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Childhood Thyroid Examinations in the Kanto Hotspot: A Report (Study Period: October 2013 to December 2017)

Yoshihiro NOSO[1)], Nobuo TAKEICHI[1,10,11)], Tsunetaka KIJIMA[1)], Yuko YANAGISAWA[2)], Motomi USHIYAMA[3)], Takashi SAWADA[4)], Yumiko OISHI TANAKA[5)], Nobuko EGUCHI[6)], Masamichi NISHIO[7)], Mitsunobu OISHI[8)], Yutaka ISHIBASHI[1)], Ken INOUE [9)], Masaharu HOSHI[11)]

[1)]*Department of General Medicine, Shimane University Faculty of Medicine, Izumo, 693-8501, Japan*

[2)]*Funabashi Futawa Hospital, Funabashi, 274-0805, Japan*

[3)]*Sagami Seikyo Hospital, Sagamihara, 252-0303, Japan*

[4)]*Minatomachi Clinic, Yokohama, 221-0056, Japan*

[5)]*Department of Radiology, Tsukuba University, Tsukuba, 305-8575, Japan*

[6)]*Hitachinaka General Hospital, Hitachinaka, 312-0057, Japan*

[7)]*Hokkaido Cancer Center, Sapporo, 003-0804, Japan*

[8)]*Co-op Jyoso, Moriya, 302-0109, Japan*

[9)]*Department of Public Health, Gunma University Graduate School of Medicine, Maebashi, 371-8511, Japan*

[10)] *Takeichi Clinic, Hiroshima, 732-0806, Japan*

[11)] *Hiroshima University, Research Institute for Radiation Biology and Medicine, Hiroshima, 734-8553, Japan*

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Similar to that in the Chernobyl nuclear accident, the occurrence of thyroid cancer in children was also feared following the Fukushima nuclear in Japan. Thyroid examination of children residing in the Fukushima Prefecture was performed quickly and nearly 200 cases or suspected cases of thyroid cancer have been reported. However, the thyroid glands of children evacuated from Fukushima and the hotspot area of Kanto have not been screened. Therefore, in response to requests from mothers outside Fukushima Prefecture, we started ultrasound examinations of the thyroid glands of children in October 2013. Since then, examinations have been performed annually until now. This report describes the results of these examinations performed through December 2017. The judgment standards for ultrasound examination of the thyroid gland were as indicated by Fukushima Prefectural University. Briefly, A1 judgment: without nodules or cysts, A2 judgment: with nodules measuring 5.0 mm or less or cysts measuring 20.0 mm or less, B judgment: nodules measuring 5.1 mm or more or cysts measuring 20.1 mm or more, and C judgment: requiring immediate secondary examination. Ultrasound examinations of the thyroid gland were conducted in the presence of family members and parents; in order to correctly convey the findings to the family, the findings were explained while viewing the images on the spot. Thyroid screening was conducted for residents of the Kanto hotspot for four years and a total of 8,171 people were examined. A1, A2, B, and C judgments were observed in 2,089 (25.6%), 5,969 (73.1%), 106 (1.3%), and 7 persons (0.1%), respectively. Nodules were noted in 226 patients (2.77%). At the time of the nuclear accident, pediatric thyroid ultrasonography was performed in a total of 7,693 children under 18 years of age. A1, A2, B, and C judgments were observed in 1,922 (25%), 5,735 (74.5%), B 34 (0.4%), and C two people (0.29%), respectively, and nodules were observed in 125 people (1.62%). The thyroid examinations were conducted annually by traveling through the hotspot. The number of A2 judgments increased each year, while the number of

Corresponding author: Yoshihiro Noso
Department of Health Service Management, Hiroshima International University Faculty of Health Service Management, 1-5 Nobori-cho, Naka-ku, Hiroshima 730-0016, Japan
Tel: +81-82-554-2069
Fax: +81-82-211-5166
Mobile: +81-90-4141-9251
E-mail: y-noso@hirokoku-u.ac.jp

B judgments did not increase. There was also no increase in the number of C judgments. The results of screening in the Kanto hotspot area revealed that, contrary to the expectation based on reports after the Chernobyl nuclear accident, the frequent occurrence of childhood thyroid cancer was not observed.

Key words: Fukushima power plant accident, childhood thyroid examination, hotspot in Kanto

INTRODUCTION

Childhood thyroid cancer is one of the many possible radiation-related health damages that occur following nuclear accidents [1]. In the Chernobyl nuclear accident, which occurred 30 years ago, many childhood thyroid cancers were observed five years after the accident. In particular, thyroid cancer occurred in girls aged between 0 and 5 years at the time of the accident [2, 3].

In March 2011, the accident at the Fukushima Daiichi Nuclear Power Plant occurred due to the Tohoku earthquake. As a result, the health hazards of residents due to radiation exposure were of great concern; therefore, thyroid examination of children under 18 years of age at the time of the accident in Fukushima Prefecture was performed by the Fukushima Health Investigation Committee [4].

The Fukushima and Chernobyl nuclear accidents were both major radiation level 7 accidents.

In the Japanese nuclear accident,

1) The residents around the nuclear power plant in Fukushima Prefecture were immediately evacuated.

2) The shipment and use of milk and food products from Fukushima Prefecture was prohibited.

3) The Fukushima nuclear accident had an approximately 10-fold lower radiation dose than that of the Chernobyl nuclear accident.

