Title	Statistical characterization of radiation doses from external exposures and relevant contributors in Fukushima Prefecture
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Citation	Health Physics, 107(4), p.326-335. (2014)
Text Version	Author Accepted Manuscript
URL	http://jolissrch-inter.tokai-sc.jaea.go.jp/search/servlet/search?5042190
DOI	http://dx.doi.org/10.1097/HP.0000000000000120
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Statistical Characterization of Radiation Doses from External Exposures and Relevant Contributors in Fukushima Prefecture

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In areas contaminated by radioactive materials, well-designed dose assessment is necessary in order to protect people from radiation exposure and manage the exposure situation appropriately. Probabilistic dose assessment is a useful method for providing a more complete characterization of information on dose distributions in the population, and requires statistically characterized data on pathway-relevant contributors. The objective of this paper is to determine statistical features of contributors to external exposures, as well as to identify causes of variabilities of individual doses to the populations living in areas contaminated by the Fukushima Daiichi Nuclear Power Plant accident. To achieve these objectives, measurements of individual doses and ambient dose rates, as well as surveys of behavioral patterns, were performed between February and April, 2012. These were made with the cooperation of indoor workers, outdoor workers, and pensioners living in Fukushima prefecture. On the basis of these results, statistical analyzes were performed in order to identify variabilities of contributors. In addition, a multi-regression analysis was made to explore a significant relationship between individual doses and relevant contributors. As a result, the ambient dose equivalent rate also distributed with lognormal form and it had the variabilities attributable to the spatial distribution of deposited radionuclides. The distribution forms of time spent outdoors depend on the characteristics of occupation, and those of indoor workers and outdoor workers were lognormal and normal, respectively. Results of a multiple-regression analysis suggested that such valiabilities of contributors give rise to significant differences of individual doses among the populations.

KEYWORDS: Fukushima Daiichi Nuclear Power Plant accident, individual dose, habit data, probabilistic approach, variability

INTRODUCTION

In areas contaminated as a result of the accident at the Fukushima Daiichi Nuclear Power Plant (1F) owned and operated by the Tokyo Electric Power Company (TEPCO), many residents are now being exposed to radiation. To protect people from radiation exposure and manage post-accident situations adequately, dose assessment is an important consideration (Jacob and Likhtarev 1996; Golikov et al. 1999; 2002; Likhtarev et al. 2002). Doses to the public can be assessed using several different approaches, including both deterministic and probabilistic approaches. In many cases, assessors have traditionally performed deterministic calculations, using point estimates representing input data, to derive mathematical expressions of exposures. This approach, however, has a number of limitations (Finley and Paustenbach 1994; Cullen and Frey 1999). For example, the degree and direction of conservatism may be completely masked by the reporting of a single number. Furthermore, a deterministic analysis does nothing to guide decision-makers about whether to conduct additional research, or whether to select from available options to reduce exposure. In contrast to the deterministic assessment, a probabilistic assessment can yield a more complete characterization of dose distributions in the population (Finley and Paustenbach 1994; Cullen and Frey 1999; USEPA 1997). In addition, a probabilistic assessment is better suited for sensitivity analysis than a deterministic assessment. The information obtained from sensitivity analysis allows assessors to identify dominant variables in the results of the assessment, and thus to provide insights to improve the precision of assessment.

When applying probabilistic approaches to the assessment of radiation doses, statistically-characterized data for contributors (such as exposure rates and behavioral patterns) are needed, accounting for the variability in the data (Tschurlovits et al. 2004; ICRP 2006). **Fig. 1** illustrates the general process of applying a probabilistic approach to assess radiation doses from external exposures. One sample from each input distribution is selected, based on statistical characters, and the set of samples is entered into the model. The process is repeated until the specified number of model iterations has been completed. In terms of results, it is possible to represent a distribution of the output of a model by generating sample values for the model input. To assess doses while realistically reflecting environmental trends and lifestyle habits, site-specific and population-specific data should be used.

This paper aims to determine statistical values and distribution forms of contributors to external exposures, based on actual measurements and surveys from Fukushima prefecture, as well as to identify causes of variability. In addition, we also aim to identify the influences of variabilities of these contributors on the extent of doses received by the population. To achieve these aims, we have performed surveys to identify behavioral patterns of the population living in the contaminated areas of Fukushima Prefecture, and have measured individual doses due to external exposure and ambient dose rates at houses and workplaces. Based on the results obtained, statistical analyses of differences in individual doses and in contributors among population groups were performed. In addition, relationships between individual doses and contributors were analyzed through multi-regression analysis.

METHODS

Measurement of individual doses

In areas contaminated by the accident at 1F, individual doses and ambient dose equivalent rates were measured, and behavioral patterns were surveyed. Four population groups participated in the research: Fukushima City office workers, Northern Fukushima affiliate of Contractors' Association, Japan Agricultural Cooperatives, and the Senior Citizens' Club of Fukushima city. Measurements and surveys were performed during the period spanning February to April 2012. **Fig. 2** shows the spatial distribution of houses of the participants. Because participating individuals were asked every month whether they wished to continue their participation, the number of participants decreased over time. The number of participants for each month is shown in **Table 1**. Measurements of individual doses were performed with personal dosimeters (Hitachi-Aloka Medical, Ltd., PDM-122-SZ), which were calibrated as the dose equivalent at a depth of 10 mm in the tissue slab, as recommended by the International Commission on Radiation Units and Measurements (ICRU). In the present study, "individual doses" refers to readings measured by the personal dosimeters.

Measured values vary with dosimeter position and with direction of incidence of photons. Zankl (1999) reported variations in measured values when the dosimeter position changes within the body trunk. Variations are up to several percent in rotation (ROT) geometries and are largest in posteroanterior (PA) geometries, with a maximum of approximately 30%. Individual doses in this study were recorded as having the same variation as in ROT geometries, because radiation is emitted from all directions in participants' daily lives.

