from a part of the rice made in Fukushima. This made headlines and resulted in spurring on the damage caused by harmful rumors. If a Japanese adult eats rice with 500 Bq/kg for 1 year (approximately 60 kg), the internal exposure is calculated to be only 0.15 mSv a year (**Figure 3**). Of course, this is a “hypothetical calculation” and does not mean that one can proactively eat rice with a higher radiation dosage than the provisional standards.

The standards have been further lowered since April 2012 and these continue to be used to this day. The current Japanese standards, including the provisional values, are considerably low, even when compared with the standards in the former Soviet Union at the time of the Chernobyl Nuclear Accident; countries such as Russia, Ukraine, etc., 5 years after the accident; and the EU (**Tables 1 & 2**).

The method used to determine the standards used by the Food Safety Commission is based on the determination, “The possibility of health effects becomes apparent when the cumulative dose exceeds 100 mS as the lifetime additional exposure, except for dosages received during everyday life such as natural radiation (2.1 mSv/year in Japan), medical exposure, etc.” The standards are then calculated so that the additional exposure received by ingesting food is within a range that does not exceed 1 mSv a year.

In terms of cesium-137, it was also not generally known that the physical half-life and biological half-life in the body are different. The physical half-life of cesium-137 is 30 years,

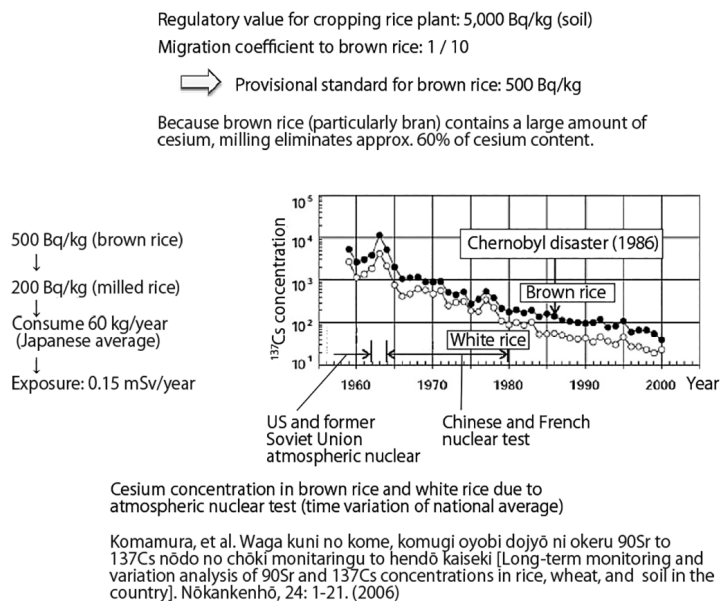


Figure 3 How about the effect of cesium contained in rice?

Retrieved from “Committee on answering questions regarding radiation”, Japan Atomic Energy Agency.

Table 1 Changes in the food intake tolerance level in the former Soviet Union–Russia, etc.
Table: Action level for cesium in food (Bq/kg)

	Codex	EC*	USSR, TPL			Belarus	Russia	Ukraine
	1989	1986	1986	1988	1991	1999	2001	1997
Milk	1,000	370	370	370	370	100	100	100
Baby food	1,000	370	—	370	185	37	40–60	40
Dairy products	1,000	600	3,700	370–1,850	370–1,850	50–200	100–500	100
Meat	1,000	600	3,700	1,850–3,000	740	180–500	160	200
Vegetable	1,000	600	3,700	740	600	40–100	40–120	40–70
Bread	1,000	600	370	370	370	40	40–60	20

* Action level for imported food prompted by the Chernobyl disaster

April 24, 2007: The Japan Nuclear Safety Commission
Retrieved from the Nuclear Safety Commission and “Q&A for radiation and food,” Consumer Affairs Agency.

Changes in the standards for radioactive cesium intake limits in Japan

Until March 31, 2012			After April 1, 2012	
Drinking water	200	➡	Drinking water	10
Milk, dairy products			Milk, baby food	50
Vegetables	500		General food	100
Grains				
Meat, egg, fish, etc.				
		(Bq/kg)	(Bq/kg)	

Table 2 Guidelines on radioactive substances in food around the world (Bq/kg).

