1. Basic Survey

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Part 2 Survey Results

1. Basic Survey

Radiation Medical Science Center for the Fukushima Health Management Survey
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1. Purpose

1) Background

The accident at TEPCO's Fukushima Daiichi Nuclear Power Plant (hereinafter "Fukushima Daiichi"), which occurred in conjunction with the Great East Japan Earthquake, resulted in the diffusion of radioactive materials into the environment, and a marked increase in air dose rates was observed in Fukushima Prefecture and other areas of eastern Japan. The effect of radiation on the human body depends on how much radiation the person has received (exposure dose). Therefore, assessing the exposure doses received by residents due to radiation originating from the nuclear power plant accident will contribute to the assessment of health effects.

There are two forms of exposure to radiation: exposure from outside the body (external exposure) and exposure from inside the body by ingestion of radioactive materials (internal exposure). External exposure is mainly caused by radiation emanating from radioactive materials deposited on the ground and other surfaces. Internal exposure is mainly caused by ingesting contaminated food and drinking water. Levels of internal exposure have been assessed using whole-body counters managed by Fukushima Prefecture and other organizations entrusted with such measurements, so the details need not be discussed here. Rather, internal exposure measurements are reported in aggregate on the prefectural government's website,[1] including the fact that internal exposure levels were less than 1 mSv for most residents of Fukushima Prefecture. According to a more detailed analysis, the number of people whose internal exposure exceeded 0.3 mSv was reported to be extremely small.[2]

As a means of knowing external exposure doses, municipalities are now lending out personal dosimeters to residents, and monitoring posts have been installed throughout the prefecture to measure and display hourly air dose rates, from which external doses of individuals can be estimated. However, in the early days after the accident, such measuring devices were not widely available.

Immediately after the accident, air dose rates were measured in the prefecture using survey meters and other tools to estimate residents' external exposure doses, but many residents evacuated to and stayed in different places with different air dose rates, so the assessment of external exposure doses was not simple. This prompted a plan to obtain information from residents at an early stage regarding their individual behavior and location, to better ascertain external exposure doses. This survey of individual behavior and external exposure dose estimation proceeded under the Basic Survey, part of the Fukushima Health Management Survey (FHMS).[3]

2) Purpose

In light of the radioactive materials released by the nuclear power plant accident after the Great East Japan Earthquake, the purpose of the Basic Survey is to estimate individual external exposure doses based on behavior records and to inform each person of the results to provide basic data for future health management.

2. Survey method and outline of support

1) External exposure dose estimation

(1) Eligible persons

Those who were registered as residents in Fukushima Prefecture between March 11, 2011 and July 1, 2011 were eligible for the Basic Survey, and we sent out questionnaires for them to fill in their behavior records. We also sent questionnaires to (i) those who lived in the prefecture between March 11 and July 1, 2011, but whose resident registration was outside the prefecture, (ii) those who lived outside the prefecture and commuted to work or school in the prefecture between March 11 and July 1, 2011, and (iii) those who temporarily stayed in the prefecture between March 11 and March 25, 2011, upon their request. Those who fall into categories (i) to (iii) above are treated as "temporary residents" and are counted separately from those who were registered residents in the prefecture at the time of the earthquake.

(2) Outline of the survey

In the Basic Survey, we ask individual residents to fill out a questionnaire and return it to Fukushima Medical University (FMU) with a record of their whereabouts (behavior record) over the first four months after the accident. External exposure doses are estimated by a program that superimposes a digitized version of people's behavior records on air dose rate maps (Figure 1). This program for estimating doses was developed at the National Institute of Radiological Sciences (NIRS), a research institute under the Quantum Life and Medical Science Directorate of the National Institute for Quantum Science and Technology (QST).[4] Individuals are notified of their exposures, which are also aggregated by region, sex, age group, etc., to ascertain external exposure doses for the entire population of the prefecture.

Based on the distribution of air dose rates in Fukushima Prefecture (Figure 2) [5] and the timing of evacuation, areas where exposure doses were considered to be relatively high (Namie Town, Iitate Village, and the Yamakiya District of Kawamata Town) were selected as the areas for a preliminary survey, to which questionnaires were distributed ahead of other areas. The questionnaires were distributed to the residents who lived in the preliminary survey areas from June 30, 2011, and then prefecture-wide to those who were registered as residents between March 11 and July 1, 2011. Ultimately, questionnaires were distributed by post to approximately 2.06 million people.

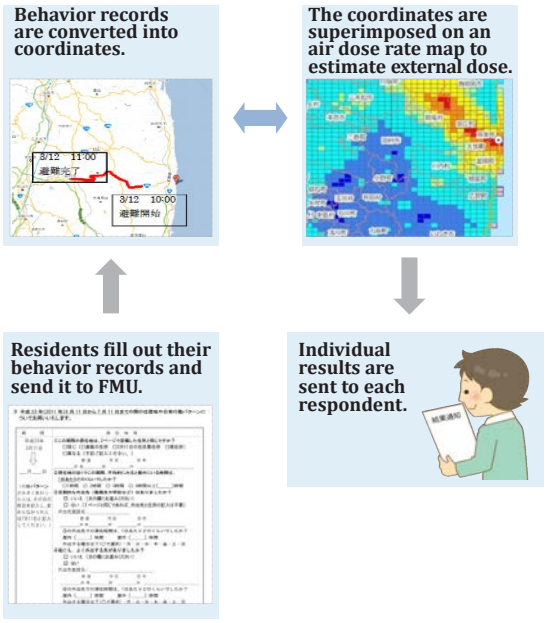
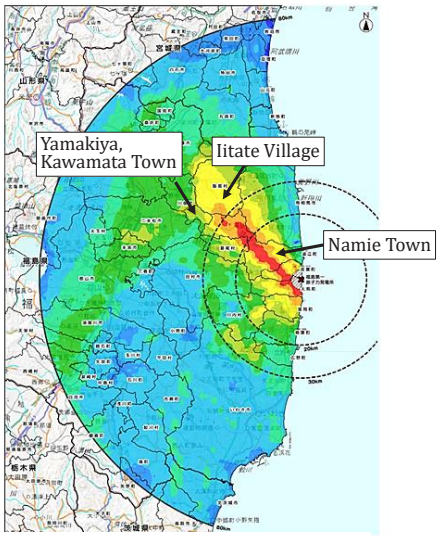


Figure 1. Flow of external exposure dose estimation and notification of results



Dose rate map as of December 16, 2011, released by the Ministry of Education, Science, Culture, and Sports

Figure 2. Distribution of air dose rates in Fukushima Prefecture (within 80 km of Fukushima Daiichi) and areas for the preliminary survey

Source for Figures 1 and 2: Ministry of the Environment. "BOOKLET to Provide Basic Information Regarding Health Effects of Radiation" (FY2019 Edition)

(3) Questionnaire form

The questionnaire form prepared at the beginning of the survey (a detailed questionnaire form) was designed for people to write hourly records of their behavior for a period of approximately two weeks after the accident (until March 25) (Figure 3). For the period from March 26 to July 11, the form was simplified to include the place of residence, average time spent outdoors per day, and addresses of regular destinations such as work and school.

In addition, as described below, we have introduced a simplified questionnaire form that is easier to fill out and is limited to those who have moved their residence or place of work only once or not at all in the four months following the accident.

In addition to the behavior record, the form asks residents to write their names, contact information, and details such as the building structure (wood, concrete, etc.) of their homes, places of work, and/or school. The information about the building structure enables more accurate assessment of exposure doses when staying indoors. In other words, while staying indoors, the degree of shielding from external radiation varies depending on the type of building and the number of floors. This is why residents were asked to provide not only their whereabouts, but also information on whether they were staying indoors or outdoors, as well as the architectural aspects of their homes or places of work.

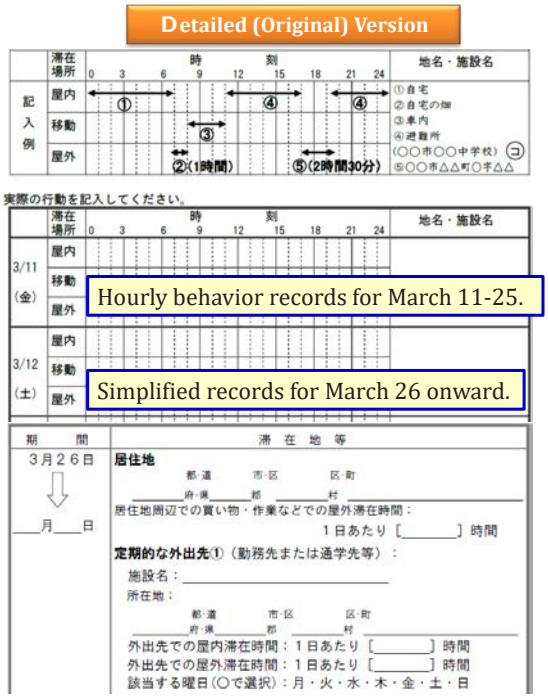


Figure 3. Main part of the detailed version of the questionnaire form

The questionnaire also asks whether a respondent has ever been a radiation worker. The purpose of this question is to estimate radiation doses by distinguishing between those employed as radiation workers in areas with high exposure risk doing restoration work after the earthquake and nuclear power plant accident, and ordinary people who evacuated from their place of residence.

(4) Digitization of completed questionnaires

When the questionnaire is returned to FMU's Radiation Medical Science Center for the FHMS (hereinafter "Center"), the Center will check the behavior records entered to confirm whether there is sufficient information for dose estimation. Sufficient information means that the behavior record continues uninterrupted and that the place(s) of stay of each day can be identified (for conversion to latitude and longitude).

The questionnaire contains a section to enter behavior records for four months after the accident, but there were some cases in which the behavior records covered less than four months. It may have been difficult to recall past behavior, since the questionnaires were distributed after June 30, 2011. Therefore, we decided to estimate radiation doses for such cases if the behavior records continued without interruption and if we had enough information to convert location entries into latitude and longitude. In this way, radiation doses received after March 11 and up to the last date of the behavior record could be estimated.

With sufficient information for dose estimation, we proceed to digitize the questionnaire (data entry). Since the behavior records written on the questionnaire are handwritten, it is necessary to convert them into electronic files (e.g., from address and place of stay to latitude and longitude information) so that the dose calculation program can process them. After conversion into electronic files, the records are sent to NIRS with the personal information (questionnaire number, name, and age) removed. There, the dose

is estimated by the program developed by NIRS, and the results are sent back to FMU.

After the questionnaires were sent out, it was necessary to deal with many questionnaires that were returned in a short period of time. The number of returned questionnaires reported to the 4th meeting of the Fukushima Prefectural Oversight Committee for the FHMS (hereinafter "Oversight Committee") held on October 17, 2011, was 13,884 of approximately 29,000 residents, or 47.5% of those in preliminary survey areas. It was also reported that 79,544 responses had been collected in the survey covering the whole prefecture, resulting in a total of 93,428 responses. At this point, a 40-person team was working to convert the questionnaires into electronic files.

After this, the growth in the number of responses slowed down in the preliminary survey areas, but the number of responses for the prefecture-wide survey peaked at around 8,000 per day. As of November 30, 2011, the number of responses to the prefecture-wide survey was 356,715, an increase of 280,000 compared to the number of responses as of October 11, 2011. In order to digitize such a huge number of responses and to provide dose estimation and result reports as soon as possible, the number of personnel for digitizing questionnaires was increased from the initial 40 to 700.

(5) Supplementing questionnaire responses

As mentioned above, location information written on the questionnaires needs to be converted into latitude and longitude. However, if an address or building name is ambiguous, as in a statement such as "I was at my relative's house on that day," such information cannot be converted to latitude and longitude, and dose estimation is not possible. For such incomplete behavior records, we have been making inquiries to each respondent by telephone to supplement the records.

At the 6th meeting of the Oversight Committee, it was reported that the number of personnel for supplementing records had been increased from 6 to 12 and that about 15% of the initial responses needed supplementary information. These responses were supplemented by contacting each respondent, and then they were electronically filed for dose estimation. The peak number of responses requiring supplementation was about 69,000 as of October 31, 2012, and about 76,000 as of January 31, 2013, as reported at the 9th and 10th meetings, respectively, of the Oversight Committee. Therefore, we secured enough personnel for supplementing and continued the work patiently.

Thus, it was necessary to contact respondents to supplement their records. If a phone number was provided, we could call the respondent to make up the information, but for questionnaires that did not include a phone number but only an address, we tried to contact the respondent by sending a letter. In the 11th meeting of the Oversight Committee held on June 5, 2013, it was reported that the number of responses requiring supplementation was about 46,000. By March 31, 2018, we were able to reduce the number of remaining responses classified as difficult to be supplemented to about 14,100.

The number of 14,100 includes responses that were returned with almost no information, in addition to those that required supplementation but had no contact information. These two types of responses were treated as "difficult-to-supplement responses," and were included in the number of responses, but without dose estimation.

Although we sent letters to those with addresses, the number of those who could be contacted and whose records could be supplemented gradually decreased, and from around 2016 it became difficult to reduce the number of difficult-to-supplement responses (i.e., difficult for dose estimation). Therefore, in 2018, we started to aggregate the number of responses excluding the difficult-to-supplement responses as the "number of valid responses." Since then, the number of responses and the response rate have been based on all responses, including difficult-to-supplement responses, while the number of valid responses and the valid response rate have excluded the difficult-to-supplement responses.

(6) Dose estimation

After supplementing the questionnaire responses when necessary and digitizing them, we proceed to dose estimation. The outline of the dose estimation method is shown in Figure-4.[5)]

The method for estimating external exposure doses in the Basic Survey had been studied by NIRS on an urgent basis before starting the survey. In order to estimate external exposure doses, it was first necessary to collect data on air dose rates in the prefecture.

With the release of radioactive materials from the nuclear accident, there were large changes in air dose rates in Fukushima Prefecture, especially soon after the accident. For this reason, monitoring data from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and calculation results from SPEEDI (System for Prediction of Environmental Emergency Dose Information) were collected, and dose distribution maps showing daily average air dose rates in the prefecture were prepared from these data (Figure 5).[5)]

Since the air dose rate data were limited, maps were prepared using 2 km × 2 km grid cells, within each of which a single air dose rate was assigned. The air dose rates exclude contributions from natural radiation (e.g., radiation from materials already in the environment since before the accident).

