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Reliability of Questionnaire Data in the Distant Past: Relevance for Radiation Exposure Assessment

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Abstract

Interviews with questionnaires are often employed to provide information that may be used for exposure assessment although the reliability of such information is largely unknown. In this work, the consistency of individual behavior and dietary data collected by means of personal interviews during two study screenings was evaluated. Data were collected for a cohort of about 11,000 persons exposed to ^{131}I in childhood and adolescence shortly after the Chernobyl accident. The best recollection was found for residential history, milk consumption patterns and, to a lesser degree, stable iodine administration, while reproducibility of responses about consumption of milk products and leafy vegetables was poor. Consistency of information reported during the personal interviews by the study subjects younger than 10 years of age at the time of the accident was somewhat lower than for the subjects aged 10-18 years. We found slightly better reproducibility of responses for female study subjects than for male subjects and when the time span between two interviews was shorter. In the majority of instances the best consistency in responses was observed when the mother was interviewed during both screenings rather than the subject. Information that was collected during two personal interviews was used to calculate two sets of thyroid doses due to ^{131}I intakes. Our study shows that, because dose-related measurements are available for all study subjects, the quality of individual behavior and dietary data has, in general, a small influence on the results of the retrospective dose assessment. For studies in which dose-related measurements are not available for all study subjects and only modeling is used for dose reconstruction, high quality individual behavior and dietary data for the study subjects are required to provide realistic and reliable dose estimates.

Keywords

Questionnaire data; radiation dose; measurement; thyroid

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Introduction

Individual data collected by means of personal interviews are an important source of information for the assessment of exposure to individuals in epidemiological studies of cancer and other diseases, including radiation epidemiology. One of the main problems in retrospective studies is an uncertainty to what extent collected data from the distant past, in particular dietary data are reliable (Byers et al. 1997; Lee-Han et al. 1989). Ideally, the information collected for the subjects in an epidemiological study should completely and precisely reflect the events that occurred in the distant past. However, this is difficult to expect when the recalled period of interest and the time of data collection are ten or more years apart (Maruti et al. 2005; Willett 1998).

We examined the reliability of responses to questions about residential history and dietary pattern in the distant past obtained for a cohort of 11,732 subjects of a long-term epidemiological study of thyroid cancer and other thyroid disease in individuals exposed in childhood and adolescence to radiation following the Chernobyl accident, which occurred on 26 April 1986 (Stezhko et al. 2004; Zablotska et al. 2011; Ostroumova et al. 2013). The majority of the study subjects or his/her relatives were interviewed at least two times between 1996 and 2007 during two medical screenings of the cohort. The personal data on residential history and diet that were collected during the interviews were needed to assess the individual thyroid doses of the study subjects due to intakes of Iodine-131 (^{131}I). Because of the short half-life, about 8 days, of ^{131}I, the period of exposure to that radionuclide was about 2 months and is considered to have been completed by 30 June 1986. The personal interview data collected 10-20 years after the period of exposure were one source of uncertainty in the doses that in turn affects the risk estimates associated with radiation. The availability of repeated interviews made it possible to evaluate the reliability of data reported for events that occurred in the distant past and its relevance for radiation exposure assessment. Such evaluation is considered in this paper.

Materials and Methods

Study Population

Information on personal behavior and food consumption patterns during the first two months following the Chernobyl accident was collected for 10,966 study subjects during two personal interviews: 12,408 dosimetry questionnaires were completed during the first screening (30 December 1996 to 31 March 2001), and 13,097 dosimetry questionnaires were administered during the second screening (1 April 2001 – 31 May 2007) (Table 1).

The study timeline is shown in Fig. 1. The time span between the recalled period of interest, i.e. the period of exposure from 26 April to 30 June 1986, and the time of recollection was 13.2±1.2 y for the first interview and 16.8±1.8 y for the second interview. The median and inter-quartile time spans between interviews were 3.2 y and 2.1-5.0 y, respectively. Seventy-eight (0.5%) of the 14,982 questionnaire pairs were administered within one year of each other; 4,092 (27.3%) interviews were performed within a time interval of less than 2.1 y, and 3,789 (25.3%) interviews were performed within a time interval of more than 5.0 y.

All study subjects were under 18 years of age at the time of the Chernobyl accident (ATA). Of the individuals included in the study, 6,800 (62.0%) were less than 10 y old ATA and 4,166 (38.0 %) were between 10 and 18 y. The mean age of subjects ATA was 7.0±4.9 y; at the times of the first and second screenings, their mean ages were 20.8±5.3 y and 24.5±5.3 y, respectively.