Nuclide	Japan		Codex		EU		US	
Radioactive cesium	Drinking water	10			Drinking water	1,000		
	Milk	50			Dairy products	1,000		
	Baby foods	50	Baby foods	1,000	Baby foods	400	All foods	1,200
	General food	100	General food	1,000	General food	1,250		
Upper limit for additional dose	1 mSv		1 mSv		1 mSv		5 mSv	
Estimated percentage of foods that contain radioactive substances	50%		10%		10%		30%	

※Because the standard values take the amount of consumption of foods, and estimated percentage of foods that contain radioactive substances, etc., into consideration, it is not possible to compare only the numerical values. The upper limits for additional doses from foods in the Codex, EU, and Japan are the same at 1 mSv/year.

Retrieved from “Q&A for radiation and food,” Consumer Affairs Agency

whereas the biological half-life in the body is 9, 38, 70, and 90 days in infants, children age ≤9 years, individuals aged ≤30 years, and individuals aged ≤50 years, respectively. In other words, the biological half-life in the body is shorter in younger children, whose metabolism is faster. Even though the same quantity of food with the same Bq/kg is taken in, children excrete it from the body more quickly than adults.

Most of the agricultural products currently distributed in Fukushima have a radiation level below the detection limit. Despite that, there is also a misunderstanding regarding internal exposure, because it is said that infants are more susceptible to radiation; it is regrettable that there are still people who are hesitant to consume agricultural products made in Fukushima.

4. Will There be Thyroid Cancer and Other Health Effects in Many Children in Fukushima in the Future?

Self-proclaimed experts have actively voiced this idea since just after the accident, and many mothers and children voluntarily evacuated because of that. However, the fact that this concern is extremely low is becoming clear based on the health survey conducted on the citizens of the Prefecture described below as well as other surveys. In reality, however, due to this false information, the younger generation still secretly has anxiety as to whether or not they are allowed to get married, and regarding whether it will be all right for them to have children in the future.

Why, then, do such things have to be said about the children in Fukushima in this way? One of the major reasons may reside in the fact that thyroid cancer increased among children due to the Chernobyl Nuclear Power Plant disaster. The fact that the TEPCO Fukushima Daiichi Nuclear Power Plant disaster was classified as level seven on the International Nuclear Event Scale (INES)—the same as Chernobyl—1 month after the accident is also one of the factors. In other words, it ended up giving rise to speculation that the same thing that happened in Chernobyl would happen in Fukushima as well.

However, in reality, the magnitude of the accidents and the measures and steps taken by the governments just after the accidents were different (**Table 3**). Furthermore, the healthcare and the economical background as well as the lifestyles, including the food of inhabitants between the former Soviet Union (at the time of the accident) or Russia, Ukraine, and Belarus (thereafter), and current Japan were also different.

Because a thyroid hormone is made from iodine, iodine is always stored in the thyroid gland at a certain ratio. Although iodine is contained in seaweed in large quantities, the inhabitants of the inland area in the former Soviet Union do not have a custom of eating seaweed, and many suffer from chronic iodine depletion. Radioiodine can easily enter a thyroid gland that lacks iodine. It is also thought that a custom of consuming many mushrooms, which easily absorb radioactive materials, resulted in even more radioiodine being absorbed.

On the other hand, Japanese have a custom of consuming iodine-rich seaweed and have a tendency toward having a chronic surplus of iodine. Therefore, it is thought that radioiodine

Table 3 Comparison between Chernobyl and Fukushima

	Chernobyl April 26, 1986	Fukushima Daiichi March 11, 2011
Reactor type	Graphite-moderated pressurized boiling water	Boiling water
Containment vessel	No	Yes
First response	Control rod not inserted	Control rod inserted
Amount of radioactive materials released	5.2 million TBq	0.57 million TBq
Announcement after the explosion	After three days Official announcement by the President was 10 days later	Same day
Maximum air dose just after the accident	3,306 $\mu\text{Sv/h}$	170 $\mu\text{Sv/h}$
Milk contained radioactive iodine	Circulated	No Circulated
Radiation dosage from radioactive iodine	50-100 mSv~2,000 mSv	0.01~0.1 $\mu\text{Sv/h}$ (45% of 1,149 people)
Thyroid cancer	6,848 people (Younger than 18 yo. at the time of accident)	?
Number of death due to thyroid cancer	15 people (0.22%)	?