External exposure doses per day are assessed by superimposing the daily air dose rate maps and electronic records of behavior (records of whereabouts including distinction between indoors and outdoors) on the computer; by repeating this process, external exposure doses for four months after the accident are assessed. In the case of responses with a record of behavior of less than four months, the external exposure doses received up to the last date of the record are assessed.

The assessed dose is called the "effective dose," which serves as a rough indication of the risk of future health effects, including cancer. This is slightly lower than the air dose rates displayed on monitoring posts, etc. (equivalent to the "ambient dose equivalent rates" in Figure 4), multiplied by the time spent in the location (0.6 times, as shown in Figure 4).

The reason for this is that the effective dose is an average of the doses received by organs and tissues of the human body, and those organs and tissues vary in their depth from the body surface; external radiation is attenuated to various degrees before reaching such organs and tissues.

Dose estimation also takes into account the effect of radiation shielding by buildings. For example, it is assumed that the radiation dose in a wooden house would be 40% of outdoor exposure (Figure 6);[5)] in a concrete building of one or two stories, 20% of outdoor exposure; and in a concrete building with three or more stories, 10% (Figure 6).

The program for estimating radiation doses

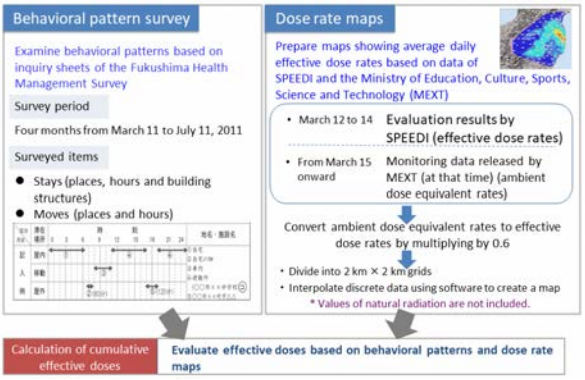
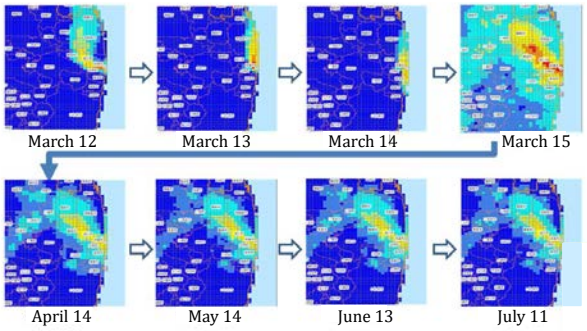


Figure 4. Outline of dose estimation



(μSv/h: microsieverts per hour)

Figure 5. Examples of the dose distribution map

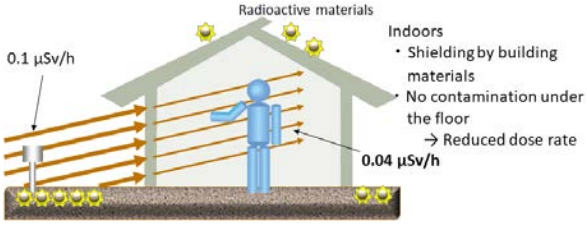


Figure 6. Conceptual illustration of radiation reduction by buildings

Source for Figures 4, 5, and 6: Ministry of the Environment. "BOOKLET to Provide Basic Information Regarding Health Effects of Radiation" (FY2019 Edition)

as described above did not exist at all before the Great East Japan Earthquake. The nuclear accident triggered its rapid development by NIRS, which made a concerted effort to study it, and in November 2011, the program was put to practical use, and radiation doses can now be estimated from behavior records.

Doses received by people differ slightly due to differences in body size and age, even if they follow the same behavior pattern. Computer simulations have shown that children receive slightly higher effective doses than adults, even with the same behavior records.

Since age is personal information, we don't provide this information to NIRS. Therefore, the NIRS estimation program estimates adult equivalent doses, and then FMU estimates the dose for each individual by multiplying the dose by an age-based correction factor to obtain the final dose. Those aged 16 and above are considered as adults for this purpose, while for those aged 15 and under, doses are calculated by multiplying the adult doses by a correction factor. The age-based correction factors are derived from past literature, and are, for example, about 1.2 for a 5-year-old child and about 1.26 for a 1-year-old child.[4)]

(7) Notification of dose estimation results

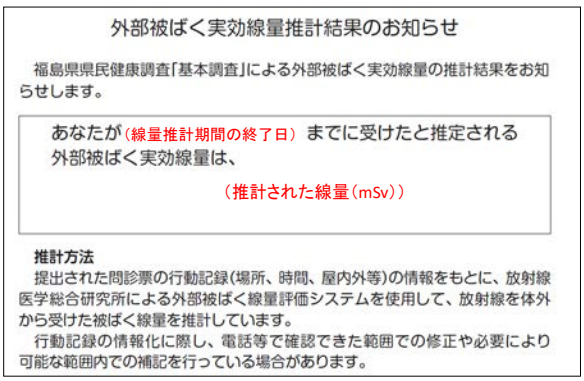
Estimated doses will be sent to each individual who has returned the questionnaire response. A part of the result report is shown in Figure 7. Along with the result report, a brief explanation of radiation doses is also enclosed to help interpret the results.

In consideration of the accuracy of the dose estimation, the figures up to the first digit are provided to those with doses of 10 mSv or more calculated by the estimation program (after age correction), and the figures up to one decimal place are provided to those with doses of less than 10 mSv. If the calculation by the estimation program results in a number less than 0.1 mSv, the result will be written as "less than 0.1 mSv."

As mentioned above, there are some responses with behavior records of less than four months. For these, dose estimation results include a clear indication of the period for dose estimation, beginning from March 11 to the date up to which the behavior record is available.

Even among family members who live together, there may be slight differences in the estimated doses due to differences in their activities (e.g., commuting to work or school). In addition, in consideration of the fact that the results of dose estimation are personal information, the results are sent, in principle, directly to the respondent and not to a proxy (family member, etc.). For this reason, even family members who live together receive their results separately.

A large number of responses came soon after distributing the questionnaires, for which dose estimations took some time. More recently, as the number of responses has settled down, we have been able to send dose estimation results approximately 4 to 5 months after receiving responses.


外部被ばく実効線量推計結果のお知らせ

福島県県民健康調査「基本調査」による外部被ばく実効線量の推計結果をお知らせします。

あなたが（線量推計期間の終了日）までに受けたと推定される外部被ばく実効線量は、

（推計された線量（mSv））

推計方法

提出された問診票の行動記録（場所、時間、屋内外等）の情報をもとに、放射線医学総合研究所による外部被ばく線量評価システムを使用して、放射線を体外から受けた被ばく線量を推計しています。

行動記録の情報化に際し、電話等で確認できた範囲での修正や必要により可能な範囲内での補記を行っている場合があります。

Figure 7. Dose estimation result report

2) Introduction of a simplified questionnaire

In the detailed version of the questionnaire created at the beginning of the Basic Survey, respondents had to record their behaviors on an hourly basis and we received comments that they could not remember their exact behaviors and that it took a long time to fill out the questionnaire. Therefore, we considered creating a simplified version of the questionnaire that would be easier to fill out.

Although a simplified questionnaire would be easier for the respondents to fill out, it might reduce the accuracy of dose estimation. Therefore, we prepared a simplified version in 2012, trying to balance the accuracy of dose estimation and the simplicity of filling out the questionnaire.

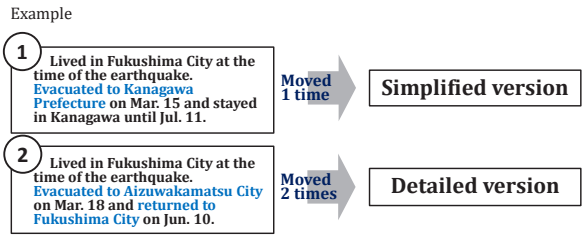
Before actually using the simplified questionnaire, we asked a small group of people to fill out both the detailed and simplified questionnaires, to ascertain the accuracy of dose estimations.[6)]

Of 143 respondents who completed both the detailed and the simplified questionnaire, results from 91 were comparably accurate. Thus, the results of dose estimation from the simplified version and the detailed version showed a high correlation in general, although there was a slightly larger difference in cases where respondents had often changed their residences and workplaces. The differences between doses estimated with the simplified version and the detailed version ranged from -0.4 mSv to +0.6 mSv. According to 89 out of 143 respondents, the average time to fill out the simplified version was 16.5 minutes, which was about one third of the time required for the detailed version.

Based on comparisons of dose estimates using the simplified and detailed questionnaires, it was decided to use the simplified version for a specific category of residents. Since there was a rather large difference in the dose estimation between the simplified and the detailed versions in cases in which respondents had moved their locations many times, it was decided to limit the use of the simplified version to those who moved their residence or place of work once or not at all in the 4 months after the accident (Figure 8). Figure 9 shows the main part of the simplified questionnaire that was finally adopted.

With the simplified questionnaire, it was expected that the response rate to the questionnaire would be improved, especially for those who live in areas far from the nuclear power plant and whose address had not changed before and after the earthquake. Taking this into consideration, it was decided to send the simplified version to those eligible for the Thyroid Ultrasound Examination (TUE) program (one of the four detailed surveys in the FHMS) who had not yet submitted the detailed questionnaire (approximately 250,000 residents), as they were thought to be likely to interested in their external exposure dose.

As described in detail elsewhere, the TUE is conducted to monitor the thyroid gland of prefectural residents aged 18 and under at the time of



【Condition for using the simplified questionnaire】
The simplified version is only for those who changed their behavior patterns (i.e., changing residences, schools, or workplaces due to evacuation) only once or less in the four months after the earthquake.

Figure 8. Conditions for using the simplified questionnaire

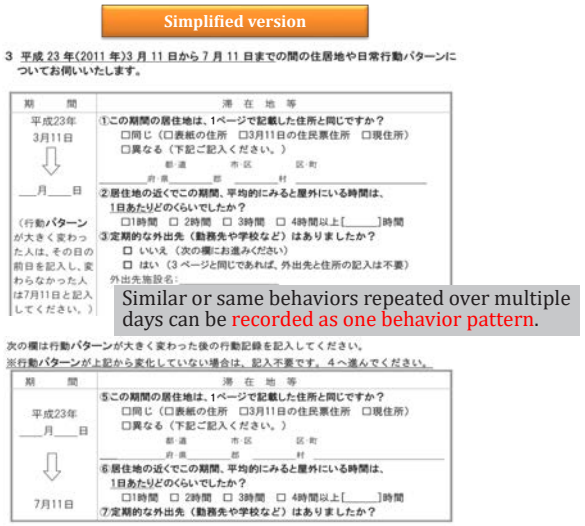


Figure 9. Main part of the finalized version of simplified questionnaire

the disaster. Due to concerns about thyroid effects from exposure to radioactive iodine released by the nuclear accident, each eligible resident is offered a thyroid examination on a regular basis.

In the 13 municipalities designated as the evacuation zone (named on p. 84), the evacuation process was considered to be complicated, and it was thought that there would be few people who would meet the conditions for the simplified questionnaire (i.e., moving their residence or place of work just once or not at all in the four months following the accident). Therefore, instead of the simplified questionnaire, we decided to send out a flyer that encourages submission of the questionnaire to those eligible for thyroid examinations who were living in the evacuation zone at the time of the disaster. The simplified questionnaire and flyers were sent out from the end of November to December 2013.

We also sent a reminder letter to about 200,000 residents who had not returned the sim-

plified questionnaire by the end of May 2014, about six months after it was sent. The simplified questionnaire has since been widely used by people in various age groups, not only those who are eligible for thyroid examinations.

Even after the introduction of the simplified questionnaire, those who moved their places of residence frequently after the accident, such as those who lived in the evacuation zone, had to fill in the detailed questionnaire on their behavior after the accident because they did not meet the conditions for using the simplified questionnaire.

As mentioned above, the detailed questionnaire requires the entry of activities on an hourly basis, and about one third of the respondents answered that they need help with how to fill in the questionnaire. Therefore, we have been providing support for filling out the questionnaire to those who want to submit the questionnaire but need assistance filling it out.

3) Efforts to improve response rates

The response rate of the questionnaire in the entire prefecture was in the 20% range at the end of 2011, with no substantial increase since then. In order to improve the response rate, we have implemented various activities since 2012.[7)]

(1) Explanation of the survey and writing support at venues for TUE

Activities to promote the survey and to support completing the questionnaire ("writing support") were launched in earnest in FY2012. Writing support has been offered mainly at thyroid examination venues where we set up a booth to provide explanations about the survey and support for filling out the questionnaire. Figure 10 shows a writing support booth. As shown in this picture, staff members are stationed at the thyroid examination venue to assist thyroid examination participants, as needed, so they can complete and submit the questionnaires on the spot.

Thyroid examinations are usually conducted at schools or hospitals, but they may also be conducted at public facilities for preschool children and other age groups. When thyroid examinations are conducted at public facilities, where relatively more space is available, we have set up booths to the extent possible, to support people who want to complete their questionnaires. After thyroid examination, participants or their guardians are offered help with the Basic Survey questionnaires, as they wish, even to the point of completing and submitting the questionnaire at the examination venue.

In FY2012, promotion activities (talking to people) at thyroid examination venues started in June, and a total of 41 sessions were held in Fukushima City. In FY2013, writing support was more broadly provided, with 140 sessions in 38 municipalities. In FY2014, a total of 101 writing support sessions were held, including several at thyroid examination venues outside the prefecture (for those who were living in the prefecture at the time of the earthquake, but who moved outside the prefecture for higher education, employment, etc.) Similarly, 101 writing support sessions were held in FY2015.

(2) Writing support in other places

In addition to thyroid examination venues, writing support was also provided at (i) city halls and other government buildings, (ii) health check venues, (iii) temporary housing facilities, (iv) hospitals and public health centers, and (v) various event venues. As with the thyroid examination venues, we set up a booth like the one shown in Figure 10, for consultation and support, including one-on-one explanations and writing support for those wishing to complete a questionnaire.