The quality of the data reported during the personal interview may depend on the type of respondent, who was often the subject, but was also, when the subject was too young ATA, his or her mother or other relatives. Therefore, we evaluated the reproducibility of the questionnaire data separately for various pairs of respondents: subject-subject, subject-mother, mother-mother, subject-other relative**, mother-other relative, and other relative-other relative; overall, 14,982 pairs of questionnaires were obtained for the 10,966 study subjects (Table 2). It should be noted that we compared pairs of questionnaires and did not account for the order of respondents in the first and second interviews. For example, out of the 4,294 pairs of subject-mother questionnaires (Table 2), the subject was the respondent during the first interview and the mother was the respondent during the second interview 3,866 times, while the mother was the respondent during the first interview and the subject was the respondent during the second interview 428 times.

The reproducibility of the responses for the most important data for dose assessment (i.e., residential history and cow's milk consumption) were also evaluated by (a) age of the subjects ATA, i.e. < 10 y or 10-18 y old, (b) subject's sex, (c) rural or urban type of subject's residence ATA, and (d) time span between interviews, i.e. < 2.1 y or 5.0+ y, which are the lowest and highest quartiles of the time span between interviews.

The study was reviewed and approved by the institutional review boards of the participating organizations in Belarus and the United States. All study subjects (or their guardians for subjects who were 16 years of age or younger at the time of screening) signed an informed consent.

Study Questionnaires

The following information was collected during the personal interviews:

– Residential history, i.e. place of residence ATA, and, if applicable, settlements where the subject was relocated between 26 April and 30 June 1986, and dates of relocation to those settlements;

– Consumption rates and dates of consumption of privately owned cow milk, milk from a commercial trade network, as well as milk products (milk soup or porridge, cottage cheese, sour milk or kefir, cream or sour cream), and leafy vegetables between 26 April and 30 June 1986;

– Dates and duration of stable iodine administration between 26 April and 31 May 1986.

**Other relatives were: sibling (55%), father (27%), and others (18%) during the first screening; father (62%), sibling (20%), grandmother (8%), aunt (6%), and others (4%) during the second screening.

Although the same type of information was collected during the first and second screenings, the designs of the questionnaires used were slightly different. In particular, in the first screening, the respondent was asked questions about the departures from places of residence, while during the second screening he/she was questioned about the sequence of relocations. In the questionnaire used during the first screening, milk consumption was tied to the dates of the beginning and end of consumption because of relocation from contaminated areas, and the amount of milk consumed was reported in liters. During the second screening, the milk consumption corresponded to the settlements where the subject lived from 26 April to 30 June 1986, and the amount of milk consumed could be reported in various units, including liters, glasses, cups, and half-liter bottles.

The questionnaires included “basic” and “follow-up” questions. A positive response to a basic question, such as “Did you drink milk?” triggered follow-up questions, e.g., “When did you drink milk?”, “What kind of milk?”, “How much?”, “How often?” etc., whereas follow-up questions were not needed when a negative answer such as “No” or “I do not remember” was given. If a respondent did not recall the exact date of, for example, relocation from one settlement to another, he or she was prompted to estimate the general period of time during which the event occurred, such as “end of April [1986]”, “beginning of May”, “middle of May”, “end of May” or “June”. The questionnaire used for the study subject (or relative) during the first screening included 24 basic and 69 follow-up questions while the questionnaire for the second screening included 17 basic and 81 follow-up questions on the same topics. The questionnaires used in the two screenings were approximately of the same length.

Personal Interview

The reliability and validity of information collected during the interview is likely to be influenced by the training and experience of the interviewer (Lee-Han et al. 1989). The interviewers who participated in this study were employees of the Dosimetry and Epidemiology Departments of the Belarusian Medical Academy of Post-Graduate Education (Minsk, Belarus) or of the Republican Research Center for Radiation Medicine and Human Ecology (Gomel, Belarus). They have an M.S., B.S., or A.B.S. degree and had received 27 hours of training. They were trained to behave during the personal interview in a neutral manner and not to show any type of emotion either when asking the questions or when listening to the answers. The interviewers were trained to use probing techniques to stimulate the memory recall of the respondent. The interviewer showed special probing cards to respondents, such as a calendar for April – May 1986 with indication of major holidays (Labor Day, 1 May; Orthodox Easter, 4 May; Victory Day, 9 May) and pictures of cups, glasses and bottles to recall the consumption pattern of cow's milk.

The interviews were conducted in person when the subject attended medical screenings within the framework of the study. The interviewer consistently read questions from a paper questionnaire and recorded the responses.

The database of information collected during the personal interview was designed for storage, further analysis, and use in the calculation of doses. Each questionnaire was double key entered by two operators. The database verification included comparison of the responses entered by the operators in two databases. When discrepancies occurred, the correct answer was checked in the paper questionnaire and the error was corrected in the database.