* 24–30 March: Measured on children aged 0–15 in City of Iwaki, Town of Kawamata and Village of Iidate 99% of the children measured 0.04 mSv/h or less, 50 mSv depository dose equivalent Nuclear Safety Commission

Retrieved from Okazaki, T. “Urgent radiation exposure guide to be learned from the basics”

has a difficult time entering thyroid glands that have a surplus of iodine. Furthermore, in terms of the response by the government after the accident, in the case of the former Soviet Union, the truth was concealed for three days, and the general public continued to live normal lives during that time. In contrast, in Fukushima the inhabitants in the surrounding area evacuated that same day. Although some local residents lived with a slightly higher radiation dose, the dose was much lower than the environmental pollution caused by the Chernobyl Accident. A subsequent survey also showed that the dose was not high enough to cause any human health influence. Shipments of all agricultural and livestock products from Fukushima were also suspended.

It is a mistake to argue as if the health effects caused by the Chernobyl disaster and the Fukushima Daiichi disaster are similar without considering such differences. To do so only gives rise to anxiety and confusion among the general public, who have lived and continue to live in Fukushima.

III. Health Survey of the Inhabitants in the Prefecture

Based on the results of the health surveys conducted thus far, it is becoming clear that the future health effects, regarding both the internal and external exposure, are extremely low in children.

1. External Exposure

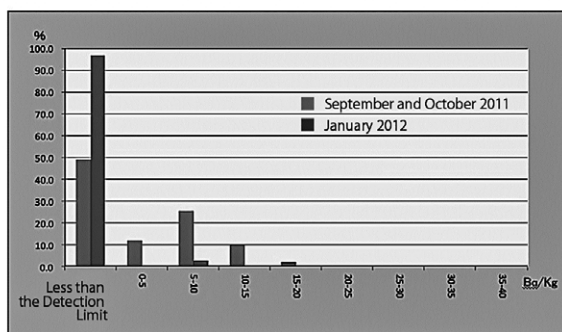
According to the survey on external exposure conducted in each municipality in the prefecture using the glass badge, >90% inhabitants received less than 1mSv per year, which is the long-term target for acceptable additional exposure set by the government based on the International Commission on Radiological Protection recommendations. Although some inhabitants received more radiation at first in 2011 (but even that dosage was not high enough to cause any human health influence), they were all adults, and it was thought that this was due to engaging in farming in the open air for a long time.

2. Internal Exposure

A survey on internal exposure using whole-body counting (WBC) has been conducted in each municipality in the prefecture since FY 2011. According to the aggregate total of the examination results from each municipality, the committed effective dose of all 7,204 people examined in October 2014 was <1 mSv. The committed effective dose is the integrated value of close to the lifetime's worth (50 years for adults, 70 years for children) of an effective dose for internal exposure caused by radioactive materials taken into the body. It is calculated as if those doses were received in the first year. Similar to the external exposure, although some inhabitants appeared to have slightly more internal exposure at first in 2011 (this was also not a level that actually causes human health influence), it is believed that this was due to the consumption of vegetables, wild boar, etc., which were not measured.

Figure 4 shows the results of the WBC performed for children living in Minamisoma City at the Minamisoma Municipal Hospital in 2011. When the results of 527 children examined in September and October in 2011 and the results of 386 children of the same group examined in January 2012 are compared, just under 60% of them were at less than the detection limit in

Number of test subjects according to Cs-137 dosage in the body
 Intended for children, conducted on September and October 2011 (n = 527) and January 2012 (n = 386)



When 527 children examined in September and October in 2011 and 386 children examined in January 2012 are compared, the percentage of the detection limit or less increased to 90% in January this year. Together with the results of the re-examination, the internal exposure from food is supposed to be next to none in children at this moment.