Writing support at city halls and other government buildings was conducted in major municipalities of 7 districts in Fukushima Prefecture (Fukushima City, Koriyama City, Aizuwakamatsu City, Iwaki City, Shirakawa City, Minamiaizu Town, and Kitakata City) in 2014. We approached people coming to the government office and assisted them in filling out questionnaires. A total of 267 sessions were held between June and July of 2014.

We also set up booths for writing support where municipalities convened annual health checks under Japan's system of universal health coverage. From June to November of 2015, a total of 119 sessions were held in 8 cities including Fukushima, Koriyama, and Iwaki.

Some residents who were living in the munic-

Figure 10. Writing support booth

ipalities designated as the evacuation zone after the nuclear accident had to move to temporary housing facilities, constructed throughout the prefecture. In order to help these residents with their questionnaires, volunteers, mainly FMU students, visited temporary housing from the beginning of FY2012 to support residents in filling out questionnaires. Later, from January to March 2013, a larger scale of visits to temporary housing was conducted. At that time, we visited about 12,000 people in 107 temporary housing facilities across six districts of the prefecture (excluding Minamiaizu), and provided assistance to those who were at home and had not submitted questionnaires.

In FY2012, a writing support booth was set up in the lobby of FMU Hospital. After that, writing support was provided 10 times at hospitals in Fukushima City during FY2014, but due to space and time limitations, writing support booths were not set up at hospitals after that. Writing support booths were set up at public health centers, although less frequently.

Furthermore, in FY2012, a total of 30 writing support sessions were offered at "Furusato Kizuna Information Stations" in Fukushima City and Koriyama City. The Furusato Kizuna (hometown connection) Information Stations were set up in supermarkets and other places in Fukushima Prefecture to provide evacuees with information on their places of residence before the accident, and to provide a place for them to exchange information and interact with each other.

Writing support booths were also set up in conjunction with health- and welfare-related events. In this way, writing support booths were set up at thyroid examination venues and other places where people gathered, to help them fill out questionnaires.

(3) On-location information sessions on how to fill out the questionnaire

Information sessions on thyroid examinations have been held for parents and teachers at schools with students eligible for thyroid examinations. After covering the thyroid examination, the Basic Survey is also explained to encourage participation.

A total of 88 information sessions were held at kindergartens, nursery schools, elementary schools, and junior high schools in FY2013, then 17 in FY2014, and 15 in FY2015. In addition to those attached to information sessions on thyroid examinations, we sent writing support staff to hold information sessions upon request of municipalities.

(4) Company visits

While the writing support at thyroid examination venues was mainly for minors, we made company visits to promote the survey among working adults. We visited companies in the prefecture and asked human resource managers to encourage participation in the survey through in-house e-mails and morning meetings. Such activity was conducted a total of 495 times in FY2012.

(5) Use of media

Articles on the Basic Survey appeared in prefectural and municipal public relations magazines and newspapers, and coverage was also obtained on TV and radio. In addition, a video on how to fill out the questionnaire was prepared and shown at public facilities in municipalities in the prefecture, and is available on the Center's website.

Before sending out the simplified version of the questionnaire at the end of November 2013, an information session was held for the media to make the simplified version of the questionnaire widely known to the residents of the prefecture.

(6) Flyer enclosed with information on the other surveys in the Fukushima Health Management Survey

The Fukushima Health Management Survey consists of four other surveys in addition to the Basic Survey (Thyroid Ultrasound Examination, Comprehensive Health Check, Pregnancy and Birth Survey, and Mental Health and Lifestyle Survey;

collectively called the "Detailed Surveys"). When the information on each of these surveys was sent out, a flyer was enclosed to encourage participation in the Basic Survey.

(7) Placement of questionnaires and leaflets at municipal offices

Since the questionnaires were sent to all residents of the prefecture in 2011, it was thought that there would be cases where the questionnaires would be lost over time. Therefore, copies of a simplified version of the questionnaire were placed in corners at municipal offices so that visitors could freely take one home. When placing the leaflets at municipal offices, FMU staff visited municipal offices and asked office staff for their cooperation in placing the questionnaires and providing them to the residents.

Since it was considered difficult to fill out the detailed questionnaires without assistance, only the simplified questionnaires were placed in municipal offices.

As years passed, we noticed that the number of copies of the simplified questionnaires placed in municipal offices was not decreasing. In light of this, from 2018, promotional leaflets on the Basic Survey have been placed instead of the simplified version of the questionnaire.

(8) Preparation of the questionnaire in foreign languages

For international residents who were living in Fukushima Prefecture at the time of the disaster, we prepared the detailed version of the questionnaires in English, Chinese, Korean, Tagalog, and simplified Japanese. Information on the FHMS and examples of how to fill out the questionnaire were also translated into these languages and made available for download from the Center's website.

(9) Resending of the questionnaire through the website and call center

The Center has been accepting request to resend the questionnaire (detailed version and simplified version) through its website and call center. The detailed version of the questionnaire was sent to all residents of the prefecture in 2011, but for those who lost their questionnaires, replacements have been resent upon request.

Of all the activities to improve the response rate, including the support for filling out questionnaires, some were conducted at the same time. Tables 1 and 2 show the list of activities to improve the response rate reported at the 8th and the 22nd meetings of the Oversight Committee, held on September 11, 2012 and February 15, 2016, respectively.

Meanwhile, a study was conducted in 2015 to

Table 1. List of activities to improve response rates (1)

Type	Content	Place/Period	No. of times
Direct approach to residents	Home visits to evacuees living in temporary housing by nursing and other university students	Fukushima City Apr. 21-Aug. 23	12
	Setting up questionnaire writing support booths in Furusato Kizuna Information Stations	Fukushima City, Koriyma City Jul. 2-Aug. 31	30
	Awareness-raising activity at the thyroid examination venues	Fukushima City Jun. 6-Jul. 11	6
	Setting up a questinnaire writing support booth for patients and visitors to the hospital	Entrance hall of Fukushima Medical University Hospital May 28-May 30	3
	Setting up a questionnaire writing support booth (Iitate Village)	Comprehensive Health Check venues in Iitate Village May 28-Jun. 3	6
Approach to working adults	Company visits	Various locations in the prefecture Feb. 1-	168
General public relations activities	Informercials on radio	Broadcasted in the entire prefecture Mar. 10-	Once everyday
	Coverage of our activities (writing support, home visits, etc.) in newspaper and TV		Newspaper: 12 TV: 7

Source: Material for the 8th Oversight Committee meeting held on September 11, 2012

Table 2. List of activities to improve response rates (2)

Type	Content	Place/Period	No. of times	Note
Direct approach to residents	Awareness raising activity at the thyroid examination on-location information sessions	Vairous locations in the prefecture May 16, 2015-	15	Explained to approximately 270 parents of kindergarten, elementary, junior high, and high school students
	Setting up questionnaire writing support booths at the thyroid examination venues	Aizuwakamatsu, Iwaki, Sukagawa, Kitakata, Soma, Kagamiishi, Shimogo, Hinoemata, Tadami, Minamiaizu, Inawashiro, Yanaizu, Mishima, Kaneyama, Showa, Nishigo, Nakajima, Yabuki, Tanagura, Yamatsuri, Hanawa, Samegawa, Ishikawa, Tamakawa, Hirata, Asakawa, Furudono, Ono, Shinchi Apr. 7, 12, 21, 28; Jul. 17-Sept. 16; Oct. 13-Dec. 25, 2015	78	Explained to approximately 11,600 people
		Cities of Sagamihara and Yokohama in Kanagawa Prefecture Jun. 6 & 7, 2015		
		Cities of Kazo and Saitama in Saitama Prefecture Sept. 26 & 27, 2015		
		Cities of Kashiwa and Chiba in Chiba Prefecture Nov. 28 & 29, 2015		
	Sending leaflets to encourage responding to the Basic Survey questionnaire	Residents of Tamura, Minamisoma, Kawamata, Hirono, Naraha, Tomioka, Kawauchi, Okuma, Futaba, Namie, Katsurao, Iitate, and Date City's specific spots recommended for evacuation; Women who received their Maternal and Child Health Handbook in Fukushima between Aug. 1, 2013 and Jul. 31, 2015; Women who received their Maternal and Child Health Handbook in other prefectures during the above period, and received prenatal health checks and delivered babies in Fukushima. (A passage to encourage responding to the Basic Survey questionnaire was included in the leaflets on the Comprehensive Health Check, etc. distributed from April to December 2015)	—	Sent to approximaly 258,000 people
	Including information about the Basic Survey questionnaire writing support booths in the invitation to the thyroid examinations	Kanawaga Prefecture May 2, 2015	—	Sent to approximately 7,000 people
		Saitama Prefecture Aug. 19 & 31, 2015		
		Chiba Prefecture Oct. 19, 2015		
Approach through municipal offices	Setting up questionnaire writing support booths at municipal health check venues	Fukushima, Koriyama, Iwaki, Shirakawa, Kitakata, Nihonmatsu, Tamura, Motomiya Jun. 3-24; Jul. 1-Nov. 30, 2015	119	Explained to approxiately 15,000 people
General public relatons activities	Coverage by newspaper, TV, radio, etc.	—	Newspaper: 2 TV: 2 Radio: 1 Municipal PR magazine: 1	Covered in information programs and prefectural government news

Source: Material for the 22nd Oversight Committee meeting held on February 15, 2016

verify the representativeness of the Basic Survey results (see the next section), and it showed that the dose distribution obtained so far is representative for the entire population of the prefecture. Therefore, we suspended activities to raise the response rate, except for writing support at thyroid examination venues.

4) Study on representativeness

Although the above-mentioned activities to improve the response rate were continued, it was difficult to improve the overall response rate across the prefecture because the survey covered approximately 2.06 million people and included areas with relatively low air dose rates (Aizu, Minamiaizu, etc.). There was some increase in the number of responses as a result of such activities, but it did not lead to a substantial increase throughout the prefecture, and the response rate as of June 30, 2015 was 27.2%.

Due to the low response rate, a concern remained that those who had not responded to the survey in the same area might have higher radiation doses than those who had responded. For this reason, a study on whether the external exposure doses estimated from responses obtained thus far were representative of the entire population of the prefecture (a representativeness study) was conducted in 2015.[8)]

The purpose of this study was to examine whether results already obtained in the Basic Survey were representative of the entire population of the prefecture by comparing the doses of those who responded to the questionnaire with doses of those who did not respond. In statistical terms, an equivalence test was planned to test whether the doses of the respondents and non-respondents were equivalent, i.e., whether data from those who had already responded was truly representative of everyone in their respective areas.

This is illustrated in Figure 11. We randomly selected a group from each district (A), and conducted door-to-door visits to some of non-respondents (D) in the group, asking them to answer the questionnaire. The doses of those who responded by door-to-door visits were compared with the doses of those who had responded before this study (B) for each district. The equivalence test was used to check whether the doses of the two groups were equivalent or not.

If the mean difference between the doses for the two groups is zero, then the two doses are equivalent, but there is an error involved in evaluating the mean difference. However, there is always a margin of error in evaluating differences in mean values, so if the difference in mean values is within a certain range (equivalence margin), the two doses are considered equivalent.

For this test, it is necessary to collect a certain number of responses. The above comparison can be done even with a relatively small number of responses for a district where the doses are distributed in a narrow range, but for a district where the doses are distributed in a wider range, a larger number of responses are required. For this reason, the number of randomly selected respondents (A in Figure 11) was set to be larger in places such as the Soso District.

Based on the above considerations, a total of 5,350 residents were randomly selected from seven districts in the prefecture (Kenpoku, Kenchu, Kennan, Aizu, Minamiaizu, Soso, and Iwaki). After checking whether the selected residents had already responded to the Basic Survey, we conducted door-to-door visits to obtain questionnaire responses from those who had not responded.

One difficulty with going door-to-door was that many people were not home, but we tried to collect a sufficient number of responses by making multiple visits. As a result, we were able to obtain responses from approximately 37% of the 2,645 residents whom we had intended to visit for this study.

Doses were estimated from these responses and compared with those of a randomly selected group of those who had already responded before the door-to-door visits (B in Figure 11).

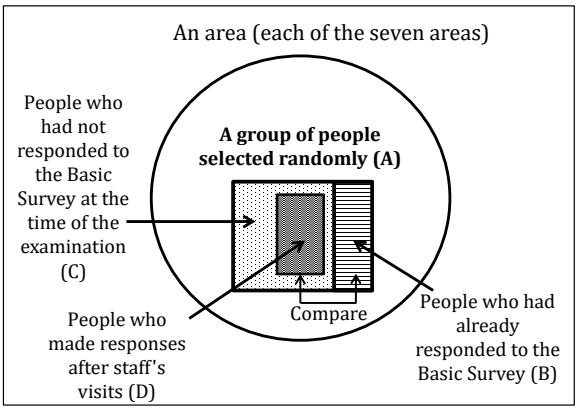


Figure 11. Comparison scheme in the representativeness study

3. Results and analysis of survey results

1) Results of the survey

(1) Response rate

A) Overall response rate in the prefecture

After sending out the questionnaires, many responses were returned within a short period of time. At the 4th meeting of the Oversight Committee (October 17, 2011), it was reported that 13,884 responses were obtained, about half (47.5%) of the approximately 29,000 eligible persons in the preliminary survey area, and 79,544 responses were collected from other areas in the prefecture, totaling 93,428 responses (Table 3).

After this, growth in the number of responses slowed down in the preliminary survey area, but responses from other areas in the prefecture increased at a rate of about 8,000 responses per day at its peak. As of November 30, 2011, the number of responses from other areas in the prefecture was 356,715, an increase of approximately 280,000 compared to the number of responses as of October 11, 2011. The total number of responses from the preliminary survey and the subsequent, broader survey was 371,039, indicating a rapid increase in the number of responses (Table 3).

By the end of 2011, the response rate to the questionnaire (responses from both the preliminary and subsequent surveys) reached the 20% level, but there was no substantial increase after that.

Figure 12 shows the changes in the response rate over time until June 30, 2015, when the activities to improve the response rate came to an end. This figure shows the response rates for both the simplified and detailed versions. Figure 13 also shows the correspondence between the major activities to improve the response rate and the change in the response rate.[7)]

The number of responses and the response rate are plotted based on the values reported to the Oversight Committee, which meets about four times a year.