Calculation of Thyroid Doses

Fig. 2 shows the simplified scheme of thyroid dose calculation for the Belarusian study subjects. The thyroid doses due to ^{131}I intakes were calculated in the study using input data specific to each study subject (measurement of exposure rate near the thyroid and personal interview) and ecological and biokinetic data (e.g., ^{131}I ground deposition in the settlements or thyroid uptake of ^{131}I). The information obtained during the interviews was included into an "ecological model" of calculation of thyroid doses due to ^{131}I intakes. This model describes the transfer of ^{131}I from ground deposition to milk and other foodstuffs, and finally to child's thyroid. In order to calculate the "instrumental" thyroid dose, the "ecological" dose was calibrated by the ^{131}I activity in the thyroid derived from the direct thyroid measurement. A detailed description of the ecological model and of the calculation of the "ecological" and "instrumental" thyroid doses can be found elsewhere (Drozdovitch et al. 2013).

For each subject, two sets of *ecological* and two sets of *instrumental* thyroid doses due to ^{131}I intakes were calculated using personal information obtained during the first and the second interviews. The same measured ^{131}I activity in the thyroid and the same parameter values for the ecological and biokinetic models were used for each study subject to calculate the thyroid doses; the only values that were different in the calculation of these sets of doses were those related to individual behavior and dietary data that were reported during the two interviews.

Statistical Analysis

The percentage of agreement, the nonparametric Spearman's rank-correlation coefficient, r_s, and the kappa statistics, κ, were used to measure the degree of agreement of the responses between the two interviews. For the responses with text, i.e., name of settlement, the percentage of agreement between the answers was estimated. For responses with dates, exact date, date ± 1 day, and general period of time during which the event occurred, such as "end of April [1986]", "beginning of May", "middle of May", "end of May", or "June", were compared between the two questionnaires, and the percentage of agreement and κ-statistics were used to measure the degree of agreement. Numerical responses were treated in two ways: (a) for whole numbers, i.e., number of settlements of residence, the percentage of agreement and Spearman's rank-correlation coefficients were calculated; and (b) for consumption rates and thyroid dose estimates, i.e. values that could not be expected to be exactly the same, the data were categorized in intervals, and the percentage of agreement in the categories and κ-statistics for categories were estimated. κ-statistics and Spearman's rank-correlation coefficients were used only for pairs without missing responses, such as "I do not remember". Kappa statistics $\kappa<0$ indicates no agreement, while 0-0.20 range corresponds to a slight agreement, 0.21-0.40 to fair, 0.41-0.60 to moderate, 0.61-0.80 to substantial, and 0.81-1.0 almost perfect agreement (Landis and Koch 1977). The two sets of consumption rates and thyroid doses were compared using the Wilcoxon and Kruskal-Wallis tests, because values were not normally distributed; here, the *p*-value represents the significance level of whether data sets differ.

Results

Table 3 shows the distribution of responses provided by different pairs of respondents during two interviews by questions and categories of respondents. As mentioned above, 14,982 pairs of questionnaires were compared in the study. Three-hundred fifty four questionnaire pairs were not included in the analysis by type of residence (rural or urban) as these respondents reported different types of residence during the first and the second interviews.

Table 4 summarizes the degree of consistency between answers in pairs of questionnaires administered to the 10,966 subjects or their relatives during the two screenings. The data related to the different topics covered in the questionnaires are given in detail in the following sections.

Residential History

A reliable residential history is important for thyroid dose calculation as the deposition of ^{131}I on the ground surface in the settlement of residence is the starting point of the ecological model that describes the processes of ^{131}I transfer to the accumulation of child's thyroid.

Name of the settlement ATA—As indicated in Table 4, there is an almost perfect agreement of the name of settlement inhabited by the subject ATA, regardless of the age, sex, or time elapsed between interviews. The name of the place of residence ATA matched for 13,206 (88%) pairs of questionnaires. The reproducibility of information reported during the personal interviews was best when the type of residence ATA was rural.

Number of settlements of residence from 26 April to 30 June 1986—3,626 (29%) respondents during the first interview and 3,358 (26%) respondents during the second reported that the subjects did not move from their place of permanent residence from 26 April through 30 June 1986; 8,465 (68%) respondents during the first interview and 9,555 (73%) during the second reported that the subjects changed residence (Table 5). The median and inter-quartile range of the numbers of relocations reported during the first interview were 3 and 1-3, respectively; the corresponding numbers collected during the second interview were 2 and 1-3, respectively.

The same number of settlements of residence was reported by 7,191 respondents (48%, r_s=0.55) during the two different interviews (Table 4). A difference of one settlement was reported in 4,567 (30%) of the pairs of interviews (not shown). As can be seen from Table 4, the reproducibility of information reported during the personal interviews was moderate to substantial and was best when the mother or the subject responded to both interviews.