Measurements of ambient dose equivalent rates and surveys on behavioral patterns were carried out after the living areas were classified into several categories, with these being homes, workplaces, and other places. Ambient dose equivalent rates were obtained from published data for workplaces and other places, because it was difficult to conduct measurements at these locations. Ambient dose equivalent rates were measured on the inside of and outside of participants' houses in early February 2012. The measurements were performed using energy compensated NaI(Tl) scintillation survey meters (Hitachi-Aloka Medical, Ltd., TCS-171B). The ambient dose equivalent rates outside houses were measured at 1.2 m from the front door. In order to determine locations for indoor measurements, interviews were used to determine places in the house where participants spent the most time. Measurement height was one meter above the outside ground surface and one meter above the inside floor level. The number of participants was 238 (215 households) for outside measurements and 207 (184 households) for indoor measurements.

Survey on habit data

To obtain information on behavioral patterns of people, surveys were performed to determine time spent inside and outside houses, at the workplace and in other places. Participants took note of the amount of time spent indoors and outdoors every day, and these notes were collected via mail once a month. Surveys were carried out for three consecutive months, from February to April 2012. Periods of time spent outside of Fukushima prefecture were also addressed by the survey.

RESULTS

Measurement of Individual Doses

Measured individual doses in each month for all groups between February and April are shown in **Fig.3**. The Shapiro-Wilk tests for logarithmic values of measured doses indicated that the significance level was more than 5%; thus, the hypothesis that the doses are from a lognormal distribution was not rejected. Therefore, lognormality is assumed for the distribution of individual doses. The test described here is also relevant to the following sections, when normality is examined for other parameters.

Measured individual doses were in the range of 60-317 μSv per month in February, 64-414 μSv per month in

March, and 82-428 μSv per month in April. To find out if the variances and averages of the doses changed during these three months, F-tests, and t-tests were carried out. The results of the F-tests showed that no differences were observed during the three months, at a significance level of 5%, while the results of the t-tests for logarithmic values of individual doses showed differences between the values of March and April, at a significance level of 5%.

The report of Nuclear Safety Research Association (NSRA) describes that the average annual effective dose due to external exposures of natural radiation sources was 0.63 mSv in Japan (NSRA 2011). Based on this report, the effective dose due to external exposures per month is estimated at about 50 μSv. Our results of the average individual doses were larger by several factors of magnitude than those from natural radiation background.

Survey on Contributing Factors to External Exposure

Measurement of Ambient Dose Equivalent Rates

Measurements of ambient dose equivalent rates were performed in early February 2012, both inside and outside of the 215 participating households' residences. The houses were comprised of 194 wooden houses, five one-story concrete buildings and 16 multistory concrete buildings. **Fig. 4** shows the distribution of ambient dose equivalent rates inside and outside houses. The measured ambient dose rate was in the range of 0.07-0.55 μSv h^{-1} inside houses and 0.07-1.76 μSv h^{-1} outside. The geometric means of these values were 0.21 μSv h^{-1} inside and 0.35 μSv h^{-1} outside. The differences were five-fold for outdoor values, when both the maximum and minimum values were compared with the mean. When normality tests were performed for their logarithmic values, the significance level was more than 5% in the case of both indoor and outdoor values. For this reason, lognormal distributions are assumed for the ambient dose equivalent rates inside and outside houses.

Ambient dose equivalent rate and gamma-ray spectra were measured in Fukushima city before and after the accident by the Environmental Radioactivity Monitoring Center of Fukushima (ERMF). On the basis of these measurement data (ERMF 2011), we can clarify two points described as follows: First, the ambient dose equivalent rates measured before the accident in Fukushima city was about 0.04 μSv h^{-1}. After the accident, a level of ambient dose equivalent rate significantly increase compared to that measured before the accident.

Secondly, results of gamma-ray spectrum measurement show existence of radioactive fission products released from 1F in the environment. These facts lead to a conclusion that the increments of ambient dose equivalent rate were caused by the released radionuclides from 1F. In addition, a part of radioactive materials released from 1F not only passed through Fukushima city but also deposited on the ground surfaces (Nuclear Regulation Authority 2011; Endo 2012). Under the influence of deposited long-lived radionuclides, such as radioactive cesium, the people living in the affected areas are now being exposed to radiation.

Fig. 5 shows the correlation between ambient dose equivalent rates measured inside and outside houses. This correlation reflects the character of participants' houses, most of which are comprised of wooden materials. In Fukushima prefecture, about 80% of residential houses are of wooden construction (Fukushima Prefecture, 2008) so the correlation shown in this study could represent this prevailing characteristic. The adjusted R-squared statistic of this correlation is 0.458, which means that there was no clear correlation. However, based on the results of the F-test, the ambient dose rates measured inside houses are explained well by the dose rates measured outside.

To determine the differences in ambient dose equivalent rates between participant groups, t-tests were performed with respect to the logarithmic value of ambient dose equivalent rates outside houses. Results indicate no differences in the mean values for three groups of participants; i.e. Fukushima City office workers, the Contractors' Association and members of the Agricultural Cooperatives. However, the mean value for the Senior Citizens' Club was higher than for the other three groups (at a significance level of 5%). These results indicate that participants from the Senior Citizens' Club live in areas exposed to higher dose rates than participants in the other three groups.

Survey on Behavioral Patterns

Fig. 6 shows average values of time spent in each place, as obtained from the results of the survey on behavioral patterns. The time shown in the figure was obtained by summing up the time spent in each place for 30 days and calculating the arithmetic mean per day and per one person.