Note that in most cases, multiple activities to improve the response rate were implemented at the same time, and there is not necessarily a one-to-one correspondence between the activities and changes in the response rate.

For example, the effect of sending out the simplified version of the questionnaire (④) in Figure 13 has continued even during the period shown in (⑤) and (⑥). In addition, some respondents did not have time to fill out the questionnaires at the writing support booth, so they took the questionnaire home. If such people returned their questionnaires after filling them out at

Table 3. Increase in the number of responses and progress in dose estimation

Date of tabulation	No. of responses	No. of dose estimates	Date of report	Occasion
2011/10/11	93,428	—	2011/10/17	4th Oversight Committee meeting
2011/11/30	371,039	1,727	2011/12/13	1st press conference
2012/1/20	426,932	1,727	2012/1/25	5th Oversight Committee meeting
2012/1/31	431,720	10,468	2012/2/20	2nd press conference
2012/3/31	451,446	10,468	2012/4/26	6th Oversight Committee meeting
2012/5/31	465,041	25,667	2012/6/12	7th Oversight Committee meeting
2012/8/31	470,593	122,798	2012/9/11	8th Oversight Committee meeting
2012/10/31	473,841	233,901	2012/11/18	9th Oversight Committee meeting
2013/1/31	477,121	394,369	2013/2/13	10th Oversight Committee meeting

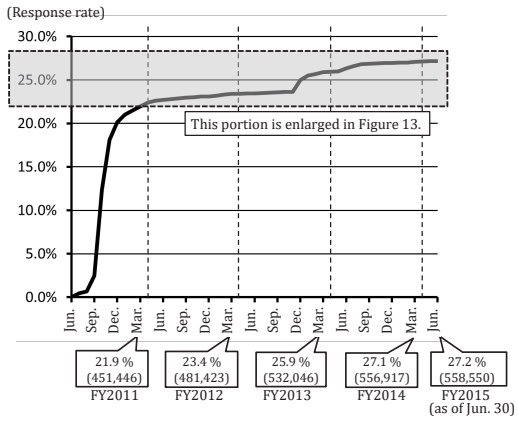


Figure 12. Changes in the response rate over time

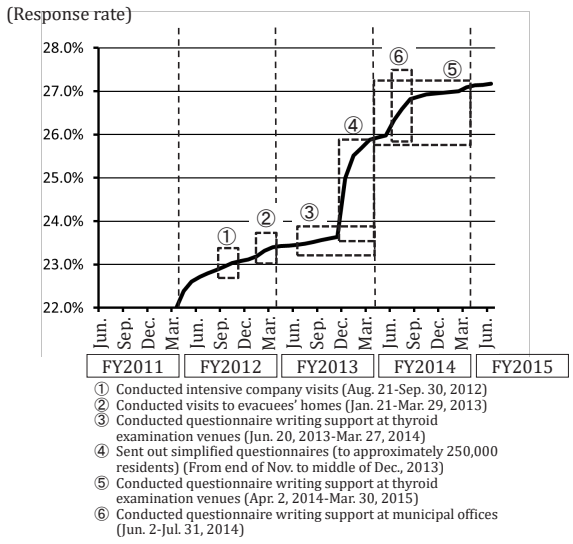


Figure 13. Activities to improve the response rate and changes in the response rate

home, it would be difficult to distinguish them from general voluntary responses.

As mentioned above, as of the end of March 2020, there were about 14,100 responses (about 2.5% of the total number of responses) that could not be processed for dose estimation because the contact information was not provided or they were returned completely blank. In addition, there were some responses in which the duration of the behavior record was less than four months, but if dose estimation is possible (i.e., the behavior record continues without interruption and the location can be described in terms of latitude and longitude), these numbers are included in the number of responses and valid responses.

Although the number of responses has been decreasing year by year, we received 46 responses to the detailed version and 255 responses to the simplified version during FY2019 (April 1, 2019 to March 31, 2020). Most of the responses were obtained through writing support provided at thyroid examination venues. As of March 31, 2020, the most recent number of responses was 568,632, for a response rate of 27.7%.

Of the 568,632 responses, the number of valid responses, excluding those for which dose estimation was difficult, was 554,517. Of these, 554,320 have been processed for dose estimation, and results have been sent to 554,132 respondents.

The number of temporary residents is counted separately, and their number of responses and valid responses is shown in Table 4

As explained above, temporary residents, are defined as (i) those who resided in the prefecture between March 11 and July 1, 2011, but whose resident registration was outside the prefecture, (ii) those who resided outside the prefecture who commuted to the prefecture between March 11 and July 1, 2011, and (iii) those who resided outside the prefecture who temporarily stayed in the prefecture between March 11 and March 25, 2011. If these temporary residents submitted questionnaires, we estimate their doses and send results in the same way as for those who resided in the prefecture at the time of the earthquake.

B) Response rate to the simplified questionnaire

Figure 14 shows the cumulative number of responses to the simplified questionnaire. The number of responses is plotted based on data compiled approximately once every three months in preparation for Oversight Committee meetings. It can be seen that a large number of

Table 4. Numbers of responses and dose estimates for temporary residents As of the end of March 2020

Number of questionnaires sent a	Number of responses b	Response rate c=b/a	Number of valid responses d	Valid response rate e=d/a	Dose estimation completed f	Rate g=f/d	Results fed back h	Rate i=h/d
4,100	2,108	51.4%	2,098	51.2%	2,088	99.5%	2,088	99.5%

responses were returned in the months following the distribution of simplified questionnaires to those who were eligible for thyroid examinations and had not responded to the detailed questionnaire by the end of November 2013 (approximately 250,000 persons).

After 2015, about one year after we started distributing the simplified questionnaire, the cumulative number of responses has increased slowly, in a way that seems mainly attributable to the writing support activities. The number of responses using the simplified questionnaire was 65,452 as of March 31, 2015, and gradually increased to 74,773 as of March 31, 2020.

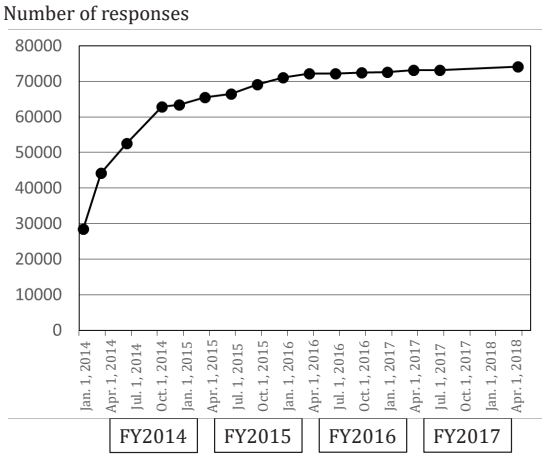


Figure 14. Cumulative number of responses to the simplified questionnaire

C) Response rate by region

Table 5 shows the numbers of responses, valid responses, dose estimates, and results sent, by municipality, as of the end of March 2020. Figure 15 shows changes in the response rate for the simplified and detailed questionnaires combined for each of the seven districts in Fukushima Prefecture through March 31, 2016, when activities to improve the response rate were completed.[7] Figure 15 is also plotted based on data that is compiled approximately once every three months for the aforementioned Oversight Committee meetings.

The vertical dotted line in Figure 15 indicates when the simplified questionnaire was distributed, and we can see that it had a certain effect, as the response rate increased to the 20% range in Kennan, Aizu, and Minamiaizu districts thereafter. In addition, the response rate was over 45%

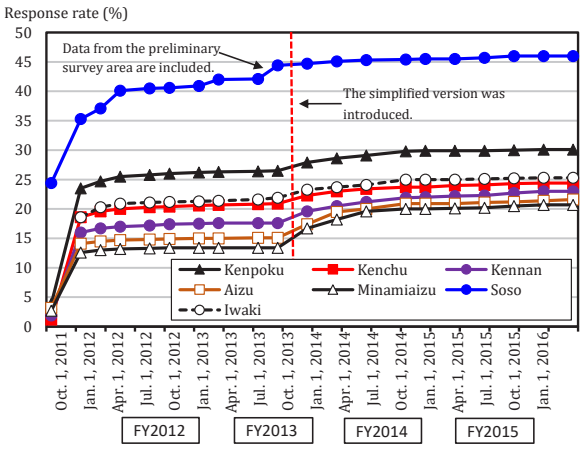


Figure 15. Changes in the response rate over time for each of the seven districts

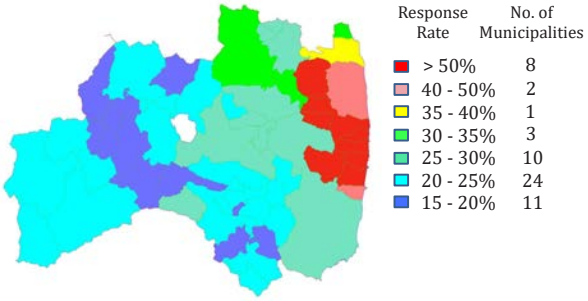


Figure 16. Map of response rates, by municipality

in Soso, where nuclear power plants are located. In Soso, there are many people who have complicated evacuation behaviors, and there are few people who meet the conditions for the simplified questionnaire (one move or no move of residence or place of work in the first four months after the accident). For this reason, the response rate for Soso did not increase substantially even after the introduction of the simplified version.

The Soso and Kenpoku districts include areas where questionnaires were distributed prior to other areas (preliminary survey area), namely, Namie Town and Iitate Village in Soso, and Yamakiya in Kawamata Town in Kenpoku. Prior to July 31, 2013, the data were aggregated separately for "preliminary survey area," "Soso excluding Namie Town and Iitate Village," and "Kenpoku excluding Yamakiya in Kawamata Town." However, from September 30, 2013, Namie Town and Iitate Village were included in Soso, and Yamakiya in Kawamata Town was included in Kenpoku. As a result, the response rate in Soso appears to have increased suddenly in the July 31, 2013 and September 30, 2013 tabulations, but this is mainly

Table 5. Numbers of responses, dose estimates, and result reports sent out, by municipality As of the end of March 2020

	Municipality	Number of eligible persons a	Number of responses b	Response rate c=b/a	Number of valid responses d	Valid response rate e=d/a	Dose estimation completed f	Rate g=f/d	Results fed back h	Rate i=h/d
Kenpoku	Fukushima City	295,633	93,965	31.8%	92,457	31.3%	92,434	100.0%	92,402	99.9%
	Nihonmatsu City	60,854	16,917	27.8%	16,552	27.2%	16,549	100.0%	16,547	100.0%
	Date City	67,574	18,309	27.1%	17,844	26.4%	17,834	99.9%	17,822	99.9%
	Motomiya City	31,759	9,113	28.7%	8,944	28.2%	8,944	100.0%	8,943	100.0%
	Koori Town	13,207	3,884	29.4%	3,775	28.6%	3,775	100.0%	3,775	100.0%
	Kunimi Town	10,316	3,029	29.4%	2,941	28.5%	2,940	100.0%	2,940	100.0%
	Kawamata Town	15,885	5,189	32.7%	5,016	31.6%	5,016	100.0%	5,011	99.9%
	Otama Village	8,791	1,935	22.0%	1,891	21.5%	1,891	100.0%	1,891	100.0%
	Subtotal	504,019	152,341	30.2%	149,420	29.6%	149,383	100.0%	149,331	99.9%
Kenchu	Koriyama City	339,678	87,266	25.7%	85,499	25.2%	85,492	100.0%	85,487	100.0%
	Sukagawa City	80,157	17,308	21.6%	16,872	21.0%	16,867	100.0%	16,867	100.0%
	Tamura City	41,723	10,576	25.3%	10,212	24.5%	10,206	99.9%	10,203	99.9%
	Kagamiishi Town	13,109	2,922	22.3%	2,859	21.8%	2,858	100.0%	2,858	100.0%
	Tenei Village	6,469	1,255	19.4%	1,224	18.9%	1,224	100.0%	1,224	100.0%
	Ishikawa Town	17,489	4,240	24.2%	4,136	23.6%	4,134	100.0%	4,134	100.0%
	Tamakawa Village	7,334	1,510	20.6%	1,462	19.9%	1,461	99.9%	1,460	99.9%
	Hirata Village	7,053	1,666	23.6%	1,610	22.8%	1,610	100.0%	1,610	100.0%
	Asakawa Town	7,163	1,531	21.4%	1,496	20.9%	1,494	99.9%	1,493	99.8%
	Furudono Town	6,321	1,325	21.0%	1,290	20.4%	1,290	100.0%	1,290	100.0%
	Miharu Town	18,989	4,880	25.7%	4,784	25.2%	4,782	100.0%	4,781	99.9%
	Ono Town	11,700	2,610	22.3%	2,546	21.8%	2,546	100.0%	2,545	100.0%
	Subtotal	557,185	137,089	24.6%	133,990	24.0%	133,964	100.0%	133,952	100.0%
Kennan	Shirakawa City	65,427	16,193	24.7%	15,861	24.2%	15,858	100.0%	15,854	100.0%
	Nishigo Village	20,088	5,069	25.2%	4,952	24.7%	4,952	100.0%	4,951	100.0%
	Izumizaki Village	6,931	1,443	20.8%	1,404	20.3%	1,404	100.0%	1,403	99.9%
	Nakajima Village	5,306	1,023	19.3%	998	18.8%	998	100.0%	998	100.0%
	Yabuki Town	18,341	4,131	22.5%	4,025	21.9%	4,017	99.8%	4,016	99.8%
	Tanagura Town	15,384	3,057	19.9%	2,992	19.4%	2,992	100.0%	2,992	100.0%
	Yamatsuri Town	6,491	1,481	22.8%	1,434	22.1%	1,434	100.0%	1,432	99.9%
	Hanawa City	10,061	2,330	23.2%	2,279	22.7%	2,279	100.0%	2,278	100.0%
	Samegawa Village	4,196	824	19.6%	796	19.0%	796	100.0%	796	100.0%
	Subtotal	152,225	35,551	23.4%	34,741	22.8%	34,730	100.0%	34,720	99.9%
Aizu	Aizuwakamatsu City	127,815	29,765	23.3%	28,790	22.5%	28,766	99.9%	28,765	99.9%
	Kitakata City	53,199	11,114	20.9%	10,686	20.1%	10,681	100.0%	10,676	99.9%
	Kitashiobara Village	3,276	611	18.7%	588	17.9%	588	100.0%	588	100.0%
	Nishiaizu Town	7,725	1,461	18.9%	1,359	17.6%	1,355	99.7%	1,355	99.7%
	Bandai Town	3,888	796	20.5%	778	20.0%	777	99.9%	776	99.7%
	Inawashiro Town	16,271	3,670	22.6%	3,538	21.7%	3,538	100.0%	3,537	100.0%
	Aizubange Town	17,881	3,317	18.6%	3,174	17.8%	3,154	99.4%	3,154	99.4%
	Yugawa Village	3,513	744	21.2%	711	20.2%	701	98.6%	701	98.6%
	Yanaizu Town	4,077	732	18.0%	700	17.2%	698	99.7%	698	99.7%
	Mishima Town	2,029	374	18.4%	340	16.8%	340	100.0%	340	100.0%
	Kaneyama Town	2,544	631	24.8%	575	22.6%	574	99.8%	574	99.8%
	Showa Village	1,569	354	22.6%	327	20.8%	327	100.0%	327	100.0%
	Aizumisato Town	23,412	4,674	20.0%	4,477	19.1%	4,461	99.6%	4,460	99.6%
	Subtotal	267,199	58,243	21.8%	56,043	21.0%	55,960	99.9%	55,951	99.8%
Minamiaizu	Shimogo Town	6,649	1,257	18.9%	1,199	18.0%	1,199	100.0%	1,199	100.0%
	Hinoemata Village	614	142	23.1%	133	21.7%	133	100.0%	133	100.0%
	Tadami Town	5,030	1,152	22.9%	1,090	21.7%	1,090	100.0%	1,090	100.0%
	Minamiaizu Town	18,495	3,870	20.9%	3,692	20.0%	3,691	100.0%	3,690	99.9%
	Subtotal	30,788	6,421	20.9%	6,114	19.9%	6,113	100.0%	6,112	100.0%
Soso	Soma City	37,366	13,319	35.6%	12,812	34.3%	12,811	100.0%	12,792	99.8%
	Minamisoma City	70,013	30,303	43.3%	29,503	42.1%	29,503	100.0%	29,482	99.9%
	Hirono Town	5,165	2,236	43.3%	2,146	41.5%	2,145	100.0%	2,143	99.9%
	Naraha Town	7,963	4,191	52.6%	4,033	50.6%	4,033	100.0%	4,025	99.8%
	Tomioka Town	15,749	8,640	54.9%	8,424	53.5%	8,424	100.0%	8,415	99.9%
	Kawauchi Village	2,996	1,543	51.5%	1,489	49.7%	1,489	100.0%	1,489	100.0%
	Okuma Town	11,473	6,092	53.1%	5,868	51.1%	5,865	99.9%	5,864	99.9%
	Futaba Town	7,051	3,953	56.1%	3,853	54.6%	3,853	100.0%	3,846	99.8%
	Namie Town	21,334	12,994	60.9%	12,700	59.5%	12,700	100.0%	12,685	99.9%
	Katsurao Village	1,541	825	53.5%	768	49.8%	768	100.0%	768	100.0%
	Shinchi Town	8,356	2,711	32.4%	2,612	31.3%	2,612	100.0%	2,609	99.9%
	Iitate Village	6,588	3,446	52.3%	3,335	50.6%	3,335	100.0%	3,328	99.8%
	Subtotal	195,595	90,253	46.1%	87,543	44.8%	87,538	100.0%	87,446	99.9%
—	Iwaki City	348,240	88,734	25.5%	86,666	24.9%	86,632	100.0%	86,620	99.9%
	Total	2,055,251	568,632	27.7%	554,517	27.0%	554,320	100.0%	554,132	99.9%