4) Because children in Fukushima Prefecture and the Kanto hotspot consume Japanese foods rich in marine products, the percentage of people with olfactory deficiency may have been lower than that in children in Chernobyl.

Based on these actions and observations, the occurrence of childhood thyroid cancer due to the Fukushima nuclear accident in Japan is reportedly is of concern [5, 6]. However, parents in the hotspot area, lacking radiation knowledge as well as medical and radiation exposure information, have been concerned about health damage caused by radiation exposure.

Children in Fukushima Prefecture have been provided three thyroid examinations by the Fukushima Prefectural Health Plan. However, children evacuated from Fukushima to other areas and children in the Kanto hotspot have not had the thyroid screening opportunities provided in Fukushima Prefecture. Many parents with children did not evacuate their children indoors because they were not informed that radiation had spread to their area of residence shortly after the accident. Therefore, they were concerned about damage to the thyroid gland of their children and wanted them to receive thyroid examinations. However, the opportunities for pediatric thyroid examinations outside Fukushima Prefecture were limited. Therefore, through the action of an NPO group (Joso Co-op Kanto Children's Health Foundation), it has become possible to conduct pediatric thyroid ultrasound examinations outside Fukushima Prefecture.

Our thyroid ultrasound examinations are conducted in the presence of parents so that their parents can fully understand the examination results. The purpose of the thyroid echo screening was not only to investigate thyroid abnormalities but also to ensure that the parents understood the results of the tests and to eliminate their anxiety regarding health problems. The examination results were carefully explained so that they could be understood correctly while viewing the ultrasound image on the spot. The ultrasonic examination apparatus was the same as that used in Fukushima and we also applied the same judgment standards.

We herein report the results of examinations in the Kanto hotspot performed between October 2013 (two years after the accident) and December 2017.

MATERIALS AND METHODS

Thyroid echography was conducted on child thyroid screening applicants outside Fukushima Prefecture and children living in the Kanto hotspot area.

That is, medical checkups were performed in Tochigi, Ibaraki, Chiba, and Kanagawa Prefectures. The study period was from October 2013 to December 2017 and examinations were performed on individuals 0-60 years of age.

Most of the examinees were 3-15 years of age. A total of 8,171 people, including adults, were emamined, of which 7,893 were under 18 years of age.

A portable Hitachi Noburus ultrasound echo system was used to perform the examinations; all examinees were provided identification cards and data management was performed.

Judgments were made according to the standard from Fukushima Medical University (Table 1).

One feature of our examination was that the family also participated in the thyroid examination and received explanations of the findings on the spot. At the same time, we also responded to the health concerns of the family. All test results, along with images, were recorded on a document and provided to the families. The goals of the thyroid examination of these children were the early detection of childhood malignancy and relief of anxiety regarding health damage caused by radiation exposure. The examinations were performed once or twice a month.

Several physicians were responsible for performing 80-120 medical examinations during for each screening visit. The results of the medical checkups were strictly handled and managed as personal information.

RESULTS

A total of 8,171 individuals were screened between October 2013 and December 2017.

The number of individuals requesting screening peaked in the third year after the accident and decreased gradually thereafter. Few people received examinations every year and, for most, it was their first examination (Fig. 1). Among surveyor classifications by prefecture, Ibaraki Prefecture, located near Fukushima, had the most applicants, followed by Chiba and Tochigi (Fig. 2).

We targeted the children who had aged 18 or less when the Fukushima nuclear accident happened for the thyroid examination. The most common age distribution for the examination was the 6-year-old (n = 966, 11.8%), followed by the 7-year-old (n = 964, 11.8%) and the 5-year-old (n = 879, 10.8%). In addition, the thyroid screening applicants also included adults. Adults applicant ages reached maximally 76 years old, with those aged 40-49 years the most frequent (n = 221), followed by those aged 30-39 years (n = 128), mostly the mothers of the children (Fig. 3).

The thyroid ultrasound examination results included 2,089 (25.6%), 5,969 (73.1%), 106 (1.3%), and seven (0.1%) A1, A2, B, and C judgments, respectively. Nodules were noted in 226 patients (2.77%). As a result, A1, A2, B, and C judgments were reported for 1,922 (25%), 5,735 (74.5%), 34 (0.4%), and two individuals (0.29%), respectively, with nodules observed in 125 (1.62%) of individuals. No malignancies were found in the secondary examinations of both individuals with C judgments (Table 2).

Examination results according to sex among children under 18 years of age revealed that, among 2,392 boys, 649 (27.13%), 1,773 (72.45%), nine (0.38%), and one (0.04%) had A1, A2, B, and C judgments, respectively. Among 2,259 girls, 536 (23.73%), 1,709 (75.65%), and 14 (0.62%) had A1, A2, and B judgments, respectively. C judgement had nothing (Fig. 4).

Examination of the results by prefecture were shown in Fig. 5.

We also compared thyroid examination results each year. Even several years after the accident, the lower the age, the greater number of A1 judgments, while the occurrence of A2 judgments; i.e., the tendency to gradually develop cysts in the thyroid, was unchanged with age. However, approximately 18 years or older people gradually experienced to be found thyroid nodules after 5 years since the nuclear accident (Fig. 6). In addition, examination of the results by sex each year showed a tendency for the number of A1 judgments to decrease in both sexes (Fig. 7).