Date of first relocation—For the subjects who changed settlement of residence after the accident, the most important contribution to the thyroid dose was, in general, received in the settlement of residence ATA and was higher as the time elapsed before the first relocation was longer. The distribution of the dates of first relocation that were reported during the interviews is shown in Table 5. During the first interview 2,506 (20%) of respondents reported that the subjects moved from their place of residence during the first 5 days after the accident (between 26 and 30 April 1986); the same response was reported by 1,913 (15%) respondents during the second interview. During the first interview 3,776 (30%) of respondents reported that the subjects moved from their place of residence between 1 and 10 May 1986; 4.652 (36%) respondents provide the same response during the second interview. It should be noted that most of the ^{131}I intake with cow's milk took place before 10 May 1986.

Agreement on the date of first relocation was observed for 42% of the questionnaire pairs (Table 4). The consistency of the answers provided during the interviews was fair to moderate and did not depend much on the age, gender, and type of residence of the subject ATA. However, the consistency was better when the mother or the subject responded to both interviews.

Name of settlement of first relocation—The name of the settlement of first relocation was the same for 4,547 (49%) questionnaire pairs. The reproducibility of the answers reported during the two interviews was somewhat better for the name of the settlement of first relocation than for the date of relocation. The consistency was highest for the subjects with an urban type of residence ATA and when the time elapsed between interviews was less than 2.1 y.

Residential History for Evacuees from the 30-km Zone

A separate analysis of the results was conducted for the inhabitants of settlements located in the 30-km zone around the Chernobyl nuclear power plant which were evacuated shortly after the accident. Knowledge of the residential history for evacuees is important as evacuated settlements were highly contaminated with ^{131}I and, therefore, evacuees received the highest thyroid doses due to ^{131}I intakes. During the first screening, 729 questionnaires were completed for 616 respondents who reported that the subjects were evacuated from the 30-km zone while during the second screening, 751 questionnaires were completed for 631 evacuees.

During the first interview, 330 (45%) respondents reported that they were evacuated before 1 May 1986; the same information was reported by 274 (37%) respondents during the second interview. The number of respondents who reported that evacuation occurred between 1 and 7 May 1986 was 299 (41%) during the first interview and 407 (54%) during the second interview. The number of respondents who reported that the evacuation occurred later than 7 May 1986 was 41 (5.6%) during the first interview and 50 (6.6%) during the second interview. In 41 (5.6%) first interviews and in 15 (2.0%) second interviews, the respondents stated that they did not leave the evacuated settlement before the end of June. This is inconsistent with published information that the evacuation of children from the 30-km zone around the Chernobyl power plant was completed in Belarus by 7 May 1986 (UNSCEAR 2000).

The consistency of the responses for evacuees was similar to that obtained for the entire group of study subjects who changed residence during the two months following the accident. For evacuees, the name of the place of residence ATA matched for 85% of the compared pairs of questionnaires, while the same name for the settlement of residence after evacuation was reported in 46% questionnaire pairs. There was agreement on the number of settlements of residence and on the date of evacuation in 36% and 49% of questionnaire pairs, respectively. Mothers interviewed during both interviews showed better consistency in the responses related to evacuation (except for the name of the settlement ATA) than the other pairs of respondents.

Consumption of Cow Milk

We compared responses provided during the first and second interviews on the consumption of milk from privately owned cows and milk from a commercial trade network, which was collected from neighborhood areas and processed in a local milk plant. These two types of milk were considered separately because the concentration of ^{131}I in the milk from privately owned cows was in general higher than that in the milk from a commercial trade network and, therefore, milk from privately owned cows had a higher potential for exposure than the milk from a commercial trade network.

We analyzed the following categories of responses: type of milk consumed; consumption rate ATA (26 April 1986), and consumption rate averaged over the period 26 April – 10 May 1986 when most of the changes in milk consumption occurred and most of the ^{131}I intake with milk took place. The average consumption rate was calculated as:

$$V=\frac{1}{15}\cdot\sum_{d=1}^{15}V_d, \quad (1)$$

where d=15 is the number of days in the time interval from 26 April through 10 May and V_d is the consumption rate of milk on day *d* (L d^{-1}).

We found that the fraction of study subjects who reported milk consumption was lower during the first interview than during the second: 58% vs 61% for consumers of milk from privately owned cows, 38% vs 45% for consumers of milk from a commercial trade network, and 78% vs 88% for consumers of any type of milk. Table 6 presents the reported consumption rates of milk from privately owned cows and of milk from a commercial trade network averaged over the period 26 April – 10 May 1986. As can be seen from the table, a higher consumption rate of privately owned cow milk was reported during the first interview than during the second (0.51 L d^{-1} vs 0.44 L d^{-1}, respectively, p<0.001). There was no statistically significant difference in the consumption rates of milk from a commercial trade network that were reported during the first and the second interviews (0.23 L d^{-1} vs 0.21 L d^{-1}, respectively, p=0.842).