*Rates (%) are rounded for each of the estimated dose levels.

due to the change in the tabulation method, not an increase in the number of responses.

A color-coded map of the response rate for each of the 59 municipalities in the prefecture as of March 31, 2018 is shown in Figure 16.[7] As a general trend, districts with relatively low air dose rates (Aizu, Minamiaizu, and Kennan) also have low response rates, while districts with relatively high air dose rates (Soso) have the highest response rates. For Kenchu and Kenpoku, which have air dose rate levels in between, the response rates also tend to be in between those of Soso, Aizu, Minamiaizu, and Kennan. While the response rate for the prefecture as a whole was about 27%, the response rate for the eight towns and villages in Soso, where nuclear power plants are located, was more than 50%.

D) Response rate by sex

Table 6 shows the response rate by sex (as of September 30, 2013) reported to the 13th Oversight Committee. In the age groups from 10 to 59 years old, the response rate of females tended to be slightly higher than that of males; however, the difference in the response rate by sex was about 2.8 points for all age groups, with 22.1% for males and 24.9% for females.

E) Response rate by age group

Table 7 shows the response rate by age group (age at the time of the earthquake) published in the Oversight Committee meeting materials. From October 31, 2012 to June 30, 2015, when we were nearing the end of our activities to increase the response rate, the response rate increased by about 17 points for ages 0 to 9 and 16 points for ages 10 to 19. As a result, the response rate for those aged 19 and under was about 40%. Distribution of the simplified questionnaire (at the end of November 2013) to those eligible for thyroid examinations (generally those aged 18 and under who were living in Fukushima Prefecture at the time of the earthquake) and writing support at thyroid examination venues may have contributed to the increase in the response rate among those aged 19 and under.

Table 6. Response rate by sex

Age group	0-9	10-19	20-29	30-39	40-49	50-59	60-	Total
Male	30.1%	21.1%	13.7%	18.9%	18.6%	19.9%	27.8%	22.1%
Female	29.9%	22.2%	19.8%	26.5%	23.0%	23.6%	26.6%	24.9%
Total	29.7%	21.6%	16.6%	22.6%	20.8%	21.7%	27.0%	23.6%

As of September 30, 2013

Table 7. Changes in the response rate by age group

Age group	0-9	10-19	20-29	30-39	40-49	50-59	60-	Total
Response rate (as of Oct. 31, 2012)	28.4%	19.4%	16.6%	21.9%	19.9%	21.6%	27.0%	23.0%
Response rate (as of Jun. 30, 2015)	45.8%	35.2%	17.8%	24.3%	22.1%	22.7%	27.6%	27.2%
Difference	17.4	15.8	1.2	2.4	2.2	1.1	0.6	4.2

(2) Results of external exposure dose estimation

A) External exposure doses for the whole prefecture and by region

In a press release issued on December 13, 2011, the dose distribution based on Basic Survey results was announced for the first time, and it was reported that about 63% of the 1,589 residents in the preliminary survey area (excluding those engaged in radiation work) received less than 1 mSv.

According to a press release on February 20, 2012, the number of dose estimates (excluding radiation workers in the preliminary survey area) was 9,747. Of these, 57.8% were less than 1 mSv and 99.3% were less than 10 mSv. This revealed that even in areas where air dose rates were considered as relatively high, most people had received less than 10 mSv.

The number of dose estimates completed gradually caught up with the number of responses received, as a result of a substantial increase in staff. As shown in Table 3, the number of dose estimates completed was 25,667 as of May 31, 2012, then 122,798 by August 31, 2012, and 233,901 by October 31, 2012, which was 49.4% of the number of responses received.

Thereafter, as of January 31, 2013, the number of dose estimates reached 394,369, which is more than 80% of the total number of responses received. In addition, the process of sending out dose estimates was gradually catching up, and at this point, the number of results sent out had reached 361,752, accounting for 75.8% of the number of responses received.

While it is of course important to report the results obtained from the Basic Surveys to the citizens of the prefecture and to the rest of Japan, it is also important to disseminate information through academic publications in English so that people overseas can understand the situation of radiation exposure in Fukushima correctly. From this perspective, we have been submitting papers as dose estimation results have become known, with results as of January 31, 2013,[9] July 31, 2013,[10] and June 30, 2014[11] published in internationally accessible journals. These papers report that the external exposure doses in the initial period after the Fukushima accident were in many cases in the low mSv range, with nearly 90% of the respondents exposed to less than 2 mSv.

Dose estimation continues. The overall distribution of external exposure doses as of March 31, 2020 is shown in Figure 17. This is a distribution of the number of respondents according to their estimated doses (excluding those who have been engaged in radiation work and those with behavior records of less than four months).

93.8% of the respondents were exposed to less than 2 mSv, and about 99.8% were exposed to less than 5 mSv. The maximum value was 25 mSv, the mean value was 0.8 mSv, and the median value was 0.6 mSv.

Table 8 shows the distribution of estimated doses by district. These estimates exclude those

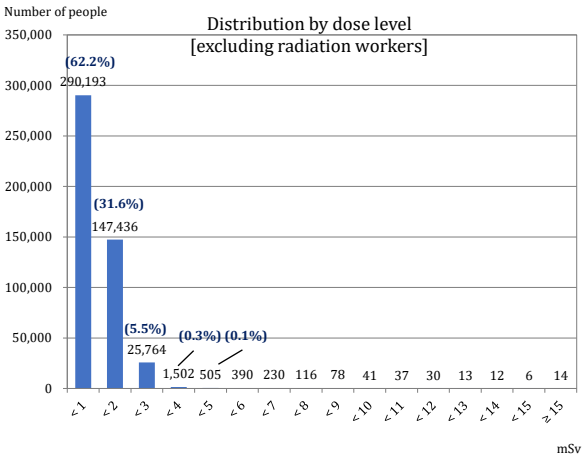


Figure 17. Distribution of the number of respondents in the whole prefecture, by estimated dose

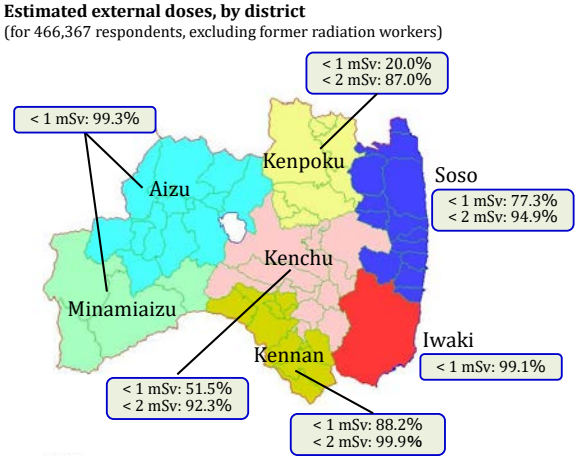


Figure 18. Estimated dose distribution by district and by estimated doses over the four months following the accident

Table 8. Distribution of the number of respondents by estimated dose and by district As of March 31, 2020

Effective dose (mSv)	Total	Excluding radiation workers	Breakdown of the total excluding radiation workers by district							Dose distribution of residents excluding radiation workers (%)		
			Kenpoku	Kenchu	Kennan	Aizu	Minamiaizu	Soso	Iwaki			
< 1	295,921	290,193	24,956	58,505	26,347	46,053	4,979	55,887	73,466	62.2	93.8	99.8
< 2	149,782	147,436	83,847	46,394	3,505	311	37	12,705	637	31.6		
< 3	26,138	25,764	15,720	8,281	18	25	0	1,690	30	5.5	5.8	
< 4	1,585	1,502	472	428	0	1	0	597	4	0.3		
< 5	551	505	40	5	0	0	0	459	1	0.1	0.2	
< 6	442	390	19	3	0	0	0	367	1	0.1		0.2
< 7	269	230	10	1	0	1	0	218	0	0.0	0.1	
< 8	155	116	1	0	0	0	0	115	0	0.0		
< 9	118	78	1	0	0	0	0	77	0	0.0	0.0	
< 10	73	41	0	0	0	0	0	41	0	0.0		
< 11	70	37	0	1	0	0	0	36	0	0.0	0.0	0.0
< 12	52	30	1	0	0	0	0	29	0	0.0		
< 13	37	13	0	0	0	0	0	13	0	0.0	0.0	
< 14	36	12	0	0	0	0	0	12	0	0.0		
< 15	27	6	0	0	0	0	0	6	0	0.0	0.0	
≥15	323	14	0	0	0	0	0	14	0	0.0	0.0	0.0
Total	475,579	466,367	125,067	113,618	29,870	46,391	5,016	72,266	74,139	100.0	100.0	100.0
Maximum	66	25	11	10	2.6	6.0	1.9	25	5.9			
Average	0.9	0.8	1.4	1.0	0.6	0.2	0.1	0.8	0.3			
Median	0.6	0.6	1.4	0.9	0.5	0.2	0.1	0.5	0.3			

* Rates (%) are rounded for each of the estimated dose levels and the total may not be 100%.

with behavior records of less than 4 months.

The results for 466,367 respondents, excluding those who have been engaged in radiation work, from the total of 475,579 respondents, shows that about 87% of the respondents in Kenpoku and about 92% of the respondents in Kenchu were estimated to have received less than 2 mSv. In Kennan, about 88% of the respondents had less than 1 mSv, and in Aizu and Minamiaizu, more than 99% of the respondents had less than 1 mSv. Furthermore, about 77% of the respondents in Soso and more than 99% of the respondents in Iwaki received less than 1 mSv (Figure 18). The distribution of the number of respondents by estimated doses and by municipality in more detail is shown in Table 9.

B) Age and sex dependencies of external exposure doses

Table 10 shows the estimated doses by sex and by age group in 10-year increments. It can be seen that there is no substantial difference in the distribution of estimated doses by sex or age group.

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), which collects knowledge on radiation doses and effects worldwide, estimated exposure doses for one year after the Fukushima accident by age group and by municipality using model calculations in its 2013 Report on the Fukushima accident.[12)]

According to this report, external exposure doses in non-evacuated areas were estimated to be about 1.7 times higher for infants (ages 0 to 5) than for adults (age 16 and above) and about 1.4 times higher for children (ages 6 to 15) than for adults in the same municipalities. This is due to the time spent outdoors and body size of each age group as estimated by UNSCEAR.

When the external doses obtained from the Basic Survey were rearranged into the same age groups as UNSCEAR, the dose for infants in non-evacuated areas was 1.08 times the adult dose, and the dose for children was 1.06 times the adult dose.