Examination of the appearance of cysts showed a gradual increase from 1 year of age, peaking at 11 years. The incidence of cysts gradually decreased with age. The incidence of cysts at 11 years of

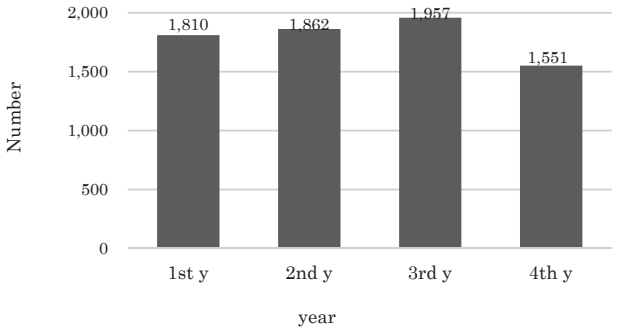

Fig. 1. Change in the number of thyroid examination people by year
At the beginning of the nuclear accident, there were a large number of medical examiners, but with the year the number of medical examination applicants has been on the decline. The thyroid examiner was mostly a first visit.

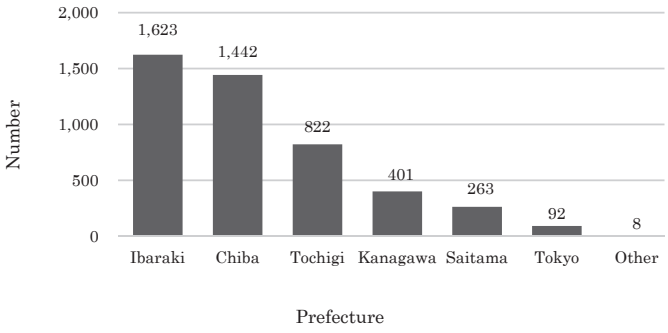

Fig. 2. Classification according to Kanto hotspots and prefectures
The most frequent thyroid examiners aged under 18 was next to Fukushima Prefecture.

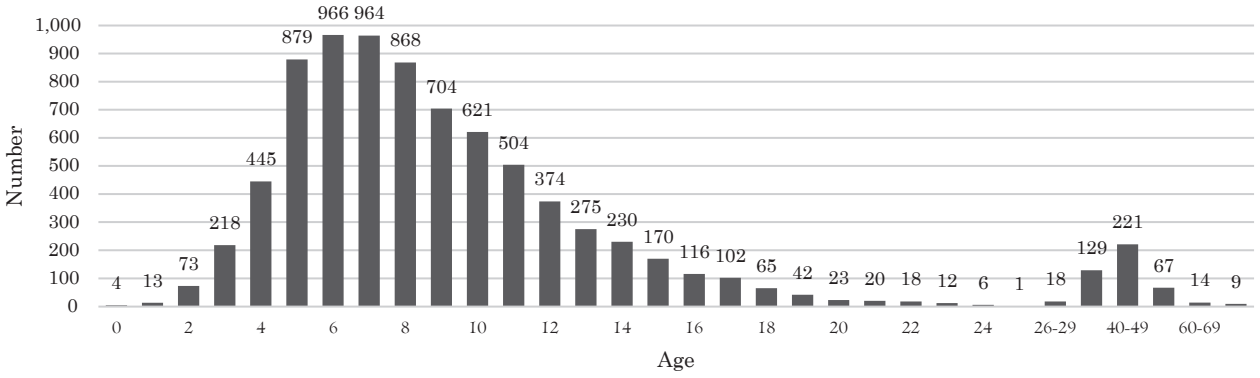

Fig. 3. Thyroid examiners and age-specific distribution
From March 2013 to December 2017, a total of 8,171 people underwent thyroid screening at the Kanto hotspot. At the time of the accident most thyroid examinations were conducted for people under 18 years old, but some parents were also examined.

Table 1. Echogenic diagnostic criteria of screening of thyroid

Evaluation	Interpretation	Recommendation
A	Normal	
A1	No nodule and/or cyst	Follow up
A2	Nodule < 5 mm or/and cyst < 20 mm	Follow up
B	Nodule > 5 mm or/and cyst > 20 mm	Second examination
C	Required examination	Urgent confirmatory examination

According to Fukushima Prefectural Medical University, thyroid ultrasonography results were classified into four categories of A1, A2, B and C.

Table 2. Thyroid examination overall result

Total	Total	A1	A2	B	C	(Nodule/s found)
	8,171	2,089	5,969	106	7	226
Constituent ratio	100.00%	25.60%	73.10%	1.30%	0.10%	2.77%

Age ≤ 18y.o	Total	A1	A2	B	C	(Nodule/s found)
At the time of accident	7,693	1,922	5,735	34	2	125
Constituent ratio	100.00%	25.00%	74.50%	0.40%	0.00%	1.62%

ID Unit Age ≤ 18y.o	Total	A1	A2	B	C	(Nodule/s found)
	4,651	1,185	3,442	23	1	102
Constituent ratio	100.00%	25.48%	74.01%	0.49%	0.02%	2.19%

Total 8,171 thyroid examination applicants were examined for Kanto hotspot from March 2013 to December 2017.