Source of milk (from privately owned cows or from a commercial trade network)—As can be seen from Table 4, the reproducibility of information reported during the personal interviews was fair to moderate with regard to the source of milk. The agreement was better for study subjects who were older than 10 y ATA than for younger subjects, when the time span between interviews was shorter than 2.1 y, and when the study subject was interviewed instead of a relative. There was no substantial difference according to the sex or type of residence of the subject ATA.

Consumption rate ATA of milk from privately owned cows—The reproducibility of the answers on that topic was fair to moderate. There was not much difference in the degree of consistency according to the type of respondent. The consistency was better when the type of residence ATA was urban rather than rural, for female subjects in comparison to male subjects, and when the span between interviews was shorter than 2.1 y.

Consumption rate of milk from privately owned cows (averaged over 15 days)—The reproducibility of the answers was fair to moderate and showed a very similar pattern to that obtained for the answers reported for the consumption rate ATA: better consistency when the type of residence ATA was urban rather than rural, for female subjects in comparison to male subjects, and when the span between interviews was shorter than 2.1 y.

Consumption rate ATA of milk from a commercial trade network—A fair to moderate agreement was found for the consumption rate ATA of milk from a commercial trade network. There were small differences according to the subject's sex or the type of respondent. The degree of consistency was better when the type of residence ATA was rural rather than urban and for study subjects who were older than 10 y ATA than for younger subjects.

Consumption rate of milk from a commercial trade network (averaged over 15 days)—The reproducibility of the answers was fair. The degree of consistency was better when the type of residence ATA was rural rather than urban, when the time span between interviews was shorter than 2.1 y, for study subjects who were older than 10 y ATA than for younger subjects, and for female subjects in comparison to male subjects.

Consumption of Milk Products

The respondents were inquired about the consumption of the following types of milk products: milk soup or porridge, cottage cheese, sour milk or kefir, sour cream or cream. It should be noted that during the first screening interview, all respondents were asked questions about the consumption rates of milk products. During the second screening, only those who claimed that the subject drank less than 0.25 L d^{-1} of milk, did not consume milk, or did not remember his/her milk consumption were asked about the consumption of milk products to address what became a potentially important source of ^{131}I intake. Therefore, the information on milk products was collected for 100% of respondents during the first screening and for 74% of respondents during the second screening.

Mean and median values as well as ranges of consumption rate of milk products are shown in Table 6. As can be seen from the table, a lower consumption of milk products was reported during the second interview (0.20 kg d^{-1}) than during the first (0.23 kg d^{-1}), ($p<0.001$).

Overall, there was only a slight agreement on the consumption pattern of milk products (Table 4). The reproducibility of the consumption rates of milk products was best when the mother of the subject was the respondent during both interviews.

Consumption of Leafy Vegetables

The parameters related to the consumption of leafy vegetables that were analyzed are the date or time period when the study subject started to consume leafy vegetables in spring of 1986, the date or time period when he or she stopped, and the consumption rate of leafy vegetables. We found that the fraction of study subjects who reported leafy vegetables consumption was lower during the second interview than during the first: 40% vs 47%. The reported consumption rate of leafy vegetables was lower during the second interview (0.031 kg d^{-1}) than during the first (0.047 kg d^{-1}) (p<0.001) (Table 6).

Kappa statistics showed only a slight agreement in the responses between the first and the second interviews on the dates of beginning of consumption of leafy vegetables, on the date of end of consumption of leafy vegetables, and on the consumption rates of leafy vegetables. The reproducibility of consumption rates of leafy vegetables was better when the mother of the subject was the respondent during both interviews (Table 4).

Stable Iodine Administration

About 30% of the thyroid dose due to ^{131}I intake was prevented if stable iodine was administered the day after the accident (on 27 April); around 15, 10 and 5 percent – if stable iodine was administered 5 days after the accident (on 1 May), 10 days after the accident (on 5 May) or 15 days after the accident (on 10 May), respectively (*8*). During the first interview, 3,462 (28%) respondents reported that the subjects took stable iodine for prophylactic purposes compared to 5,033 (38%) respondents during the second interview. Information on the dates when stable iodine was administered is presented in Table 7. During the first interview, 2,405 (19%) respondents reported that they took stable iodine before 10 May 1986; the same information was reported by 3,614 (28%) respondents during the second interview. However, only 590 (4.7%) respondents during the first interview and 913 (7.0%) respondents during the second interview reported intake of stable iodine shortly after the accident, between 26 April and 30 April 1986, when blockade of radioactive iodine uptake was the most effective to prevent thyroid exposure.

Overall, according to Table 4, there was fair to moderate agreement between the responses of the respondents on the occurrence of stable iodine administration, date of beginning, and duration of stable iodine administration. The reproducibility of information on administration of stable iodine was best when the mother of the subject was the respondent during both interviews.