In contrast to model calculations by UNSCEAR, doses from the Basic Survey are based on actual behavior records and show less age dependence, so doses for infants and children were not so different from those for adults.[13)]

In the evacuated area, the ratios of these doses were 0.82 (infant dose to adult) and 0.87 (child dose to adult), respectively. This may be

Table 9. Estimated dose distribution by municipality

As of the end of March 2020

Municipality		External dose (mSv)																Total
		< 1	< 2	< 3	< 4	< 5	< 6	< 7	< 8	< 9	< 10	< 11	< 12	< 13	< 14	< 15	≥ 15	
Kenpoku	Fukushima City	16,187	52,615	9,399	151	13	10	4	0	0	0	0	0	0	0	0	0	78,379
	Nihonmatsu City	1,318	8,664	3,531	90	1	0	0	0	0	0	0	0	0	0	0	0	13,604
	Date City	4,386	9,091	1,135	147	8	2	3	1	1	0	0	0	0	0	0	0	14,774
	Motomiya City	746	5,463	1,259	24	1	0	0	0	0	0	0	0	0	0	0	0	7,493
	Koori Town	315	2,752	66	2	0	1	0	0	0	0	0	0	0	0	0	0	3,136
	Kunimi Town	967	1,436	12	0	0	0	0	0	0	0	0	0	0	0	0	0	2,415
	Kawamata Town	643	2,753	185	56	17	6	3	0	0	0	0	1	0	0	0	0	3,664
	Otama Village	394	1,073	133	2	0	0	0	0	0	0	0	0	0	0	0	0	1,602
Subtotal		24,956	83,847	15,720	472	40	19	10	1	1	0	0	1	0	0	0	0	125,067
Kenchu	Koriyama City	24,041	40,812	7,830	418	5	3	1	0	0	0	0	0	0	0	0	0	73,110
	Sukagawa City	10,865	3,218	335	4	0	0	0	0	0	0	0	0	0	0	0	0	14,422
	Tamura City	7,686	682	24	3	0	0	0	0	0	0	0	0	0	0	0	0	8,395
	Kagamiishi Town	2,369	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,445
	Tenei Village	405	587	59	1	0	0	0	0	0	0	0	0	0	0	0	0	1,052
	Ishikawa Town	3,196	39	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3,237
	Tamakawa Village	1,183	19	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1,205
	Hirata Village	1,301	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,335
	Asakawa Town	1,232	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,247
	Furudono Town	1,073	14	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1,089
	Miharu Town	3,128	815	24	2	0	0	0	0	0	0	1	0	0	0	0	0	3,970
	Ono Town	2,026	83	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2,111
Subtotal		58,505	46,394	8,281	428	5	3	1	0	0	0	1	0	0	0	0	0	113,618
Kennan	Shirakawa City	12,484	1,281	9	0	0	0	0	0	0	0	0	0	0	0	0	0	13,774
	Nishigo Village	2,248	2,036	3	0	0	0	0	0	0	0	0	0	0	0	0	0	4,287
	Izumizaki Village	1,163	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1,185
	Nakajima Village	843	13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	857
	Yabuki Town	3,376	83	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3,460
	Tanagura Town	2,555	28	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2,586
	Yamatsuri Town	1,156	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,165
	Hanawa City	1,869	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,892
	Samegawa Village	653	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	664
Subtotal		26,347	3,505	18	0	0	0	0	0	0	0	0	0	0	0	0	0	29,870
Aizu	Aizuwakamatsu City	23,770	160	13	0	0	0	1	0	0	0	0	0	0	0	0	0	23,944
	Kitakata City	8,940	56	3	1	0	0	0	0	0	0	0	0	0	0	0	0	9,000
	Kitashiobara Village	479	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	483
	Nishiaizu Town	1,016	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,018
	Bandai Town	656	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	666
	Inawashiro Town	2,861	31	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2,895
	Aizubange Town	2,649	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,664
	Yugawa Village	597	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	601
	Yanaizu Town	554	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	559
	Mishima Town	247	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	247
	Kaneyama Town	406	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	409
	Showa Village	245	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	246
	Aizumisato Town	3,633	23	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3,659
Subtotal		46,053	311	25	1	0	0	1	0	0	0	0	0	0	0	0	0	46,391
Minamiaizu	Shimogo Town	969	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	974
	Hinoemata Village	103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	103
	Tadami Town	882	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	887
	Minamiaizu Town	3,025	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,052
Subtotal		4,979	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,016
Soso	Soma City	10,029	467	87	20	5	0	0	0	0	2	0	0	0	0	0	0	10,610
	Minamisoma City	19,137	6,225	513	99	35	3	7	4	1	0	0	1	0	0	0	0	26,025
	Hirono Town	1,839	59	2	0	0	0	1	0	1	0	0	0	0	0	0	0	1,902
	Naraha Town	3,403	131	13	2	0	1	1	0	0	0	0	0	0	0	0	0	3,551
	Tomioka Town	5,834	1,104	100	18	3	2	0	3	2	0	0	1	0	0	0	0	7,067
	Kawauchi Village	963	350	16	1	0	1	1	1	0	0	0	0	0	0	0	0	1,333
	Okuma Town	3,371	1,284	112	17	6	4	4	3	0	2	2	1	0	4	0	1	4,811
	Futaba Town	2,676	468	77	19	6	4	3	6	2	1	0	2	0	0	0	1	3,265
	Namie Town	5,767	2,118	383	68	40	17	12	13	9	6	11	7	5	4	3	8	8,471
	Katsurao Village	502	162	24	4	0	1	0	0	0	0	0	0	0	0	0	0	693
	Shinchi Town	2,180	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,200
	Iitate Village	186	317	363	349	364	334	189	85	62	30	23	17	8	4	3	4	2,338
Subtotal		55,887	12,705	1,690	597	459	367	218	115	77	41	36	29	13	12	6	14	72,266
Iwaki	Iwaki City	73,466	637	30	4	1	1	0	0	0	0	0	0	0	0	0	0	74,139
Total (A)		290,193	147,436	25,764	1,502	505	390	230	116	78	41	37	30	13	12	6	14	466,367
Rate (%)		62.2	31.6	5.5	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
			93.8		5.8		0.2		0.1		0.0		0.0		0.0	0.0	0.0	100.0
						99.8					0.2					0.0	0.0	100.0
Temporary visitors, etc. (B)		1,521	278	18	2	0	0	0	0	0	0	0	0	0	0	0	1	1,820
Total (A) + (B)		291,714	147,714	25,782	1,504	505	390	230	116	78	41	37	30	13	12	6	15	468,187

* Rates are rounded for each of the estimated dose levels and the total may not be 100%.

Table 10. Estimated dose distribution by sex and by age group As of the end of March 2020

Effective dose (mSv)	Age at the time of the earthquake									Total
	0 - 9	10 - 19	20 - 29	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	80 -	
< 1	48,242	45,238	21,429	34,397	28,759	32,904	36,334	25,735	17,155	290,193
< 2	23,070	21,839	10,174	18,362	16,703	18,558	19,497	12,293	6,940	147,436
< 3	6,491	4,296	1,142	2,351	2,251	2,973	3,424	1,996	840	25,764
< 4	253	160	81	158	153	230	233	164	70	1,502
< 5	19	47	35	39	75	95	81	76	38	505
< 6	14	13	29	34	47	86	73	66	28	390
< 7	3	6	10	22	24	45	52	47	21	230
< 8	4	4	8	9	13	35	22	14	7	116
< 9	2	6	2	7	8	16	16	12	9	78
< 10	0	1	2	3	3	12	11	5	4	41
< 11	1	1	2	2	6	11	5	6	3	37
< 12	0	0	1	3	0	5	8	11	2	30
< 13	0	0	0	0	1	6	4	1	1	13
< 14	0	0	1	1	1	4	3	2	0	12
< 15	0	0	0	0	0	3	3	0	0	6
≥ 15	0	0	0	0	2	3	6	1	2	14
Total	78,099	71,611	32,916	55,388	48,046	54,986	59,772	40,429	25,120	466,367

Effective dose (mSv)	By gender				Total	Rate by dose level at left (%)
	Male	Rate by dose level at left (%)	Female	Rate by dose level at left (%)		
< 1	129,469	60.6	160,724	63.6	290,193	62.2
< 2	68,307	32.0	79,129	31.3	147,436	31.6
< 3	13,993	6.6	11,771	4.7	25,764	5.5
< 4	953	0.4	549	0.2	1,502	0.3
< 5	282	0.1	223	0.1	505	0.1
< 6	199	0.1	191	0.1	390	0.1
< 7	130	0.1	100	0.0	230	0.0
< 8	64	0.0	52	0.0	116	0.0
< 9	49	0.0	29	0.0	78	0.0
< 10	24	0.0	17	0.0	41	0.0
< 11	23	0.0	14	0.0	37	0.0
< 12	16	0.0	14	0.0	30	0.0
< 13	6	0.0	7	0.0	13	0.0
< 14	8	0.0	4	0.0	12	0.0
< 15	3	0.0	3	0.0	6	0.0
≥ 15	11	0.0	3	0.0	14	0.0
Total	213,537	100.0	252,830	100.0	466,367	100.0

* Rates are rounded for each of the estimated dose levels and the total may not be 100%.

due to the fact that infants and children were evacuated earlier than adults.

C) Differences in external exposure doses depending on the timing of questionnaire submission

The Basic Survey is still ongoing, and by March 31, 2020, the number of respondents for whom dose estimation for the four months following the accident had been completed reached 466,367 (excluding those who have been engaged in radiation work).

The questionnaires for filling in behavior records were self-administered, and it was thought that as the years passed since the accident, memories of behavior would fade and the behavior records might be far from the actual ones. In recent years, the number of responses voluntarily returned has been decreasing, and the majority of questionnaires have been collected through the writing support activities at thyroid examination venues.

A situation like this could result in reporting irregularities arising from recall bias, for which reason, the following comparisons were made for dose distributions due to differences in the timing of responses.

Table 11 shows the dose distributions as of

Table 11. Estimated dose distributions by timing of receipt of responses
Dose distributions as of June 30, 2015 (which was confirmed to be representative of the entire population of the prefecture)

Effective dose (mSv)	Dose distribution by district (excluding former radiation workers)							Total	
	Kenpoku	Kenchu	Kennan	Aizu	Minamiaizu	Soso	Iwaki	No.	%
<1	24,789	56,569	24,846	43,955	4,771	55,298	71,999	282,227	62
<2	82,689	45,269	3,320	298	34	12,402	624	144,636	31
<3	15,397	8,050	17	25	0	1,650	30	25,169	5.4
<4	464	417	0	1	0	584	4	1,470	0.3
<5	40	5	0	0	0	449	1	495	0.1
≥ 5	31	4	0	1	0	906	1	943	0.2
Total	123,410	110,314	28,183	44,280	4,805	71,289	72,659	454,940	100
%	27.1	24.2	6.2	9.7	1.1	15.7	16	—	100

Dose distributions estimated from the responses collected from June 30, 2015 to March 31, 2019

Effective dose (mSv)	Dose distribution by district (excluding former radiation workers)							Total	
	Kenpoku	Kenchu	Kennan	Aizu	Minamiaizu	Soso	Iwaki	No.	%
<1	160	1,893	1,460	2,047	203	567	1,387	7,717	69.8
<2	1,108	1,092	178	13	3	299	13	2,706	24.5
<3	309	220	1	0	0	40	0	570	5.2
<4	8	11	0	0	0	13	0	32	0.3
<5	0	0	0	0	0	10	0	10	0.1
≥ 5	1	1	0	0	0	22	0	24	0.2
Total	1,586	3,217	1,639	2,060	206	951	1,400	11,059	100
%	14.3	29.1	14.8	18.6	1.9	8.6	12.7	—	100

June 30, 2015, which was shown to be representative of the entire population of the prefecture by the representativeness study conducted in 2015 (see the next section for details), and the dose distributions of the responses for which dose estimation had been performed since then until March 31, 2019.

The results show no substantial difference in dose distributions (1 mSv increments) between the two groups, suggesting minimal effects related to the number of respondents then and now, and imperfect recall.[14)]

(3) Verification of representativeness of the responses received

To examine the representativeness of the responses received, we selected a group of residents who were covered by the Basic Survey by random sampling from seven districts of Fukushima Prefecture, and conducted door-to-door visits for those who had not responded to the survey and asked them to fill in the questionnaire. Although there were many cases where the residents were not at home during the door-to-door visits, we made efforts to secure a sufficient number of responses by making multiple visits.

A total of 2,645 residents were selected for door-to-door visits throughout the prefecture, and we received responses from 990 of them. The results of these visits are shown in Table 12. We compared the doses of 961 respondents (excluding 3 respondents who lived outside the prefecture during the survey period, 2 respondents who were born after the earthquake, and 24 respondents who had been engaged in radiation work) with the doses of those who had responded before the representative study.

The results of the comparison are shown in Table 13. The difference between the mean doses for those who responded during door-to-door visits and the mean doses for those who had already responded before the representative study was between -0.09 mSv and +0.12 mSv.

Results of equivalence testing for the mean dose values indicate that the doses of the two groups were equivalent with a probability of 95% or more (5% level of significance) by the equivalence criterion set for 0.25 mSv or less.

By district, there were no significant differences in dose distributions for the entire group of respondents, the randomly selected respondents (B in Figure 11), and those who responded during

Table 12. Results of door-to-door visits

Results of visits	Entire prefecture		Kenpoku		Kenchu		Kennan	
	No.	%	No.	%	No.	%	No.	%
(1) Met and responded	990	37.4	177	41.8	227	36.0	71	38.6
(2) Met but did not respond	327	12.4	87	20.6	88	14.0	33	17.9
(3) No meeting	664	25.1	104	24.6	185	29.4	49	26.6
(4) Moved out	212	8.0	28	6.6	30	4.8	12	6.5
(5) Met but refused to respond	452	17.1	27	6.4	100	15.9	19	10.3
Total	2,645	100	423	100	630	100	184	100

Results of visits	Aizu		Minamiaizu		Soso		Iwaki	
	No.	%	No.	%	No.	%	No.	%
(1) Responded the questionnaire	34	46.6	49	65.3	407	33.9	25	42.4
(2) Met but did not respond	8	11.0	7	9.3	95	7.9	9	15.3
(3) No meeting	5	6.8	6	8.0	299	24.9	16	27.1
(4) Moved out	3	4.1	5	6.7	132	11.0	2	3.4
(5) Met but refused to respond	23	31.5	8	10.7	268	22.3	7	11.9
Total	73	100	75	100	1201	100	59	100

Explanation of results
(1) Met and responded: We were able to meet the resident and he/she responded to the questionnaire.
(2) Met but did not respond: We were able to meet the resident or his/her family and handed them a questionnaire form, but we could not collect the response.
(3) No meeting: We visited multiple times and left notes with our contact information, but could never meet the resident or his/her family.
(4) Moved out: We sent an advance notice of our visit and it was not forwarded or returned to us, but when we visited, we found out that the resident had already moved out.
(5) Met but refused to respond: We were able to meet the resident, but he/she refused to respond to the questionnaire.