Participants from all groups spent most time inside their houses. Those from the Senior Citizens' Club stayed inside their houses for 21 hours, accounting for 90% of time in a day. The participants from the three other groups

(Fukushima City office workers, the Contractors' Association and the Agricultural Cooperatives) stayed inside their houses for about 14-17 hours daily. The time spent outside houses was 1.2 hours for the Senior Citizens' Club and 2.2 hours for members of the Agricultural Cooperatives. It should be noted that some participants from the two groups regarded the time spent at farmlands near their houses as time spent outside their homes, even though they were engaged in agricultural work. Meanwhile, participants from Fukushima City office spent 0.2 hours outside their houses and those from the Contractors' Association spent 0.3 hours outside their homes.

A different trend is observed for the different groups, with respect to time spent in workplaces. The participants from Fukushima City office stayed inside office buildings for a long period of time (7.0 hours of arithmetic mean) and stayed outside of office buildings for only 0.1 hours. The participants from the Contractors' Association stayed inside buildings for 2.3 hours on average and stayed outside for about 6.2 hours. The participants from the Agricultural Cooperatives spent most of their working hours outside buildings, staying inside for 0.3 hours and outside for 2.4 hours.

Fig. 7 shows the one-day average of time spent outdoors for each group in each month. This average time is calculated as the summation of time spent outside of houses, workplaces and other places. Clear differences are found between the groups in terms of time spent outdoors and its distribution. As for participants from Fukushima City office and the Senior Citizens' Club, normality was examined for the logarithmic values of time spent outdoors in a day. Resultant significance levels were more than 5% for both groups. Lognormal distribution is thus assumed for the time spent outdoors for the two groups. When the time spent outdoors is expressed as geometric means for each month between February and April, it is in the range of 0.41-0.82 hours per day for participants from Fukushima City office and 0.96-1.68 hours for those from the Senior Citizens' Club. (An arithmetic mean is in the range of 0.72-1.01 hours for those from Fukushima City office and 1.66-2.55 hours for those from the Senior Citizens' Club)

Normality tests were performed for the time spent outdoors in a day for the remaining two groups, i.e. the Contractors' Association and the Agricultural Cooperatives. The result indicates that normality is not rejected. Normal distribution is thus assumed for proportion of time in a day spent outdoors for these groups, though it should be noted that in the case of the participants from the Contractors' Association, the normality test was performed excluding those five participants who stayed inside the office only. When the time spent outdoors is expressed as arithmetic means for each month between February and April, it is in the range of 7.46-7.62 hours per day for those from the Contractors' Association and 5.18-7.89 hours for those from the Agricultural Cooperatives. To examine changes in the time spent outdoors over the three months, t-tests were performed for time spent outdoors in a day of each month. The tests were performed with the logarithmic values of time spent outdoors if the distribution form was lognormal. Results show that the time spent outdoors by members of the Agricultural Cooperatives increased significantly in each month, from February to March (significance level of 5%). This is because working times outdoors increase as the season changes from agricultural off-season to spring. A significant increase was also observed in the time spent outdoors by the Senior Citizens' Club, when a comparison is made between values obtained in February and those obtained in April. This is because some participants from the group are engaged in agricultural work.

DISCUSSION

Homogeneity of individual doses

Homogeneity addresses the degree to which extremes in particular habit data are, or are not, included in the assessment (ICRP 2006). ICRP recommends that the necessary degree of homogeneity in data used for assessments depends on the ratio of the mean dose in the population group to the relevant dose limit or constraint (ICRP 2006). If that ratio is less than about one-tenth, the group should be regarded as homogenous, on condition that the difference between the maximum value and the minimum value lies within a range of a factor of 10. If the ratio is above one-tenth, the range should be less than a factor of 3, to be in accordance with homogeneity. In our case, based on the data shown in **Fig. 3**, the annual individual doses to the populations were estimated as several mSv. The ratio of the estimated mean of individual doses, which was obtained from the data for whole population groups, to the dose limit (i.e. 1 mSv per year) is greater than one-tenth. Thus, the difference between maximum and minimum values should be less than a factor of 3 to meet the requirements for homogeneity. Measurement results, however, indicate that differences exceed a factor of 5, so the data cannot be reasonably assumed to be homogeneous.

To identify the causes of non-homogeneity in measured individual doses, we carried out statistical analyses on differences of individual doses between population groups. **Fig. 8** shows the distribution of measured individual doses, classified as per participant group. From the results of normality tests, lognormal distribution is assumed for the measured individual doses of each population group. The annual individual doses to each population group were estimated to be several mSv, in the same manner as in the case of the whole population group described above. Thus, it is thought that the range of individual doses of these population groups should be smaller than a factor of 3. For participants from Fukushima City office, the Senior Citizens' Club and the Contractors' Association, the ranges of individual doses could be reduced to around a factor of 3. It is noted that the total range of dose distribution has a tendency to be wider when there is a person who has different behavioral patterns from the prevailing trend in the group. For example, a significant difference was found between the maximum and minimum value of individual doses measured in February 2012 for participants from the Contractors' Association. When the participants from this group were classified according to behavioral patterns, two sub-groups were identified. The first consisted of five participants who stayed inside office buildings only. The second consisted of 48 participants who stayed inside the office for part of their day, but who also spent time outside of office buildings. The minimum value of individual doses to this population group is determined by the dose to members of the first sub-group, resulting in a big difference in the dose distribution range of this group. In the light of the discussions above, the extent of variability of individual doses due to external exposures could be reduced by classifying the data for each population group in terms of time spent outdoors as a result of their work. However, if the population group includes various types of sub-groups in terms of behavior patterns further consideration would be needed, in order to take into account more detailed information concerning their working styles.

Even after the data were classified with respect to each participant group, clear non-homogeneity was found in individual doses received by participants from the Agricultural Cooperatives. This non-homogeneity might be attributable to differences in work styles, based on differences between agricultural products. In this study, we obtained the cooperation of farmers who produce rice, vegetables, fruits and flowers, as well as those who breed livestock. The average doses received by each type of agricultural producer are shown in **Table 2**. The data indicates that rice and fruit producers received higher doses than other producers. However, to reveal variabilities between various types of agricultural producers, further investigations are needed, with the cooperation of more farmers producing each type of product.