Thyroid Doses from ^{131}I Intakes

Individual thyroid doses, both *ecological* and *instrumental*, were calculated using behavioral and dietary data obtained during the first and the second interviews (Table 8). As can be seen from the table, a moderate agreement was observed (r_s=0.66) between the *ecological* dose values calculated using the data from the two interviews. With regard to the exposure pathways that contributed to the thyroid dose, which were, by decreasing order of importance, the consumption of cows' milk, the consumption of milk products, the consumption of leafy vegetables, and inhalation, a high correlation (r_s=0.88) was observed between the *ecological* doses due to inhalation of ^{131}I calculated using the data from the two interviews, but the agreement was not as good for the *ecological* doses due to intakes of ^{131}I in milk (r_s=0.46), milk products (r_s=0.26) and leafy vegetables (r_s=0.25). On the other hand, the *instrumental* doses calculated using data from the two interviews yielded an almost perfect agreement (r_s=0.97).

Fig. 3 and 4 compare the individual *ecological* and *instrumental* thyroid doses, respectively, calculated for all study subjects using information from the first and second interviews. As can be seen from Fig. 3, the *ecological* thyroid doses estimated for the same study subject using the results of different interviews were spread over five orders of magnitude. The low degree of agreement between the *ecological* doses calculated for the same person using different questionnaires was caused by the rather poor agreement on dietary information and, to a lesser degree, residential history, reported during two personal interviews. For most study subjects, the *ecological* dose is, as a first approximation, directly proportional to the ^{131}I deposition density in the main settlement of residence and to the consumption rate of fresh cows' milk. Therefore, the low degree of agreement in the individual behavioral and dietary data reported during the two interviews led to the low degree of agreement between the *ecological* doses that were calculated using this individual information.

Essentially better agreement was observed for the *instrumental* doses (Fig.4). For 96% of the *instrumental* doses (κ=0.809) and 51% of the *ecological* doses (κ=0.260) the two sets of doses agreed within 50% (Table 4). A difference of less than 10% in the *instrumental* doses calculated from the data collected during the two interviews was found for 43% of the respondents, while the corresponding percentage was only 8.2% for the *ecological* doses (not shown). The mean ratios of the doses calculated for the entire cohort using data from the first and the second interviews were 3.8±33 for the *ecological* doses and 1.1±0.7 for the *instrumental* doses; the corresponding median ratios were 0.82 and 1.0 for the *ecological* and the *instrumental* doses, respectively (Fig.5).

Discussion and Conclusions

We evaluated the reproducibility of the individual behavior and dietary consumption data for about 11,000 study subjects reported during two personal interviews. In general, the data collected during the two interviews were rather consistent with regard to answers to basic questions such as “Did you move from place of permanent residence?”, “Did you consume milk?”, “Did you take stable iodine?”. For more detailed information on dates and consumption rates obtained from responses to follow-up questions, the agreement between the two interviews was not as good. The best recollection in our study was found for residential history, milk consumption and, to a lesser degree, stable iodine administration, while responses about the consumption of milk products and leafy vegetables were disappointing in terms of reproducibility. Responses agreed better on number of relocations, names of settlements and consumption pattern rather than on dates of relocations.

We found that male and female study subjects showed similar consistency in answers regarding residential history while female subjects showed better reproducibility of responses on consumption of cows' milk. There is inconsistency in the literature regarding the quality of the recall by gender. While Byers et al. (1983) reported higher correlations among females than males in his diet study, null or opposite findings have been reported in other studies (Friedenreich et al. 1992; Jensen et al. 1984; Kuzma and Lindsted 1990). Many characteristics influence this analysis, particularly the timing in history, the culinary characteristics in the population being studies, socioeconomic status and the types of instruments being used to assess the original and recalled diet. Given the population characteristics in Belarus, it is likely that the female subjects were more responsible for the diet, particularly for children; therefore, they recalled dietary information better than boys.

We did not find systematic difference in reproducibility of response between urban and rural respondents. They showed different direction of consistency in the responses on residential history and consumption patterns.

We found that the reproducibility of the responses was higher when the time span between interviews was shorter. This result agrees with other studies (Riboli et al. 1997; Thompson et al. 1987).

We found that lower consumption rates of milk and milk products were reported during the second screening. It is generally recognized that recall of past diet is strongly influenced by present dietary habits (Rohan and Potter 1984; Thompson et al. 1987; Dwyer et al. 1989). We do not have information about respondent's diet at the time of the interview; however, more people may recognize lactose intolerance in later adolescence that might cause reporting lower consumption rates during the second interview.

Respondents provided more information on relocations during the second interview. As respondents were asked questions about the sequence of relocations in the second interview but only about the dates of departure from places of residence in the first interview, they may have remembered the chain of events better than a single event.