Table 13. Comparison of doses in the representativeness study

Area	Item	Previous respondents among the randomly selected people (Group B in Figure 11)	Respondents through door-to-door visits (Group D in Figure 11)	Difference of the average effective doses (D-B) (mSv)
Kenpoku	Average effective dose (mSv)	1.41	1.53	0.12
	Number of the relevant people	168	171	
Kenchu	Average effective dose (mSv)	1.04	0.95	-0.09
	Number of the relevant people	190	224	
Kennan	Average effective dose (mSv)	0.73	0.68	-0.05
	Number of the relevant people	41	71	
Aizu	Average effective dose (mSv)	0.19	0.24	0.05
	Number of the relevant people	11	34	
Minamiaizu	Average effective dose (mSv)	0.19	0.19	0.00
	Number of the relevant people	15	49	
Soso	Average effective dose (mSv)	0.73	0.81	0.08
	Number of the relevant people	1,138	388	
Iwaki	Average effective dose (mSv)	0.32	0.40	0.08
	Number of the relevant people	25	24	

Table 14. Comparison of dose distribution, by district

Kenpoku

Effective dose (mSv)	All respondents (as of Jun. 30, 2015)		Those who had responded before our home visits (Group B in Figure 11)		Those who responded at the time of our visit (Group D in Figure 11)	
	No.	%	No.	%	No.	%
<1	24,789	20.1	25	14.9	20	11.7
<2	82,689	67.0	118	70.2	119	69.6
<3	15,397	12.5	25	14.9	31	18.1
<4	464	0.4			1	0.6
<5	40	0.0				
<6	18	0.0				
<7	10	0.0				
<8	1	0.0				
<9	1	0.0				
<10						
<11						
<12	1	0.0				
Total No.	123,410	100.0	168	100.0	171	100.0
Max. (mSv)	11		2.9		3.1	
Mean (mSv)	1.4		1.3		1.5	

Kenchu

Effective dose (mSv)	All respondents (as of Jun. 30, 2015)		Those who had responded before our home visits (Group B in Figure 11)		Those who responded at the time of our visit (Group D in Figure 11)	
	No.	%	No.	%	No.	%
<1	56,569	51.3	97	51.1	134	59.8
<2	45,269	41.0	79	41.6	68	30.4
<3	8,050	7.3	13	6.8	22	9.8
<4	417	0.4	1	0.5		
<5	5	0.0				
<6	3	0.0				
<7	1	0.0				
Total No.	110,314	100.0	190	100.0	224	100.0
Max. (mSv)	6.3		3		2.7	
Mean (mSv)	0.9		0.9		0.7	

Kennan

Effective dose (mSv)	All respondents (as of Jun. 30, 2015)		Those who had responded before our home visits (Group B in Figure 11)		Those who responded at the time of our visit (Group D in Figure 11)	
	No.	%	No.	%	No.	%
<1	24,846	88.2	31	75.6	58	81.7
<2	3,320	11.8	10	24.4	13	18.3
<3	17	0.1				
Total No.	28,183	100.0	41	100.0	71	100.0
Max. (mSv)	2.6		1.4		1.8	
Mean (mSv)	0.5		0.7		0.5	

Aizu

Effective dose (mSv)	All respondents (as of Jun. 30, 2015)		Those who had responded before our home visits (Group B in Figure 11)		Those who responded at the time of our visit (Group D in Figure 11)	
	No.	%	No.	%	No.	%
<1	43,955	99.3	11	100	33	97.1
<2	298	0.7			1	2.9
<3	25	0.1				
<4	1	0.0				
<5						
<6						
<7	1	0.0				
Total No.	44,280	100.0	11	100.0	34	100.0
Max. (mSv)	6		0.3		1.3	
Mean (mSv)	0.2		0.2		0.2	

Minamiaizu

Effective dose (mSv)	All respondents (as of Jun. 30, 2015)		Those who had responded before our home visits (Group B in Figure 11)		Those who responded at the time of our visit (Group D in Figure 11)	
	No.	%	No.	%	No.	%
<1	4,771	99.3	15	100	49	100
<2	34	0.7				
Total No.	4,805	100.0	15	100.0	49	100.0
Max. (mSv)	1.9		0.2		0.2	
Mean (mSv)	0.1		0.2		0.2	

Soso

Effective dose (mSv)	All respondents (as of Jun. 30, 2015)		Those who had responded before our home visits (Group B in Figure 11)		Those who responded at the time of our visit (Group D in Figure 11)	
	No.	%	No.	%	No.	%
<1	55,298	77.6	874	76.8	287	74.0
<2	12,402	17.4	227	19.9	88	22.7
<3	1,650	2.3	18	1.6	7	1.8
<4	584	0.8	2	0.2		
<5	449	0.6	6	0.5	4	1.0
<6	356	0.5	5	0.4	1	0.3
<7	217	0.3	2	0.2		
<8	113	0.2	2	0.2	1	0.3
<9	72	0.1	1	0.1		
<10	39	0.1				
<11	35	0.0	1	0.1		
<12	29	0.0				
<13	13	0.0				
<14	12	0.0				
<15	6	0.0				
≥15	14	0.0				
Total No.	71,289	100.0	1,138	100.0	388	100.0
Max. (mSv)	25		10		7.4	
Mean (mSv)	0.5		0.6		0.6	

Iwaki

Effective dose (mSv)	All respondents (as of Jun. 30, 2015)		Those who had responded before our home visits (Group B in Figure 11)		Those who responded at the time of our visit (Group D in Figure 11)	
	No.	%	No.	%	No.	%
<1	71,999	99.1	25	100	24	100
<2	624	0.9				
<3	30	0.0				
<4	4	0.0				
<5	1	0.0				
<6	1	0.0				
Total No.	72,659	100.0	25	100.0	24	100.0
Max. (mSv)	5.9		0.6		0.7	
Mean (mSv)	0.3		0.3		0.4	

door-to-door visits (D in Figure 11) (Table 14).

Therefore, the dose distributions obtained so far in each district can be seen as representative of each district's population, without bias.[8)]

2) Analysis of survey results

(1) Analysis using the behavior records obtained in the Basic Survey

The Basic Survey was originally designed to assess external radiation doses, but it has also been used for other analyses.

For example, the analysis of the time spent outdoors per day based on the behavior records in Iitate Village showed that the average time spent outdoors was about 2 hours.[15)] Therefore, we reported that the assumption of staying outdoors for 8 hours per day, which is often used for external exposure calculations, would overestimate external exposure doses.

Behavior records were also used to analyze relationships between evacuation behavior obtained from the Basic Survey and internal exposure doses from radioactive cesium,[16), 17)] and to evaluate internal thyroid exposure doses based on evacuation behavior and computer simulations of how radioactive materials emitted from Fukushima Daiichi diffused over time.[18)-21)] In this way, the Basic Survey results can be used to reconstruct exposure doses other than external exposure.

The results obtained from such analyses are shown below.

A) Analysis of the time spent outdoors after the accident

Since the Fukushima accident, many studies have been conducted on dose assessment for residents. The time spent outdoors is one of the factors that affect the assessment of external exposure doses based on the data of air dose rates measured outdoors. For example, in the case of wooden houses, the radiation dose received while indoors is estimated to be about 40% of that received while outdoors, due to the shielding effects of wood.

Since there was little information on the actual time spent outdoors by residents after the accident, several different values for the average time spent outdoors per day have been used in post-accident dose assessment. The most conservative assessment is based on the assumption of 24 hours (all day outdoors), while the 2013 report of UNSCEAR adopted a value of 2.4 hours for a typical indoor worker. An assumption that has been widely used in the assessment of external exposure doses after the accident was that people spent 8 hours outdoors and 16 hours indoors every day.

In this study,[15)] we analyzed the behavior records obtained from the Basic Survey and evaluated the average time spent outdoors per day.

As an example, for Iitate Village, we randomly selected 170 residents who submitted their 4-month behavior records, among whom the average daily time spent outdoors was estimated as 2.08 hours, and less than 1 hour for about half of the residents.

Using 2.08 hours instead of 8 hours as the average time spent outdoors per day, the estimated external doses fell by about 25%. In other words, external exposure doses based on an assumption of 8 hours spent outdoors per day were overestimates.

B) Relationship between evacuation behavior and initial internal exposure dose (a)

From June 27 to July 28, 2011, NIRS conducted whole-body counter measurements on 174 persons, including evacuees from Iitate Village and Namie Town. The distribution of internal effective doses from radioactive cesium for these people was found to be about 0.1 mSv at the 90th percentile (corresponding to the top 10%, or 17 to 18 of the 174 people listed in order of decreasing dose). We investigated whether these 174 people had submitted the questionnaires for the Basic Survey (their behavior records after the accident), and found that 112 of them had submitted the questionnaires. We analyzed the relationship between behavior records and internal radiation doses for these people.[16)]

The distribution of internal effective doses among the 112 people matched that of the larger group of 174 that included those who did not submit questionnaires, and the 90th percentile value was about 0.1 mSv. Next, we analyzed the relationship between evacuation behavior and

internal radiation dose for these 112 people. As a result, we found that most of them had evacuated outside the 20 km zone by the night of March 12. For each individual, the relationship between the distance from their place of residence to Fukushima Daiichi at a certain point in March and their internal radiation dose was also analyzed, but no relationship was found between the distance from the nuclear power plant and radiation dose at any point in March.

However, when we analyzed the top 10% of people with high internal exposure doses (those with doses of 0.1 mSv or higher), all of them were within the 20 km zone at 16:00 on March 12, and 42.9% of them were still within the 20 km zone at midnight on March 15. In the same way, we evaluated the percentage of people whose radiation dose was 0.1 mSv or less, and found that 15.5% of them were within the 20 km zone at 16:00 on March 12, and none of them were still in the 20 km zone at 0:00 on March 15. Conversely, among those whose radiation dose was 0.1 mSv or higher, more of them remained within the 20 km zone. These results suggests that the time of evacuation is one of the factors affecting initial internal exposure dose. However, we consider it necessary to analyze more behavior records to reach a more certain conclusion.

C) Relationship between evacuation behavior and initial internal exposure dose (b)

A few months after the nuclear accident, internal exposure measurements with whole-body counters began. By the time these measurements started, almost all radioactive iodine had decayed to non-radioactive isotopes, and only radioactive cesium could be detected by the whole-body counter. While this device can quantify the amount of radioactive cesium present in the body at the time of measurement, it cannot determine when the detected radioactive cesium was taken into the body. To elucidate this, we analyzed the relationship between evacuation behavior and the amount of radioactive cesium detected among those who submitted their questionnaires (those with behavior records after the accident), were living in Namie Town at the time of the earthquake, and underwent whole-body counter measurements after evacuation.[17)]

A total of 1,639 people were divided into two groups: those who evacuated early (moved out of the 20 km radius of the nuclear power plant before 15:00 on March 12) and those who evacuated late (moved out of the 20 km radius after 15:00 on March 12). Radioactive cesium detected by whole-body counter was compared. The detection rate of radioactive cesium for adults in the former group was about 20%, while the latter group tended to have a higher detection rate of about 60% for adults. However, those who evacuated late accounted for about 20% of the total.

This was probably due to the fact that the latter group was affected by a radioactive plume that passed through on the afternoon of March 12 (i.e., they inhaled the radioactive cesium contained in the plume). Therefore, it was inferred that the radioactive cesium detected by whole-body counting in this analysis was taken into the body immediately after the accident, but this was not necessarily the case for all the survey participants.

This study may also be useful in reconstructing internal thyroid doses. In other words, by estimating the amount of radioactive cesium taken into the body immediately after the accident and the amount of radioactive iodine that might have been taken into the body at the same time, based on the amount of radioactive cesium measured by the whole-body counter, useful information was obtained for estimating internal thyroid exposure doses due to radioactive iodine.

D) Assessment of internal thyroid exposure doses using behavior records

In late March after the nuclear accident, pediatric thyroid examinations were conducted to measure radioactive iodine taken into the thyroid glands of 1,080 children in three Fukushima municipalities in Fukushima Prefecture (Kawamata, Iwaki, and Iitate). This was done in recognition of the high incidence of thyroid cancer among children who consumed milk contaminated with radioactive iodine after the Chernobyl nuclear power plant accident in 1986. Beyond those three municipalities, in evacuation zones and surrounding areas, thyroid exposure doses were not systematically measured.

Instead, estimation methods for internal thy-

roid exposure doses have been developed mainly by national research institutes. Since the assessment of internal thyroid exposure doses based on actual measurements of the thyroid gland was conducted only for 1,080 children, several methods have been considered in order to obtain an overall picture.[18)]

One method, previously mentioned, estimates internal thyroid exposure to radioactive iodine based on the amount of radioactive cesium taken into the body immediately after the accident and the amount of iodine that might have been taken in at the same time. However, only a few thousand people were checked for cesium using whole-body counters at a relatively early stage after the accident, so the data are insufficient to grasp the entire picture of exposure.

The second method proposed was to reproduce airborne radionuclide concentrations immediately after the accident by computer simulation, and to evaluate the exposure dose due to inhalation by superimposing it on the movement of people. UNSCEAR uses this method to assess inhalation exposure, and adds oral intake (radioactive iodine from food and drinking water) assessed using applicable food databases to assess internal exposure to the thyroid gland. However, the values assessed by UNSCEAR in this way are several times higher than the internal doses based on the actual measurements of the 1,080 children mentioned above.[19)] This is probably due to the fact that the evacuation behavior assumed by UNSCEAR was different from the actual situation, and also due to the overestimation of oral intake (radioactive iodine from food and drinking water).