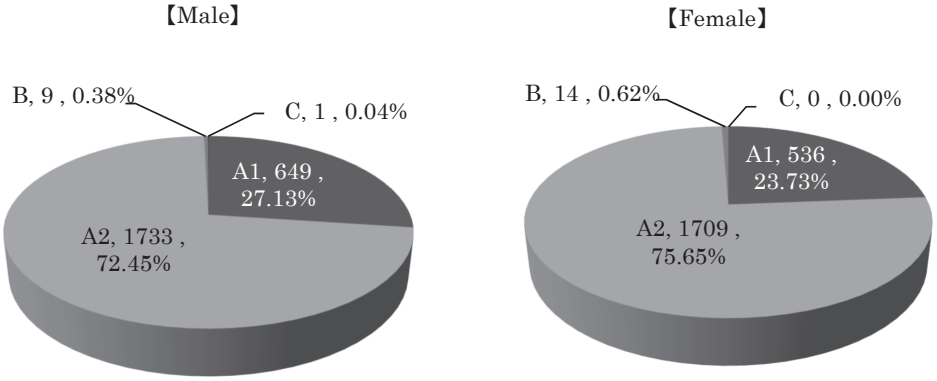

Fig. 4. At the time of accident under 18 years old examination result by a gender (total number 4,651)
There was no gender difference in thyroid examination determination, and it was almost A2 determination. There were more women than men in B judgment.

age was 86% (Fig. 8). In all cases, the size of the cysts was mostly several mm and no cysts were larger than 2 cm.

Examination of the results by age for each year for those 18 years and younger indicated that the occurrence of A1 judgments was highest in those 0 years of age and decreased with age, with the lowest rate occurring at 11 years of age, and then tended to increase gradually. In contrast, the number of A2 judgements increased with age, peaking at 11 years and decreasing gradually with age. The occurrence of B judgments (nodule) tended to increase gradually from the age of 10 to a small number every year, then gradually increased from 18 to 51 years of age (Fig. 9).

Examination of the transition of age-specific nodules revealed their gradual appearance from 3 years of age and a rapid increase from around 13 years of age to 19 years, the age at which nodules were most frequently observed (11.8%) (Fig. 10).

Both males and females had almost no nodules until the age of 16; however, the occurrence increased rapidly in both sexes from 17 years of age. Although men were rarely seen after 18 years of age, women seemed to increase gradually (Fig. 11).

DISCUSSION

While the Chernobyl and Fukushima nuclear accidents were both level 7 nuclear explosions, the radioactive concentration in the Fukushima nuclear accident was relatively low and children in the Kan-

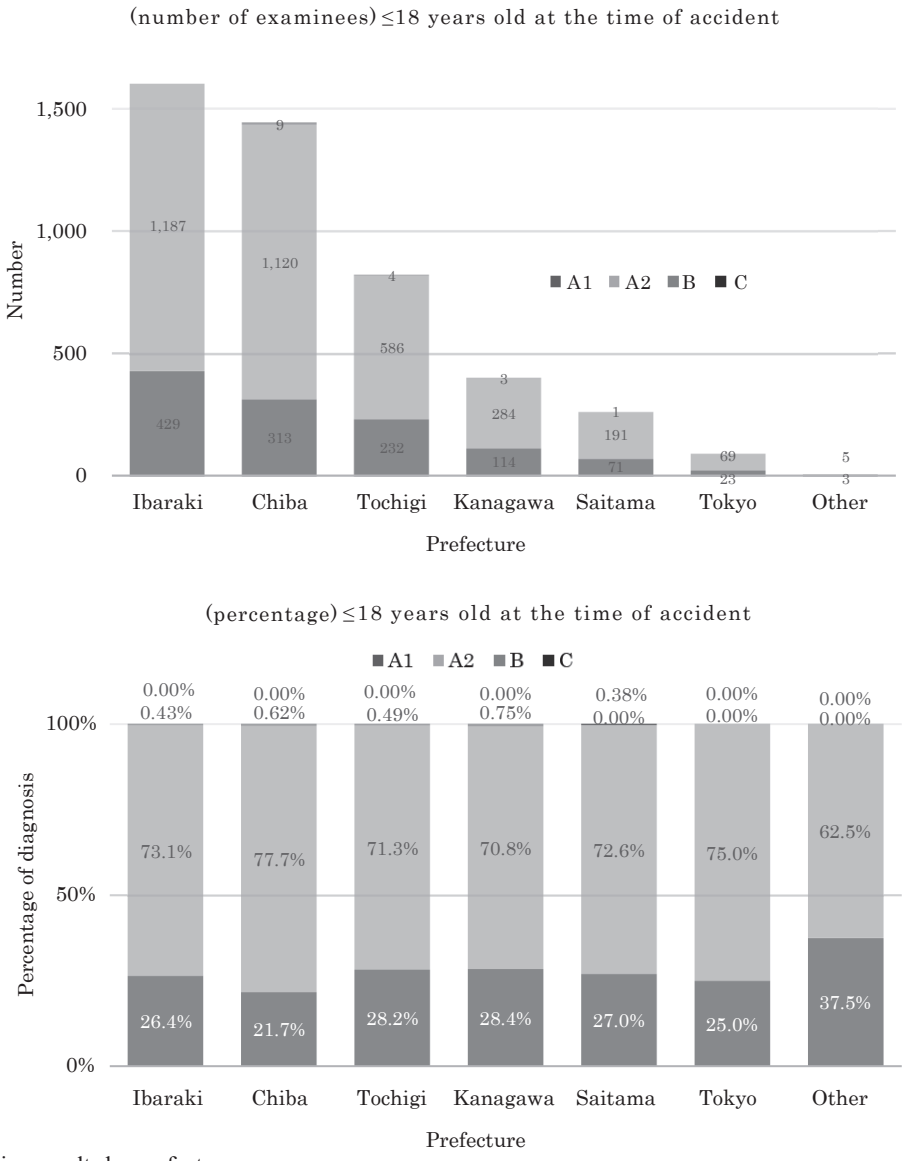

Fig. 5. Examination results by prefecture
The thyroid examination result judgment was compared by prefecture. There were no differences in the judgment results in the four prefectures of Kanto.

to area suffered from iodine deficiency due to their diets. The few people present were evacuated immediately from the Fukushima nuclear power plant and the sale and distribution of most of the food in the radiation-contaminated area were stopped. Therefore, the incidence of childhood thyroid cancer cases is likely to be lower than that in Chernobyl [7].