We found that the agreement for most of the responses provided during the two interviews was fair or moderate. There are a few reasons for the relatively poor reproducibility of information in our study:

– First, such results are not surprising as the time span between the period of interest and time of recollection in this study was from 10 to 20 years. It is generally recognized that reporting accuracy decreases as the time span between the reference and the recollection period increases. Low validity and reproducibility of data on recalled diet was reported for recollections exceeding 10 years (Maruti et al. 2005; Willett 1998). Studies with intervals ranging from 1-10 years yield average correlations of 0.50-0.75, while studies with recall periods of 10-15 years in the past yield correlations of 0.35-0.55 (Friedenreich 1994). It has also been noted that studies that include instruments assessing many aspects of diet and contain more than 100 items show higher correlations than those with 50 or fewer items. This may have a cognitive aspect of placing the person closer to the time period in question. Recollection can be more accurate if asked about unique events in person's life, like pregnancy for women (Bunin et al. 2001). The Chernobyl accident was a unique event for the study subjects and their relatives.

– Second, although the same type of information was collected during the first and second interviews, the designs of the questionnaires used for the first and second interviews were slightly different. The questionnaire wording and level of detail of the questions likely influence recall ability during data collection (Friedenreich 1994). To check if responses to the same questionnaire were more consistent than those to different questionnaires, we extended our analysis with 1,589 questionnaire pairs completed for 1,361 subjects using the same questionnaire within the first screening and with 2,215 questionnaire pairs completed using the same questionnaire for 2,083 subjects within the second screening. We found that reproducibility of information within the same screening was similar to that obtained in different screenings. For example, we found moderate agreement for information on source of milk for study subjects (61% agreed, κ=0.442 and 69% agreed, κ=0.550 for interviewed twice within the first and within the second screening, respectively) and mothers (61% agreed, κ=0.459 and 63% agreed, κ=0.509 for interviewed twice within the first and within the second screening, respectively). The similar consistency of responses on source of milk between two interviews conducted during two different screenings was observed for subjects (62% agreed, κ=0.447) and for mothers (60% agreed, κ=0.449) (Table 4).

– Another factor that might cause the differences in the responses was the selection of respondent in the first and second interview. It was expected that mother could provide the most reliable information on behavior and dietary data for her child on events in early childhood. While it is typical to have mothers report for children under age 10 y (Baranowski et al. 2012; Burrows et al. 2010), it may be useful to have the mother report for older children as well. This may be especially true for a rural population where the mother would spend much time overseeing all aspects of the family's diet. Indeed, we found that in the majority of instances the best reproducibility was observed when mother was interviewed during both first and second interviews rather than subject.

We found no difference in reproducibility of responses depending on whether the subject or the mother was interviewed first. We analyzed the consistency of answers between the 3,866 pairs of questionnaires when subject was the respondent during the first interview and mother was the respondent during the second interview, and the 428 pairs of questionnaires when mother was the respondent during the first interview and subject was the respondent during the second interview. Overall, a rather good agreement between these two categories was found for (1) the number of settlements of residence (42% agreed, r_s=0.41 and 43% agreed, r_s=0.44, respectively); (2) date of the first relocation (37% agreed, κ=0.274 and 34% agreed, κ=0.264); (3) name of the settlement of residence ATA (86% and 81% agreed); and (4) name of the settlement of first relocation (46% and 41% agreed).

Out of the 6,800 subjects who were younger than 10 y ATA, 4,183 and 1,566 subjects were administered personal interviews during the first and the second screening, respectively. We found that the reproducibility of information reported during the personal interviews by subjects younger than 10 y ATA was, in general, lower, but sometimes similar, than that reported by older subjects. It should be noted that along with the invitation to the interview the study subject received a self-administered questionnaire. The subject was asked to complete and return a self-administered questionnaire or to bring it to the personal interview. To stimulate memory recall, the self-administered questionnaire consisted of a small number of questions, such as “What was your place of residence at the time of the Chernobyl accident on 26 April 1986?”, related to the main topics of the questionnaire. Completing a self-administered questionnaire by young subjects caused discussion with parents and other relatives. So, sharing memories with relatives may have improved the recollection.

Individual behavior and dietary consumption data that were collected during the first and the second interviews were used to calculate, for each study subject, two sets of *ecological* and two sets of *instrumental* thyroid doses due to ^{131}I intakes. We found poor agreement between *ecological* doses calculated for the same person using different questionnaires. High uncertainties in *ecological* doses were caused by discrepancies in residential history and dietary data reported during two interviews. Essentially better agreement was found for the *instrumental* doses, which are results of calibration of ecological doses using the result of the direct thyroid measurement. This confirms our early finding that, in general, uncertainties in *instrumental* thyroid doses are not driven by questionnaire data (Drozdovitch et al. 2015). It should be noted that although the two values of *instrumental* dose calculated for the same study subject using different interviews' data are, in general, rather consistent, substantial differences (> 10 times) were obtained for 23 of the 14,982 compared dose pairs. Further work is underway to explain such discrepancies.