Results of t-tests for the logarithmic values of measured individual doses of each group indicated that the doses received by participants from Fukushima City office are lower than those received by other groups, at a significance level of 5%. The differences in doses between Fukushima City office employees and outdoor workers can be explained by difference in time spent outdoors. Although the behavioral patterns of the participants from Senior Citizens' Club were not different from those of Fukushima City office workers, the doses received by these groups were significantly different. This is because, as already discussed, many of the participants from the Senior Citizens' Club live in an area with higher dose rates than the areas where members of the other three groups reside. This finding suggests that the spatial distribution of dose rate in Fukushima prefecture can result in statistically-significant differences in doses to the population living there.

To identify seasonal changes of individual doses, t-tests were performed for the logarithmic values of measured individual doses in each month. As a result, no significant differences were confirmed between individual doses of participants from Fukushima City office, the Contractors' Association and the Senior Citizens' Club. On the other hand, significant differences were found in the individual doses measured for the participants from the Agricultural Cooperatives. Their received doses increased with changing season from an agricultural off-season to a farming season. In particular, the individual doses measured in April were higher than those in February, at a significance level of 5%.

On the basis of spectral information (Yoshida et al 2013), most of external exposures in the population living in the areas contaminated by the accident are caused by the contribution of gamma-ray from ^{134}Cs and ^{137}Cs. Since these radionuclides decrease with time due to radioactive decay, ambient dose equivalent rates also decrease. In fact, the monotonic decreases of ambient dose equivalent rates for the duration of our measurements in Fukushima city were observed (Nuclear Regulation Authority 2014). Thus, the increase of individual doses in the participants of the Agricultural Cooperatives from February to April cannot be attributable to the change of exposure rates. The increase of individual doses is explained well by seasonal changes in the time spent outdoors, as shown in **Fig. 7**.

Consequently, individual doses received by the population living in the contaminated areas are influenced by the spatial variability of exposure rate, and by temporal and interpopulational variabilities of behavioral patterns.

Influence of the variability of contributors to individual doses

A multi-regression analysis was conducted to estimate the relationship between individual doses and contributors to this. The results of the analysis indicate that individual doses change when any one of the contributors is varied, even when other contributors remain constant. The regression model developed in this study is expressed as follows:

$$INDIVIDUAL = \beta_1 \cdot DOSE1_{\mathrm{out}} + \beta_2 \cdot DOSE2_{\mathrm{out}} + \beta_3 \cdot TIME1 + \varepsilon \qquad (1)$$

The objective variable, *INDIVIDUAL*, was a logarithmic value of the measured individual dose, and its normality was confirmed by the normality test. Explanatory variables were selected from amongst the contributors, so as to be independent of each other. The ambient dose rates measured inside and outside of the same location cannot both be selected for the model, because they have the correlation shown in **Fig. 5**. Since the total time spent outside and inside of various places is constant, any one value of the time spent in various places is adopted as an explanatory variable in the regression model. As a result, ambient dose equivalent rates outside of houses, $DOSE1_{\mathrm{out}}$, and workplaces, $DOSE2_{\mathrm{out}}$, as well as time spent outdoors at participants' workplace, $TIME1$, were adopted as explanatory variables, in accordance with the Akaike Information Criterion (AIC). ε represents an error term.

The results of multi-regression analysis are shown in **Table 3**. The analyses were conducted excluding the data of participants from the Senior Citizens' club, since these are retired and not working. The adjusted R-squared statistic for the data of each participant group was not enough to explain the variance of the objective variable. However, p-values of F-tests were below the significance level of 5%, so that the null hypothesis, stating that the coefficients of explanatory variables are zero, was rejected. The objective variable was therefore explained by the model shown in eq. (1).

On the basis of the results of the multi-regression analysis shown in **Table 3**, the first point to be discussed is the contribution of doses received at a house to individual doses. $DOSE1_{\mathrm{out}}$ is positively significant for all population groups. These results suggest that the individual doses increase with increasing ambient dose equivalent rates outside of houses. On the other hand, the ambient dose rates outside of workplaces, $DOSE2_{out}$, were insignificant for all population groups. The dose rates outside of workplaces were gathered from published data, i.e. these were not directly measured at workplaces. To analyze the contribution of doses received at workplaces to individual doses, further study will be needed, to provide more realistic data concerning workplace exposures.

Values for *TIME*1 for participants from Fukushima City office were insignificant. This result suggests that doses received at workplaces cause no differences in individual doses for participants from Fukushima City office. *TIME1*, however, is positively significant for participants from the Contractors' Association and the Agricultural Cooperatives, with a significance level of 5% and 10%, respectively. These results indicate that the exposures of these participants during their stay at the workplace resulted in a statistically significant differences between these outdoor workers.

Overall, the results of our multi-regression analysis confirmed that doses received by the population living in contaminated areas are strongly influenced by the contribution of exposed doses in their houses. In addition, to assess individual doses more accurately for outdoor workers, measurements of exposure rates and surveys of behavioral patterns are needed, taking into account not only participants' houses but also their workplaces.