The Children's Health Survey Committee carried out early childhood thyroid examinations in Fukushima Prefecture [4]; however, these examinations were not conducted outside Fukushima Prefecture. Many residents of hotspots outside Fukushima Prefecture requested thyroid examination; therefore, we conducted the examinations in response to these requests. The subjects of this project included children who were evacuated from Fukushima Prefecture to areas outside of the prefecture.

With the cooperation of many volunteers, we conducted thyroid examinations in the hotspot area. In our survey performed from 2013 to today, we have not observed nodules suspected of childhood thyroid cancer, large cysts, or the frequent occurrence of abnormal nodules. However, we have identified nodules and several cancer patients during our examinations of the families of these children, including their parents, grandfathers, and grandmothers. These cases are presumed to have existed before the nuclear accident, considering the rate of thyroid cancer development and growth. After the Fukushima nuclear accident, parents living outside Fukushima

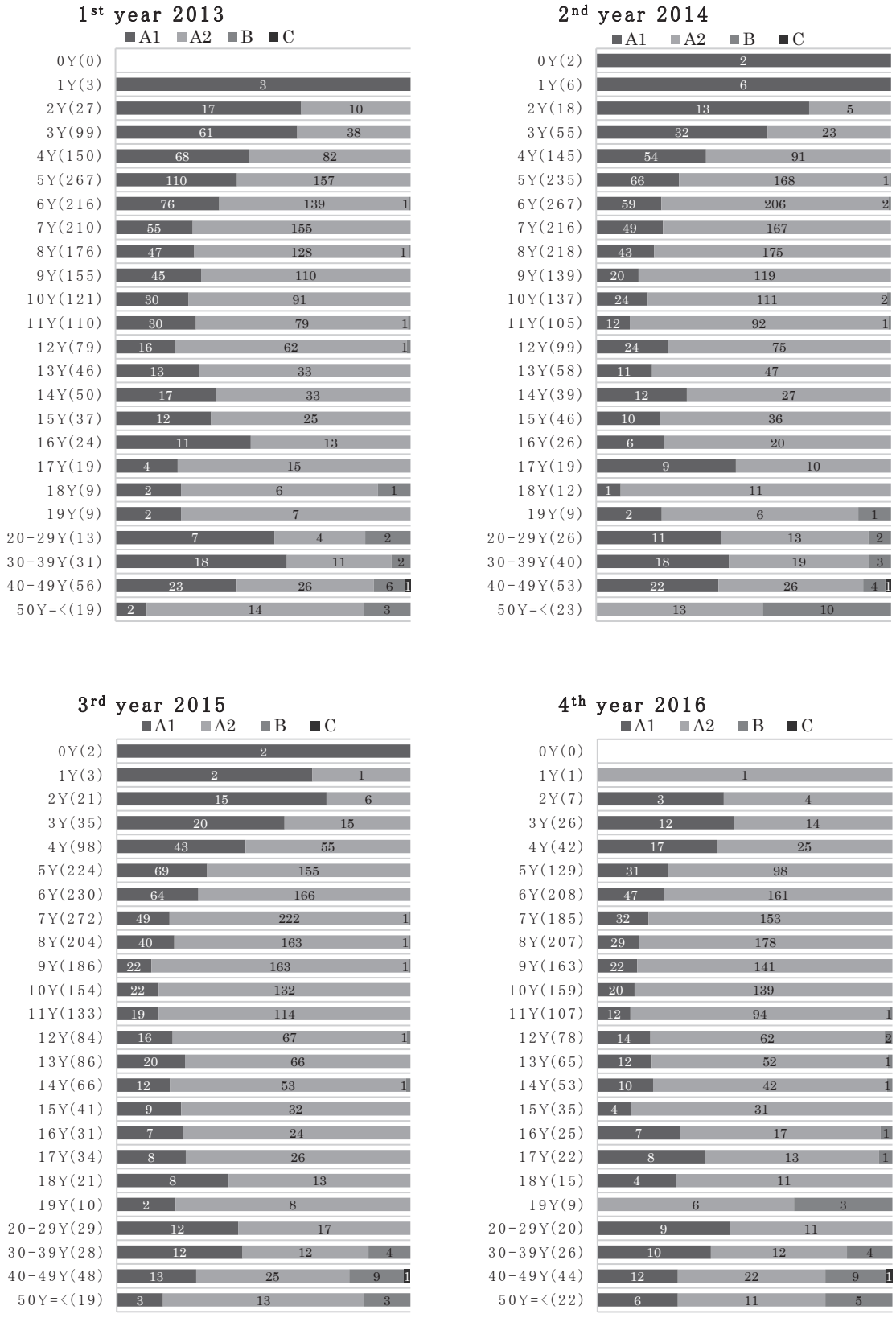

Fig. 6. Changes in ratio of thyroid test results by age

Examine thyroid examination results by year. At the beginning of the examination and at the fifth year after the accident, there was no change in the A1 and A2 judgments and the examination results were almost the same. At the beginning of the checkup, there was no B-age under the age of 18 but B-classes have been gradually seen in the lower age group under the age of 18 from the fourth year after the accident.