Figure 4 Internal exposure examination in Minamisoma City
 Retrieved from Minamisoma Municipal Hospital website.

September and October, whereas the percentage increased to 90% 3 months later in January, indicating the elimination of cesium from the body.

The consumers' cooperative Co-op Fukushima has been continuously measuring the radioactive materials contained in the food prepared with the cooperation of its members since November 2011 to confirm the safety of food and to eliminate the anxiety toward internal exposure. In the duplicate diet method, one more set of meals than those needed for the number of family numbers is prepared every time, and the radioactive materials contained in 1 kg of the 2 days' worth of meals are measured. Over 90% of the 100 households who participated in the survey used ingredients made in Fukushima.

In the second half of FY 2011, ≥ 1 Bq/kg of cesium were detected in 10 households. If we assume that these households consume the same foods used for the measurement for 1 year and calculate the effective dose of cesium, it will only be approximately ≤ 0.02 – 0.14 mSv per year. In the second half of FY 2013, ≥ 1 Bq/kg of cesium were detected in four households out of 100. When we calculated the effective dose in the same way, it was 0.04 mSv at the maximum. Most of that detected on the graph is potassium-40 (**Figure 5**).

Based on the observations above, it is assumed that the concern about human health influence due to internal exposure is next to none, even if people consume agricultural products from Fukushima.

3. Thyroid Inspection

In Fukushima Prefecture, thyroid gland examinations using ultrasound have been conducted for all children aged ≤ 18 years in the prefecture, who were born at the time of the accident, since November 2011. The judgment of the results is done based on the criteria of the Thyroid Cancer Society as follows:

A: Considered to be within a normal range

A1: There are no cysts or tubercles

A2: Tubercles of ≤ 5.0 mm, and/or cysts of ≤ 20.0 mm

B: Tubercles of ≥ 5.1 mm, and/or cysts of ≥ 20.0 mm

C: A detailed examination appears to be required immediately

To compare this with other prefectures, similar examinations were also performed in three