CONCLUSIONS

Measurements of individual doses and radiation dose rates, as well as surveys of behavioral patterns, were performed between February and April, 2012. These measurements and surveys were carried out with the participations of indoor workers, outdoor workers and pensioners living in Fukushima prefecture. In addition, in order to clarify the relationship between individual doses and contributors to this, multi-regression analyses were conducted. The distributions of individual doses for each population group were lognormal. The distributions of ambient dose equivalent rates, measured inside and outside houses were lognormal, distributed within a range of a factor 5 on both sides of the mean. The distribution forms of the time spent outdoors depend on the characteristics of occupation, and those of indoor workers and outdoor workers were lognormal and normal, respectively. Individual doses are influenced significantly, not only by the spatial variability of ambient dose equivalent rates, but also by temporal and interpopulational variabilities of behavioral patterns. In particular, to assess the doses received by outdoor workers, data on exposure rates and behavioral patterns are necessary, taking into account not only participants' houses but also their workplaces. The results indicate that measurements and surveys should be designed in a way that allows them to reflect seasonal changes and differences among various types of working styles. These site-specific and population-specific statistical characters could provide useful information for application of probabilistic approaches to dose assessment of the public living in areas contaminated by the accident at 1F.

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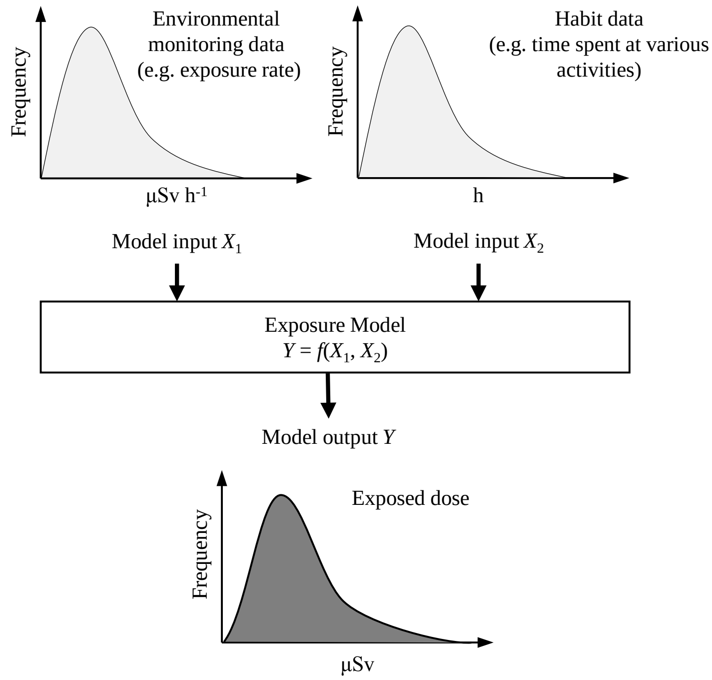

Fig. 1. Schematic, illustrating the application of a probabilistic approach to assess radiation doses from external exposure

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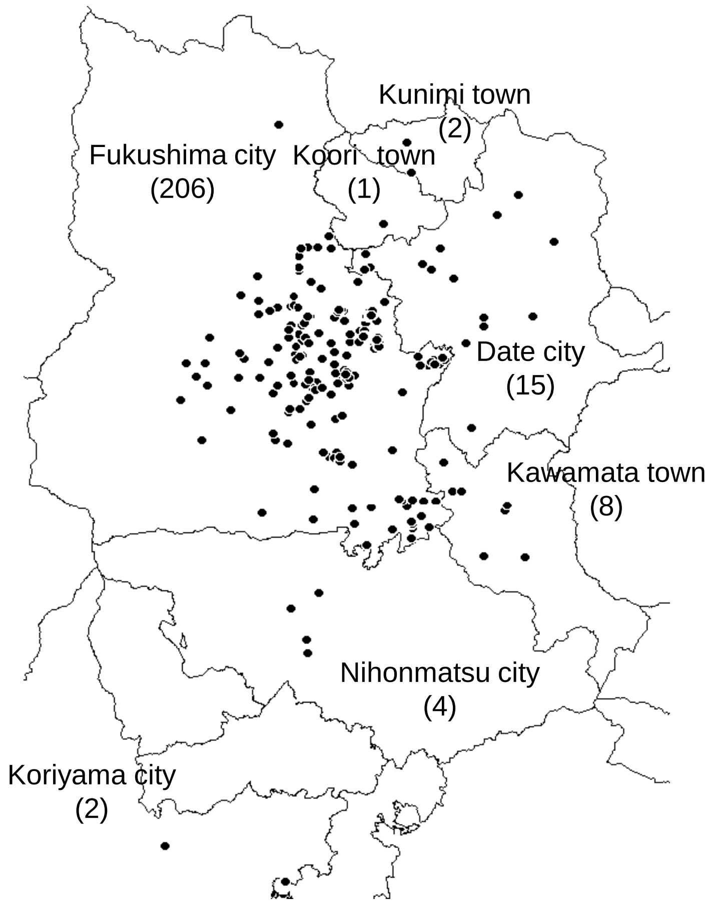

The number of participants is shown in brackets ().

Fig. 2. Place of residence of individuals participating in measurements and surveys