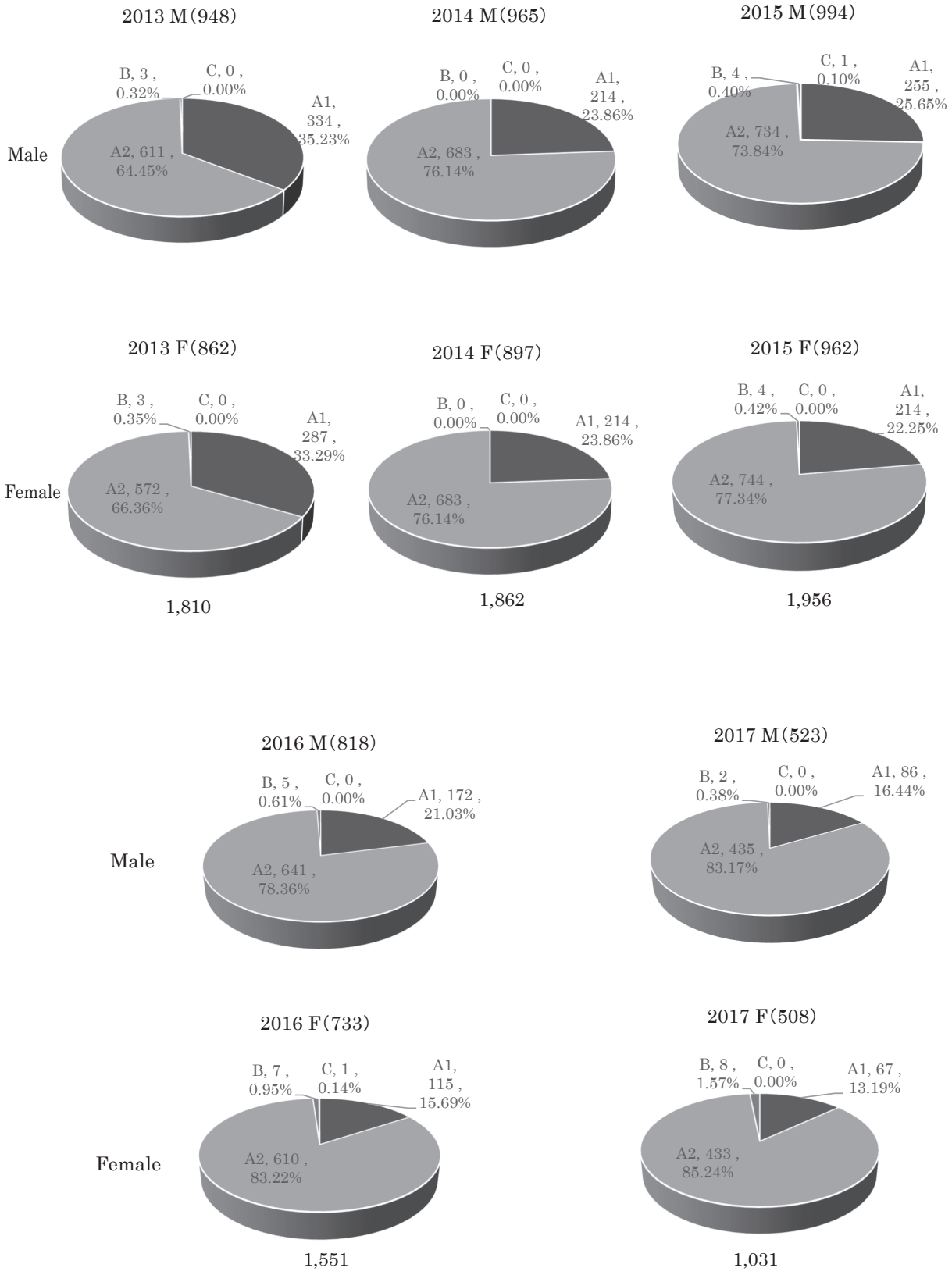

Fig. 7. Results of male and female screening under the age of 18 at the time of the accident
The thyroid examination results were compared year by year for men and women. For both men and women, A1 judgment decreased by thyroid examination every year and both 2 judgment increased.