Research groups in Japan have also been trying to estimate internal thyroid exposure doses due to inhalation by combining behavior records from the Basic Survey with simulations of how radioactive materials from the nuclear power plant spread into the atmosphere.

NIRS developed such a tool to assess internal thyroid doses based on an air dispersion simulation and Basic Survey behavior records.[20)] We compared internal thyroid doses measured in the thyroid examination with internal doses estimated by this NIRS tool for 309 out of 1,080 children who underwent pediatric thyroid examinations conducted in late March 2011.

The results of this comparison suggest that the internal thyroid doses estimated by simulation do not reproduce the doses assessed from actual measurements, and that further research is needed in the future.

The above study was conducted to compare simulated and measured doses on an individual basis, but a study was also conducted to compare the two on a municipal basis.[21)] In this study, 100 to 300 residents under age 20 were randomly selected from each of the seven municipalities designated as evacuation zones based on the responses (behavior records) obtained from the Basic Survey and their internal thyroid doses due to inhalation were assessed by combining their behavior records with the temporal and spatial distribution of radioactive iodine concentrations in the air, as estimated by WSPEEDI, a worldwide version of SPEEDI (System for Prediction of Environmental Emergency Dose Information). In conducting dose assessment, the high dietary iodine intake of Japanese people and the protective effects of indoor evacuation were also taken into account.

WSPEEDI estimated the temporal changes in airborne radioactive iodine concentration 1 m above the ground in 1 km^2 grid cells covering Fukushima and neighboring prefectures. Also taken into account was that radioactive iodine is less likely to accumulate in the thyroid glands of Japanese people, compared to Westerners, because Japanese people usually consume a large amount of iodine-rich marine products. Therefore, the thyroid dose conversion coefficients (internal dose received by the thyroid gland per 1 Bq of radioactive iodine ingested), which are set based on Western dietary habits, were corrected to match the characteristics of a typical Japanese diet, and the range of uncertainty in the coefficients was calculated.

In addition, since evacuees generally stayed inside Japanese-style houses during the evacuation process, the shielding effect of such buildings on inhalational exposure was taken into account to avoid overestimation of radioactive iodine ingestion. Inhalation doses were assessed using shielding effect coefficients (and their range of uncertainty) based on previous reports,

taking into account the distribution of houses by construction age in Fukushima Prefecture at the time of the nuclear accident.

The results showed that the estimated internal thyroid doses of children in the seven municipalities designated as the evacuation zone were highly consistent with the distribution of the assessed thyroid doses based on actual measurements of pediatric thyroid examinations.

By reducing various uncertainties, the average internal thyroid doses for children aged 1 year in each of the seven municipalities in the evacuation zone ranged from 1.2 to 15 mSv, which is much lower than the average value (15 to 83 mGy) estimated by UNSCEAR for the municipalities concerned. We were able to identify four to five representative evacuation route patterns for each of the seven municipalities and estimate the frequency of their use.

From the above studies, it seems that it is very difficult to accurately assess internal thyroid doses on an individual basis, but we believe that methods developed through these studies will be useful for estimating average values for groups of people, such as those living in particular municipalities.

3) Evaluation by the Oversight Committee

(1) External dose estimation

External dose estimates derived from the Basic Survey were announced for the first time in a press release on December 13, 2011, along with an evaluation by the Oversight Committee on the results. At that time, the Committee's evaluation stated that according to epidemiological studies to date, no health effects have been confirmed at doses of 100 mSv or less, and the estimated external doses for 1,589 people, excluding those engaged in radiation work, were less than 15 mSv, so it is unlikely that any health effects due to radiation will be evident.

Since then, the number of completed dose estimates has increased substantially, but the distribution of doses (such as the proportion of those who were exposed to less than 5 mSv) has not changed substantially, so the Oversight Committee's evaluation remains largely unchanged. The interim summary by the Oversight Committee (March 2016) also stated that the dose estimation results obtained from the Basic Survey (99.8% of respondents had received less than 5 mSv through external exposure over the first 4 months) are (not at a level where health effects can be confirmed with statistical significance in light of the scientific knowledge obtained to date.) This is based on the contents of the UNSCEAR 2008 Report,[22] which summarized the scientific knowledge on radiation effects accumulated to that date.

(2) Verification of representativeness of responses

As mentioned above, the analysis of the representativeness of responses has shown that the dose distributions obtained thus far for each district in the prefecture are representative of the relevant district and are considered to be an unbiased depiction of dose distribution for the entire prefecture. In regard to this point, the interim summary of the Oversight Committee evaluated that the distribution of external doses calculated and published so far correctly reflects the situation of the entire population of the prefecture and is unbiased.

4. Publication of survey results and support/feedback

1) Feedback to residents

Dose distributions obtained from the Basic Survey have been disclosed at Oversight Committee meetings that convene about four times per year. However, from FY2018, due to fewer changes in the number of responses, we present a progress report once a year at the Oversight Committee meeting held at the beginning of each fiscal year.

The results of the survey are also made public through other means, such as the Report of the Fukushima Health Management Survey, the Center's website, and the Ministry of the Environment's BOOKLET to Provide Basic Information regarding Health Effects of Radiation.[5]

Individual dose estimates are sent to each respondent and aggregate dose estimates by district and by municipality are published.

After sending out the questionnaires to all residents of the prefecture in 2011, we received a huge number of responses, about 8,000 per day at the peak, prompting us to increase the number of staff members engaged in the work of processing questionnaires and sending out results.

As a result, as of October 31, 2012, the number of completed dose estimates reached 49.4% of the responses received, and the percentage of result reports sent to respondents from the preliminary survey area was 97.1%, as reported at the 9th meeting of the Oversight Committee (November 18, 2012). However, at that time, the percentage of result reports sent to respondents from municipalities other than the preliminary survey area was only 23%.

As of January 31, 2013, the number of dose estimates reached 394,369, which is more than 80% of the total number of responses. In addition, the work of sending out results has been gradually catching up, and at this point, the number of results sent out has reached 361,752, accounting for 75.8% of the responses received.

At present, result reports have already been sent to almost all of the respondents for whom dose estimations have been completed.

2) Provision of information to international organizations

Various domestic and international organizations have reported on external exposure doses in the early post-accident period, but these were all obtained based on assumptions of evacuation behavior and living patterns of residents. For example, the UNSCEAR Report[12] based its evaluations on the assumption of 18 typical evacuation patterns and an assumed ratio of time spent indoors and outdoors.

The World Health Organization (WHO) report[23), 24)] estimated radiation doses based on the assumption that residents in the planned evacuation zone took 4 months to evacuate (they stayed in the planned evacuation zone for 4 months and then evacuated out of it), and on the assumption that they spent 16 hours indoors and 8 hours outdoors per day. In reality, residents in the planned evacuation zone generally evacuated earlier than this, and it was unlikely that they would stay outdoors for 8 hours.

Therefore, exposure doses reported by UNSCEAR and WHO tend to be overestimated. The two reports of WHO were published in 2012 and 2013, and the UNSCEAR Report was published in 2014. After this, we have reported in English-language journals that actual exposure doses are almost certainly lower than WHO and UNSCEAR dose estimates.[25)-27)]

Table 15 compares the external exposure doses for the first four months after the accident derived from the Basic Survey, and dose estimates by UNSCEAR and WHO for external exposure, internal exposure, or the total of external and internal exposure for one year after the accident.[28)] The comparison was made by dividing the area into Namie Town, Iitate Village, other evacuated areas, and non-evacuated areas. UNSCEAR shows internal and external exposure doses separately for non-evacuated areas, but for evacuated areas, the total dose from internal and external exposure is shown.

Since the Basic Survey evaluates external exposure doses for four months after the accident, it cannot be directly compared with the estimates of UNSCEAR and WHO, which evaluate doses for one year after the accident. However, as personal dosimeters became widely available about six months after the accident, external exposure doses since then have been assessed using personal dosimeters distributed by municipalities. According to personal dosimeter results, the median annual external exposure dose in 22 municipalities in the prefecture was less than 1 mSv in FY2011.[29)]

In regard to the internal exposure dose, measurement is typically done using whole-body counters. The results of two surveys using this method are shown in Table 15. Based on these results, the internal exposure dose due to radioactive cesium was considered to be less than 0.1 mSv, even for people living in the evacuation zone.[30), 31)]

When assessed based on the surveys and measurements described above, including the Basic Survey, measurements by personal dosimeters, and internal exposure doses by whole-body counters, the effective dose (total of external and internal exposure) for those who were living in

Namie Town and Iitate Village at the time of the earthquake for one year after the accident is considered to be less than 10 mSv on average.[28)]

According to the WHO report,[23)] the effective dose for one year after the accident in the most affected areas (Namie Town and Iitate Village) was considered to be 10-50 mSv. In other words, actual doses are considered to be less than the lower end of the dose range (10-50 mSv) estimated in the WHO report.

In contrast to the overestimation of doses by international organizations as described above, the Basic Survey is of special significance for its assessments based more closely on real conditions.

Table 15. Doses estimated by international organizations and doses assessed on the basis of actual measurements

Exposure type	Method of dose estimation	Literature/ Source	Covered population	Additional doses due to the accident (mSv)					
				Quantities shown in the right columns	Namie	Iitate	Other municipalities in the evacuation zone	Non-evacuation zone	Period for dose estimation
External dose	Basic Survey	Ishikawa et al.[11)]	All age groups	Mean value	1	4	1	0.1-1.5	4 months after the accident
	Air dose rates and typical behavior patterns	UNSCEAR [12)]	Adults (Age 20)	Mean value	—	—	—	0-3.0	1 year after the accident
			Children (Age 10)	Mean value	—	—	—	0-4.3	
			Infants (Age 1)	Mean value	—	—	—	0-5.0	
Internal dose	Whole body counter measurement	Kim et al. [30)]	> Age 17	90th percentile value	0.12	0.085	0.07	—	Committed doses due to inhalation after the accident
			≤ Age 17	90th percentile value	0.12	0.095		—	
		Momose et al. [31)]	Ages 13 - 17	Median value	0.02			—	
			≥ 18	Median value	0.025			—	
	Radionuclide dispersion/ deposition modelling and food databases	UNSCEAR [12)]	Adults (Age 20)	Mean value	—	—	—	0.94 -1.41	1 year after the accident
			Children (Age 10)	Mean value	—	—	—	1.16-1.94	
			Infants (Age 1)	Mean value	—	—	—	1.90-2.82	
Sum of external and internal doses	External doses: Air dose rates and typical behavior patterns Internal doses: Radionuclide dispersion/ deposition modelling and food databases	WHO [23)]	All age groups	Range	10-50		1-10		1 year after the accident
		WHO [24)]	All age groups	Range	12-25		1-5		
		UNSCEAR [12)]	Adults (Age 20)	Mean value	5.0-7.0	7.8-8.0	1.1-9.3	—	
			Children (Age 10)	Mean value	7.0-8.9	8.7-9.0	1.3-10.2	—	
			Infants (Age 1)	Mean value	8.8-11.1	11.2-11.5	1.6-13.1	—	

Committed dose is a cumulative dose a person will receive while radionuclides are present in the body. The excretion rate of radioacesium is comparatively fast and there will be almost no radiation exposure after 2 years from the intake of radiocesium.

5. Summary (significance of the survey)

1) Grasping the external exposure dose levels of prefectural residents in the early post-accident period

Immediately after the nuclear power plant accident, there was a marked increase in the air dose rate in Fukushima Prefecture. However, at that time, measuring instruments such as personal dosimeters and monitoring posts were not widely available, and it was difficult to ascertain the external exposure doses of residents. Therefore, the Basic Survey, in which external exposure doses were estimated based on information obtained from records of individual behavior (records of evacuation behavior after the accident, etc.), was the predominant tool for assessing individual external exposure doses in the early days.

By aggregating the doses obtained from the Basic Survey, it was possible to ascertain the level of exposure of the entire population of the prefecture due to the accident, and to provide scientific evidence as to whether or not the level of radiation was high enough to cause direct health effects.

2) Notification to individuals of exposure doses in the early post-accident period

The Basic Survey is characterized by the fact that the results of dose estimation are sent to each individual.

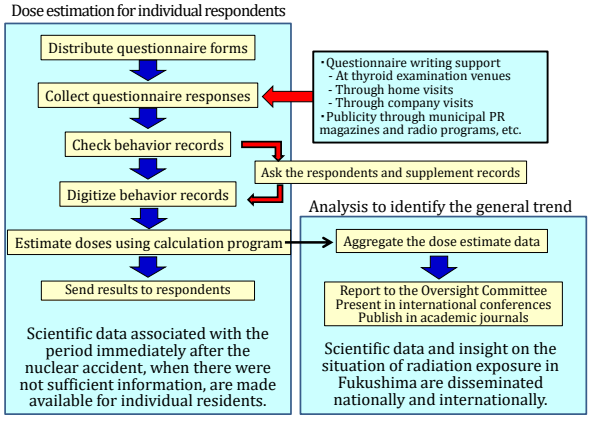


Figure 19. Flow of the Basic Survey

In other words, the Basic Survey has two aspects: one is that it is a survey in which the doses of each individual are compiled by municipality and district and the dose distributions, etc. are made public, and the other is that it is a health service for residents in which the estimated doses are sent to each individual for use in their own future health management (Figure 19).[32)]

3) Provision of information to international organizations

Various domestic and international organizations have reported on external exposure doses in the early period after the nuclear power plant accident, but these were all obtained by making conservative assumptions about the evacuation behavior and living patterns of the residents. In general, these conservative assumptions tend to overestimate exposures. In contrast, the Basic Survey is invaluable because it assesses doses closer to reality.

The next UNSCEAR report is currently under preparation, and it is expected that the papers published based on the results of the Basic Survey will be reflected in it, resulting in more realistic dose estimates. UNSCEAR is an organization that compiles information on radiation doses and protection from around the world, and is recognized as an authoritative body worldwide. The incorporation of the results of the Basic Survey into the UNSCEAR report is expected to help radiation researchers and others around the world to have a better understanding of the exposure caused by the Fukushima Daiichi Nuclear Power Plant accident.

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