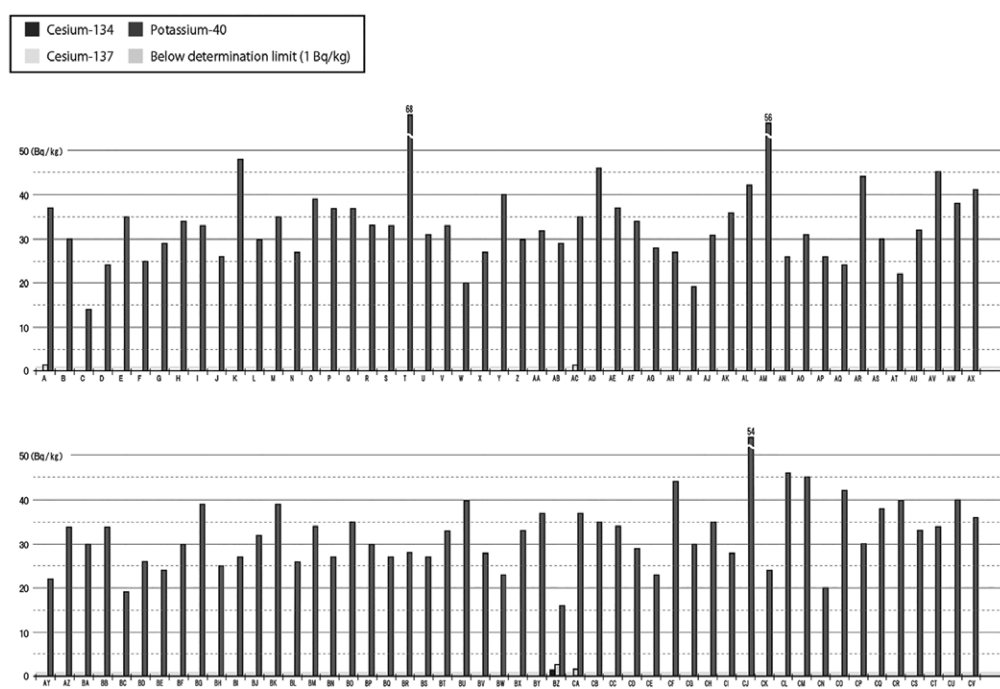


Figure 5 Duplicate diet method radiation dosage survey results (reported on March 7, 2014)
Retrieved from Co-op Fukushima website.

Prefectures: Aomori, Yamanashi, and Nagasaki. The results show that there was no difference in the percentages of A1 and A2 between Fukushima Prefecture and other prefectures (Figure 6).

In terms of the B and C verdicts, malignancy or possible malignancy totaled 109 people (Among them, 85 people were operated on. Breakdown: benign tubercle, 1; papillary cancer, 81; poorly differentiated cancer, 3); the ratio of male to female, 38–71; average age, 17.2 ± 2.7 years (8–21 years; at the time of the earthquake, 14.8 ± 2.6 years (6–18 years); and average tumor diameter, 14.1 ± 7.3 mm (5.1–40.5 mm) as of November 11, 2014. It is said that thyroid cancer in children because the Chernobyl disaster increased beginning 4–5 years after the accident, and the primary ages of onset were babies and toddlers. On the other hand, most of the malignancy to possible malignancy cases were in their late teens according to the results of the thyroid inspection conducted in Fukushima (Figure 7).

If the thyroid cancer cases detected in the thyroid inspections currently being performed in Fukushima are occurring due to the exposure to radioiodine generated by the nuclear plant accident, the cases should be more detectable among local children in the area where the radiation dose was high, and in infants and toddlers said to be susceptible to radiation exposure. However, there have been no differences seen in the rate of onset among children in Hamadori District, the evacuation zone, Nakadori District, and Aizu District.

In addition, as shown in Table 3, the dosage in Fukushima was considerably lower than that in the Chernobyl disaster. Therefore, it is considered to be appropriate to assume that the thyroid cancer cases currently being detected are not due to the effects of radiation exposure, but something that already existed that is being detected early by the screenings.

The progress of thyroid cancer, and papillary cancer in particular is slow, and it is said

First round thyroid examination: Comparison of Fukushima Prefecture and three other Prefectures

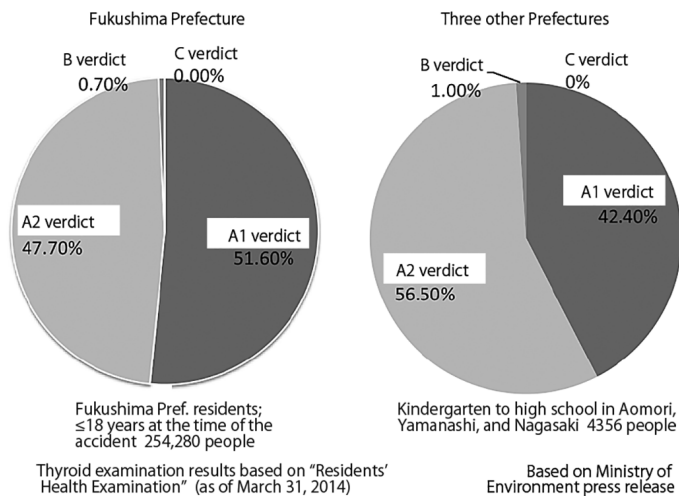


Figure 6 Comparison of Fukushima and three other Prefectures

Total from 2011–2013

- Malignancy to possible malignancy; 109 (operated, 85: benign tubercle, 1; papillary cancer, 81; poorly differentiated cancer, 3)
- Male:female = 38:71
- Average age, 17.2 ± 2.7 years (8–21 years); at the time of the earthquake, 14.8 ± 2.6 years (6–18 years)
- Average tumor diameter, 14.1 ± 7.3 mm (5.1 – 40.5 mm)