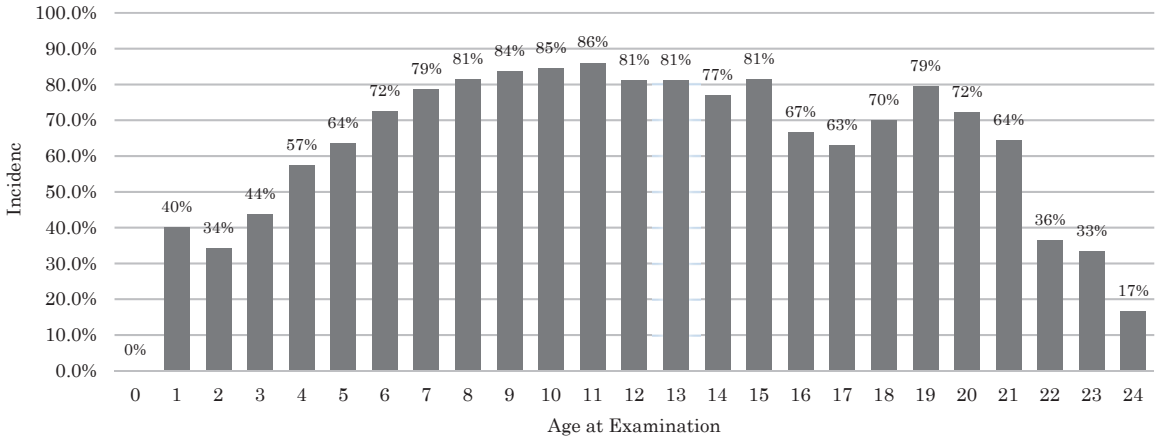

Fig. 8. Thyroid cysts and age-specific examinations for those under 18 years old at the time of accident
Childhood thyroid cysts increase with increasing age, with cysts found in up to 86% of children at 11 years of age. Thereafter, the cysts decreased with increasing age and disappeared rapidly after adulthood.

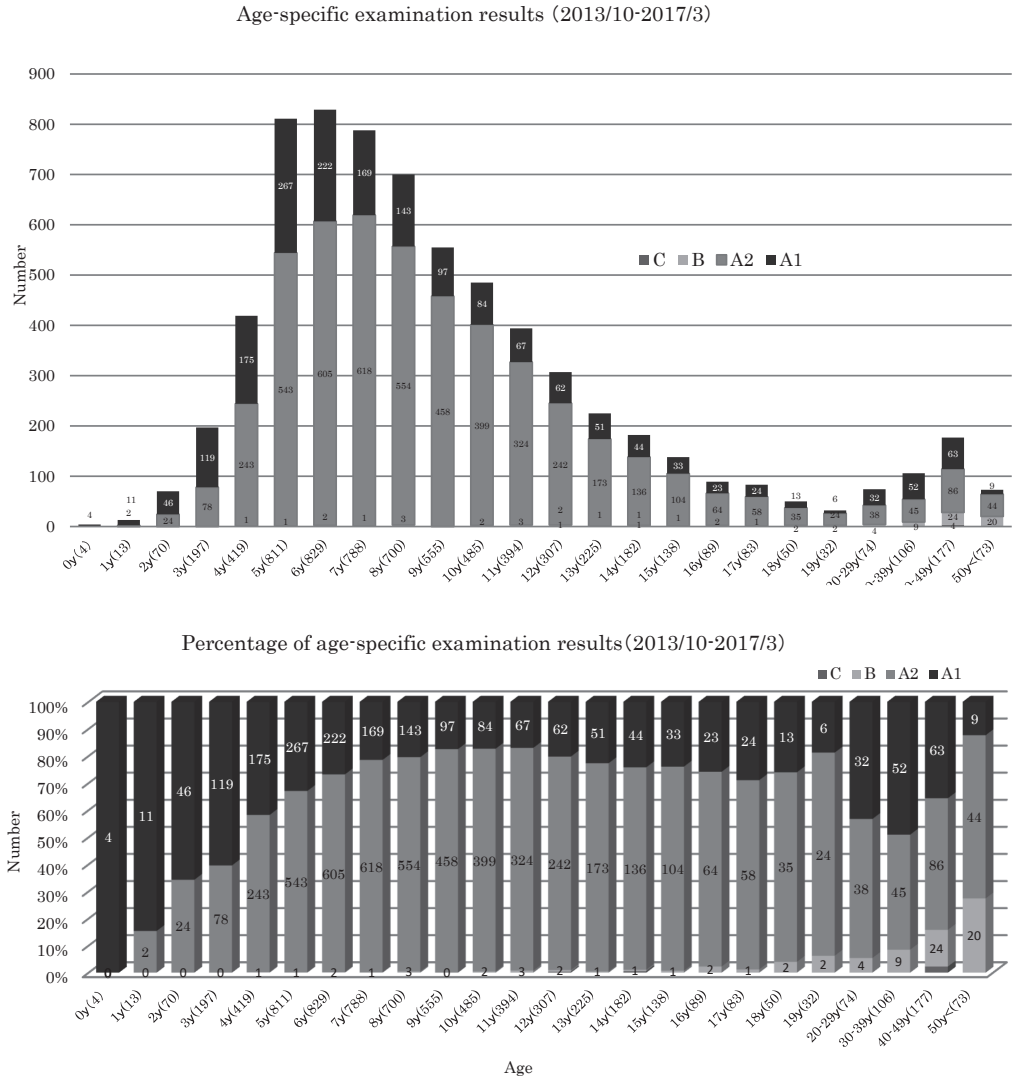

Fig. 9. Examine thyroid examination results by age
The thyroid is normal in a newborn baby, but with the growth, a cyst suddenly appears in the thyroid from 5 years of age. After that, the cysts gradually decreased and most of them disappeared around 18 years old and nodules gradually increased from about 30 years old.