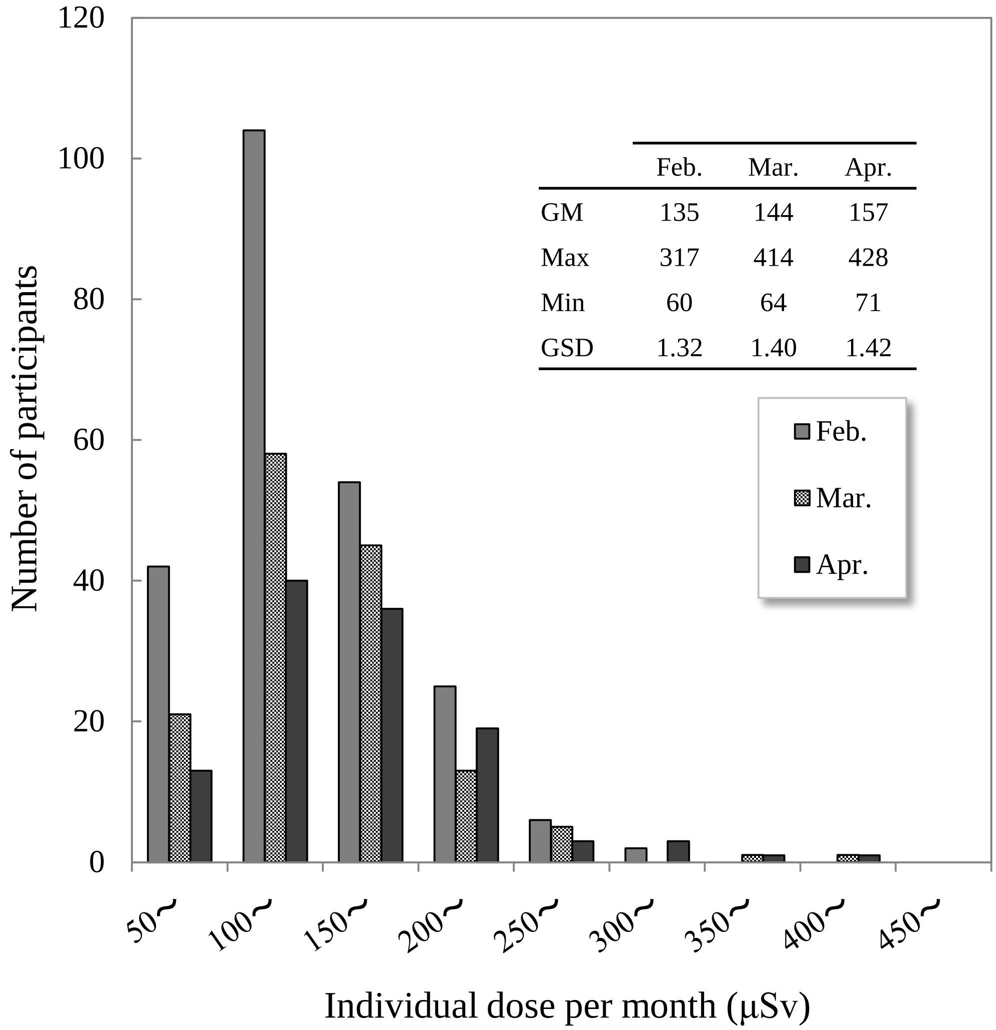

Fig. 3. Measured individual doses in each month between February and April, 2012

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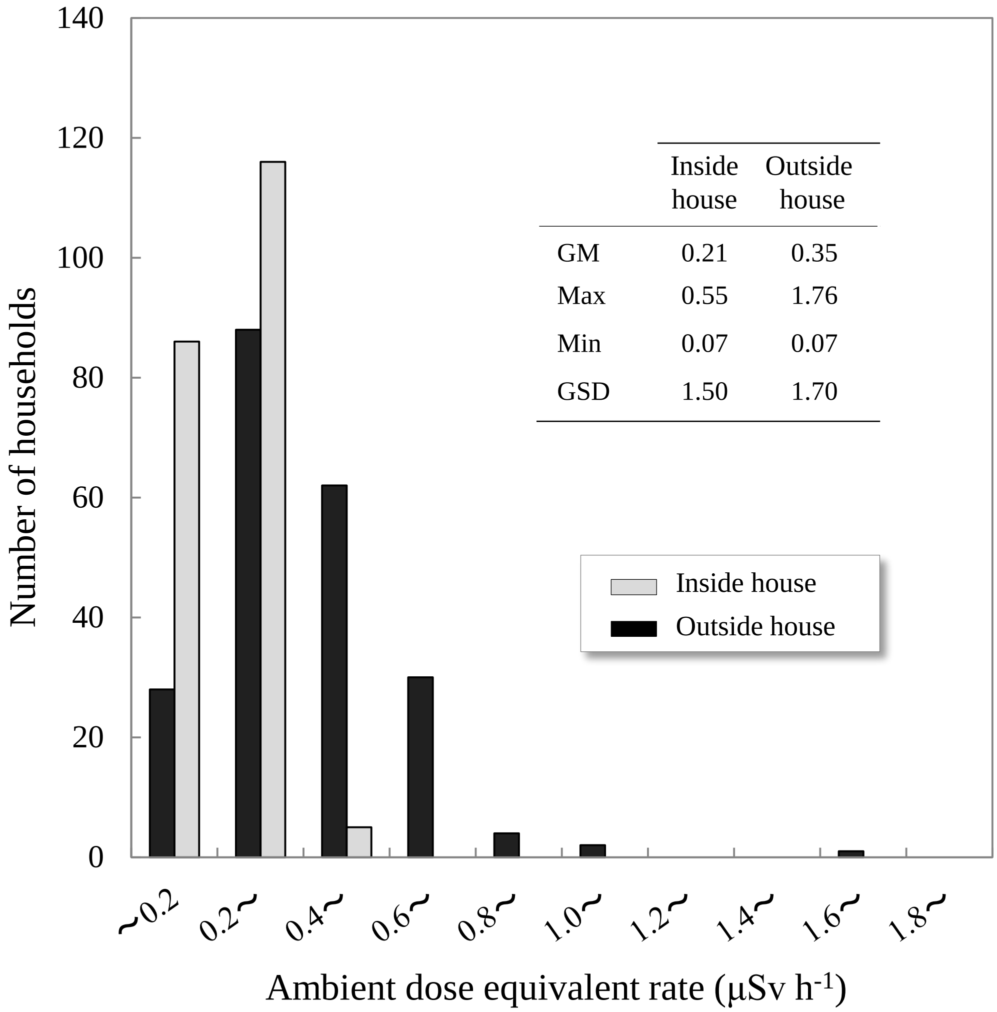

Fig. 4. Distribution of ambient dose equivalent rates, measured inside and outside houses