Age and gender distribution of 104 people diagnosed as malignant or possibly malignant by biopsy

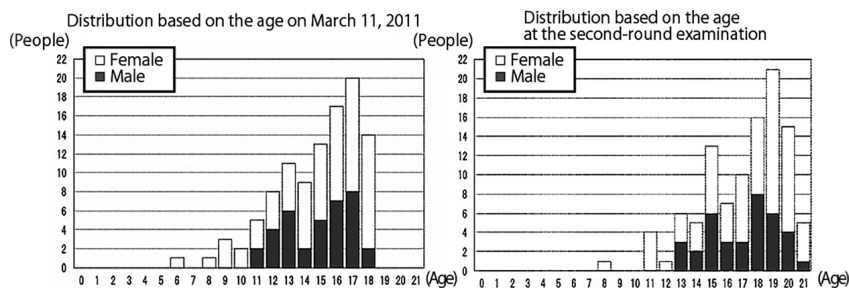


Figure 7 Overview of the results of thyroid examination in Fukushima Prefecture
Retrieved from Fukushima Prefecture website.

that there is 3%–10% of latent thyroid cancer discovered during autopsies in cases where the victims died of another disease, and most of these are papillary cancers of ≤ 5 mm diameter. Thyroid cancer with a maximum diameter of ≤ 10 mm is classified as micro-cancer, and the majority of these are papillary cancers. It has been thought that it remains as latent cancer, because it does not develop into a clinically tangible thyroid tumor. With the recent rapid improvement in image analysis through ultrasound diagnosis, the detection rate of micro-cancers has also increased. It is well known that, when the ultrasound diagnosis of the thyroid gland is conducted in tandem with that of breast cancer in Korea, thyroid cancer

increased. Similarly, there is a possibility that the detection rate of micro-cancers in thyroid inspection could increase as the number of cases inspected increases, which has been pointed out in Fukushima as well.

Following the first round of examinations conducted in 2011, the second round of examinations are being conducted as of April 2014. There was a report that thyroid cancer was found in four children on December 23rd of this year (2015). These four children are the ones with the A verdict in the first round. According to Fukushima Prefecture, the houses where those four children lived at the time of the accident does not have a tendency, and the dosage is much lower than that of Chernobyl; therefore, it is hard to imagine that there are effects from the Fukushima nuclear plant accident.

In Fukushima Prefecture, examinations are expected to be conducted every 2 years until the children reach 20 years of age and every 5 years thereafter. Some view these examinations as excessive. However, the author thinks that they are important for alleviating the anxiety of the citizens in the prefecture in the future to prove whether or not the radiation exposure has had any effect on the children in Fukushima Prefecture, and that the continuous follow-ups are required to protect the health of children in the future.

IV. Creativity in Life Going Forward

The safety of all food products from Fukushima currently in the marketplace has been confirmed, and the local environmental radiation levels in the areas where the general public is living are considered to pose little to no human health influence. For the healthy growth of children in Fukushima in the future, one must nurture the five senses so as to understand the true taste and deliciousness of seasonal ingredients; engage in play using the body; and repeat experiences to directly feel the nature by touching soil, trees, plants, water, etc.

To that end, we the adults need to properly understand the meaning of becquerel and sievert and recognize that the current exposure dose that is added to the dose received from the natural environment poses almost no health effect in the future. It is also important to understand that most of the causes of cancer and other diseases are strongly affected by one's lifestyle such as smoking, alcohol consumption, an unbalanced diet, anxiety, stress, etc.; consider a lifestyle that minimizes these factors apart from the radiation; and raise children with strong hearts and serene love, while not being confused by anxiety-fomenting information.

V. Summary

Children, even the babies who do not yet speak, hear the conversations of adults and sense their unstable psychological conditions. That never has good effects on children's minds. The author thinks that, rather than living frightened by the slight risks that may or may not occur in the future, tidying up one's lifestyle and living every day with a bright and positive attitude leads to the healthy growth of children, which in turn plays a part in restoring normalcy.

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