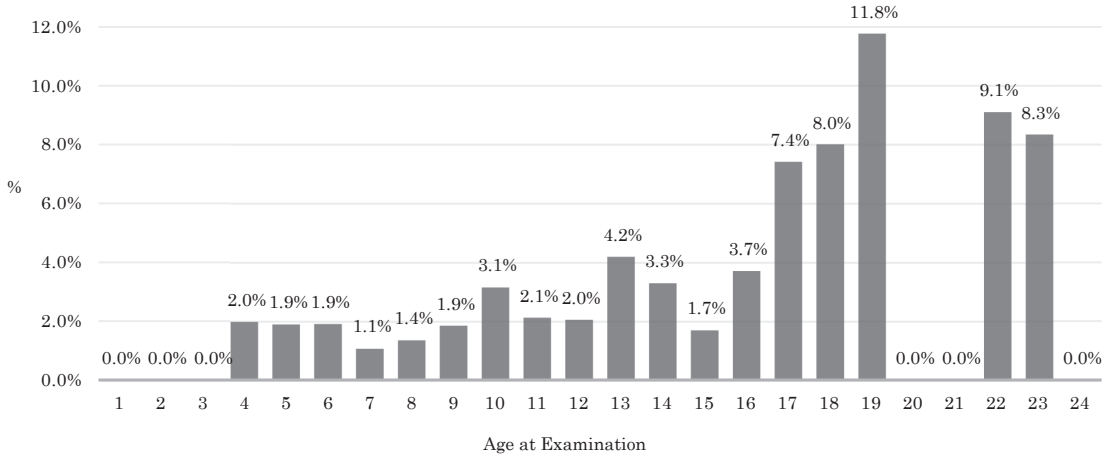

Fig. 10. At the time of the accident, examined thyroid nodules according to age, targeting children under 18 years old
No nodules were found in children, but they gradually increased from the age of ten. At 18 years of age, there was a nodule at 11.8% and decreased again as an adult.

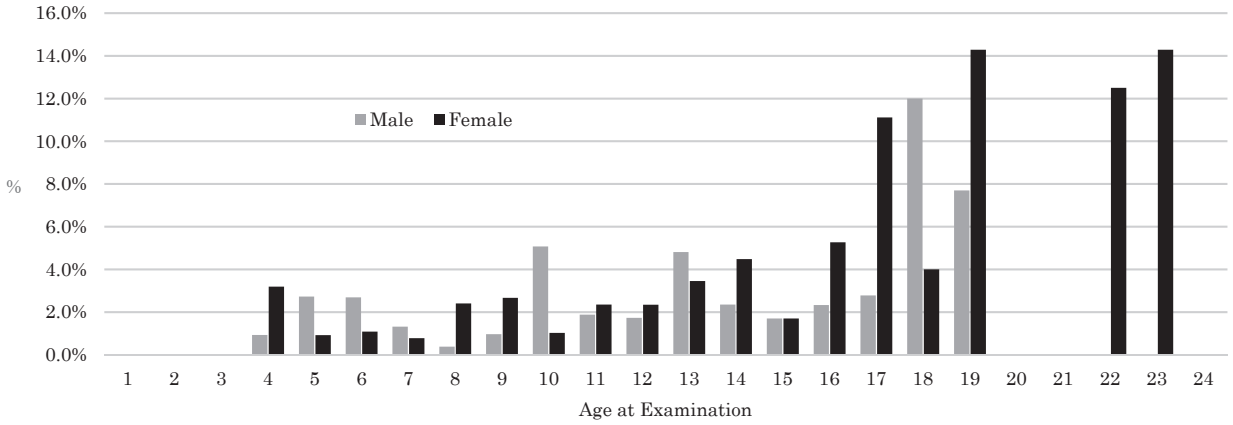

Fig. 11. At the time of the accident, examined thyroid nodules by age for men and women, targeting children under 18 years old
In both men and women, nodules increase from about 5 years of age and gradually increase with age, but in men, it gradually decreases after peaking at 18 years of age. On the other hand, in women, even after the age of eighteen, there was no decrease in thyroid nodules.

Prefecture were concerned about health damage due to low-level radiation, which we aimed to relieve with our screening results.

The echo instrument used to perform these examinations is a high-performance device capable of detecting lesions as small as approximately 1 mm. Moreover, it is a minimally invasive test method. Therefore, it is useful for the detection of thyroid cancer in children [8].

We observed many cysts during the pediatric thyroid examinations. The thyroid cysts were mostly small, around 1 mm, and many were beaded, mainly in the dorsal to lower pole of the thyroid. Such polycysts were not observed in infants and infants but tended to increase in number in both boys and girls from 3 to 5 years of age and appeared to increase with physical growth. However, the number of cysts tended to decrease gradually from the age of 15 years.

In contrast, problematic thyroid nodules tended to

develop gradually from the age of 15 years, as the number of cysts decreased. Although our study has not found any cases of childhood thyroid cancer, some of the many nodules identified may harbor malignant lesions.

We detected no thyroid cancer among a large number of thyroid examinations performed in children in the Kanto hotspot. However, considering the onset and growth period of cancer, we would like to conduct thyroid examinations in children, at least, for about 10 years after the accident to investigate the actual situation following radiation exposure.

CONCLUSION

We reported the results of thyroid examinations of hotspot residents around the Kanto area performed from October 2013 to December 2017. Fortunately, no thyroid cancer was found in our survey. However, as we have observed a large number of nodules in the thyroid glands, malignant lesions cannot be ruled out. Although six years have passed since the nuclear accident, many people desire continued thyroid examinations and investigation of the radiation exposure-related health damage to residents in the Kanto hotspot area.

ETHICAL APPROVAL

Not required.

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CONFICT OF INTEREST

The authors have no conflicts of interest directly relevant to the contents of this article.

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