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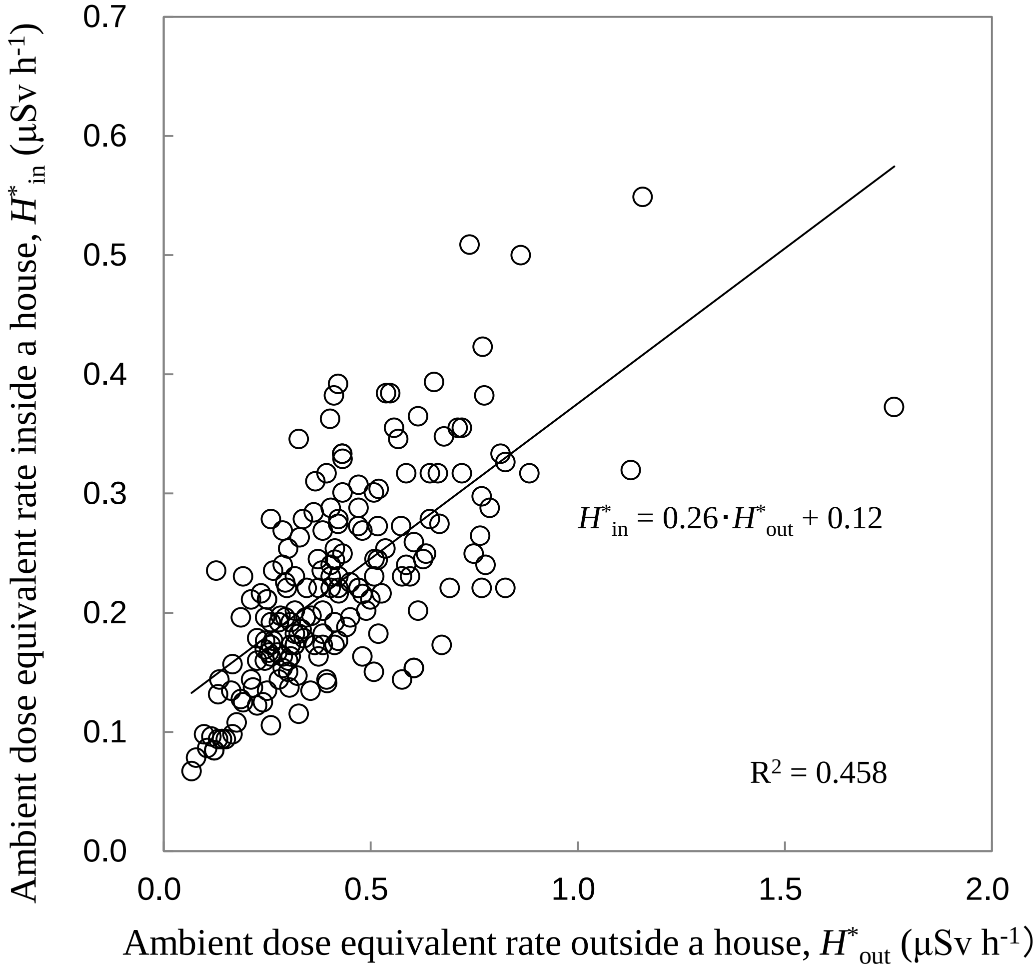

Fig. 5. Relationship between ambient dose equivalent rates measured inside and outside houses

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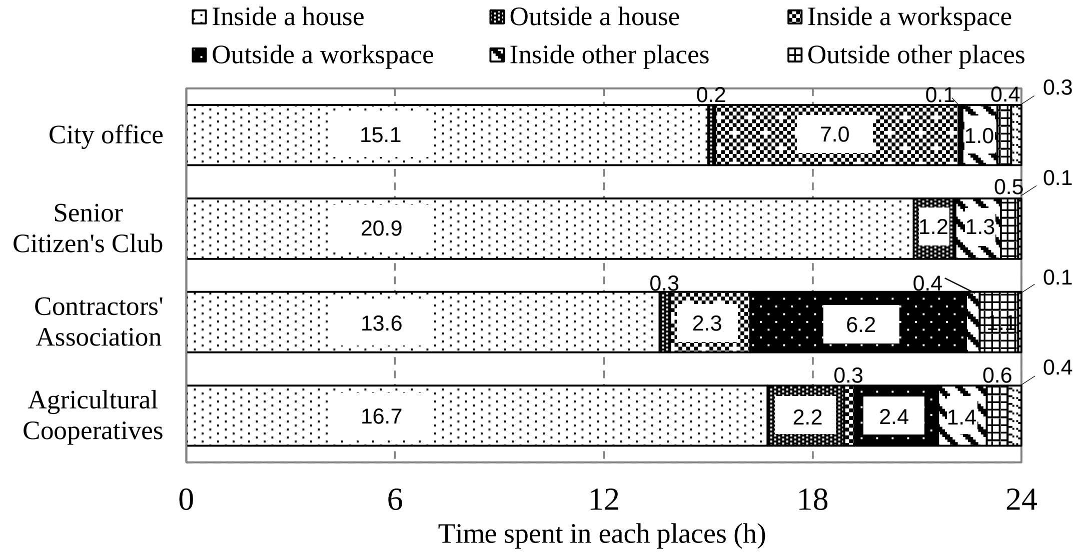

Fig.6. Mean value of time spent in house, workplaces, and other places (Feb. 2012)

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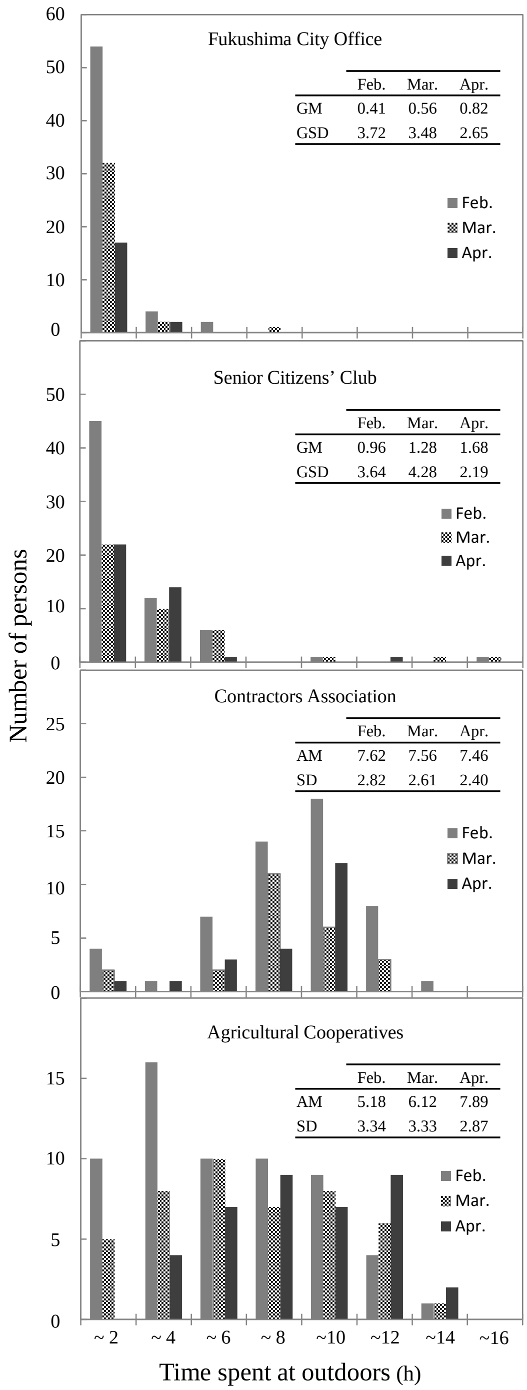

Fig. 7. Time spent outdoors per day in each month between February and April

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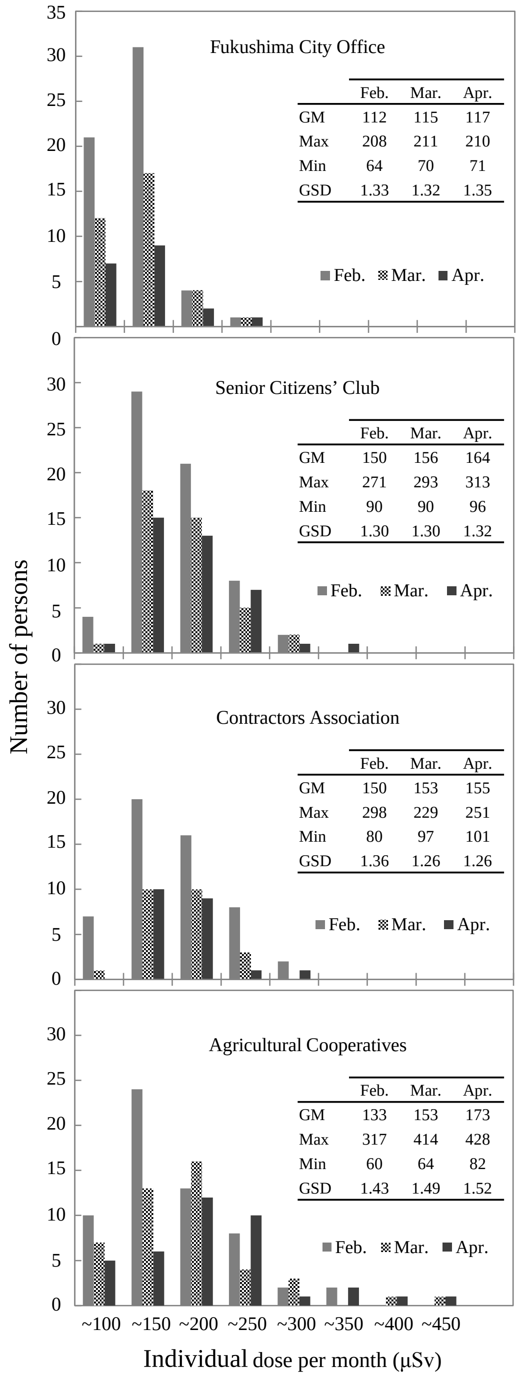

Fig. 8. Distributions of measured individual doses for each participant group in each month between February and April 2012

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Table 1. Number of participants from various population groups

	Feb. 2012	Mar. 2012	Apr. 2012
Fukushima City office	60	35	19
Senior Citizens' Club	65	41	38
Contractors' Association	53	24	21
Agricultural Cooperatives	60	45	38
total	238	145	116

Table 2. Average individual doses received by various types of agricultural producers

Types of agricultural product	Average individual doses per month (μSv)	
	Feb. 2012	Apr. 2012
Rice	160 (n=20)	224 (n=9)
Vegetable	124 (n=4)	156 (n=4)
Fruit	164 (n=23)	200 (n=19)
Flower	138 (n=6)	119 (n=2)
Livestock	123 (n=4)	152 (n=3)

Table 3. Results of multi-regression analysis

	Fukushima City office	Contractors' Association	Agricultural Cooperatives
β_1	0.8722***	0.9451***	1.4470***
	(0.1571)	(0.1988)	(0.2977)
β_2	0.05361	0.0372	-0.0852
	(0.1344)	(0.0819)	(0.1457)
β_3	-0.0007	0.0009**	0.0008.
	(0.0008)	(0.0003)	(0.0004)
ε	4.4642***	4.4674***	4.4514***
	(0.2364)	(0.1229)	(0.0958)
Sample size	56	49	55
R^2	0.356	0.362	0.405
p-value for F-test	< 0.05	< 0.05	< 0.05
AIC	-1.02	6.32	20.3

Values in parentheses are standard deviations.
** Significant code: '***' 0.001, '**' 0.01, '*'0.5, '.' 0.1

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