Without a gold standard, i.e. individual data collected shortly after the accident, we are not able to check the true validity of the responses. However, our study shows that using only modeling for dose reconstruction requires high quality of individual data collected through personal interviews of the study subjects or their mothers. When radiation measurements (in this case, direct thyroid measurements) are available for the study subjects, the quality of individual behavior and dietary data has, in general, a small influence on the quality of the retrospective dose assessment.

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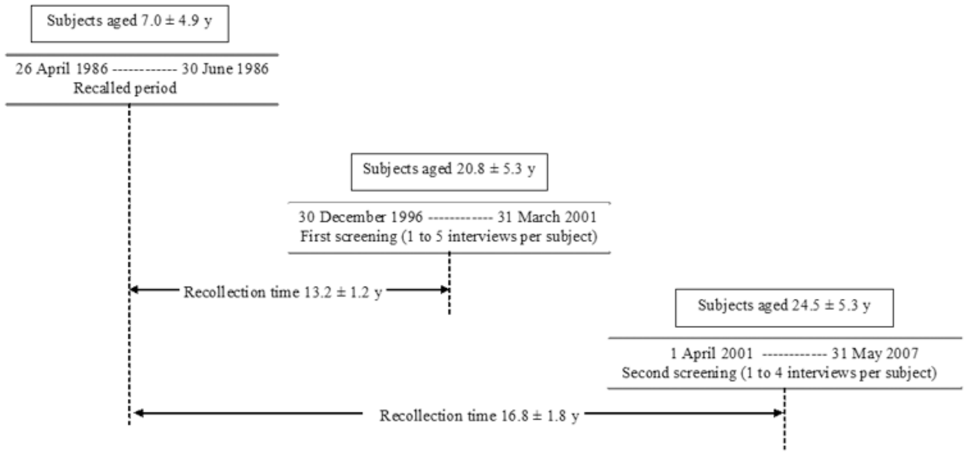

Fig. 1.
Study timeline.

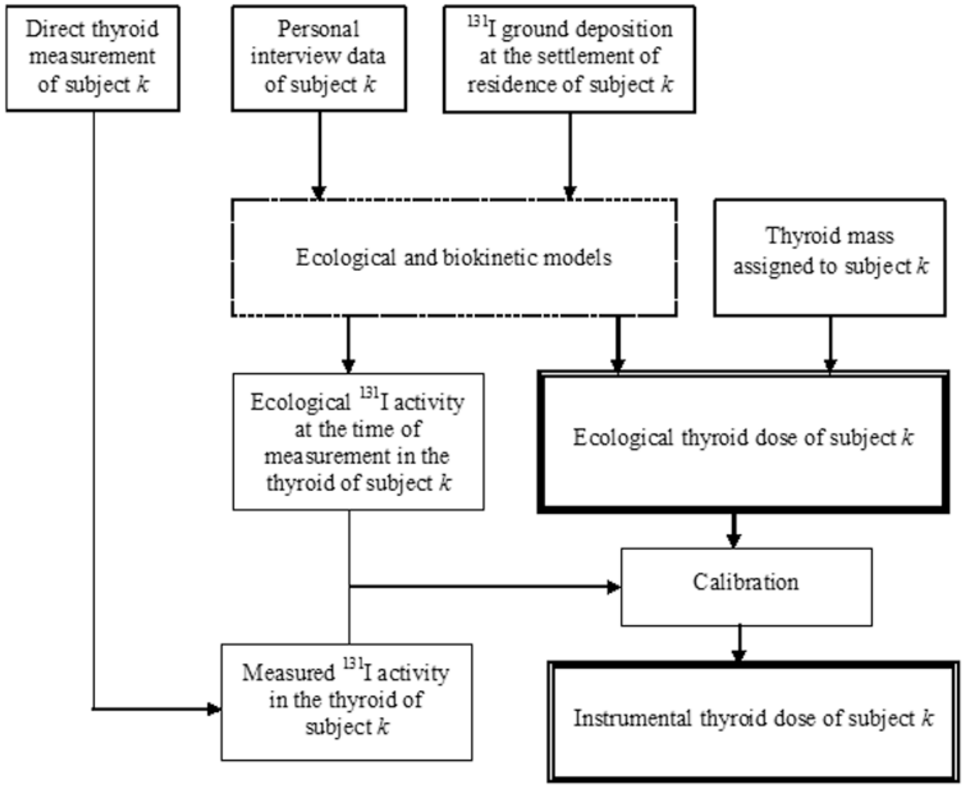

Fig. 2.

Scheme of thyroid dose calculation for the Belarusian study subjects.

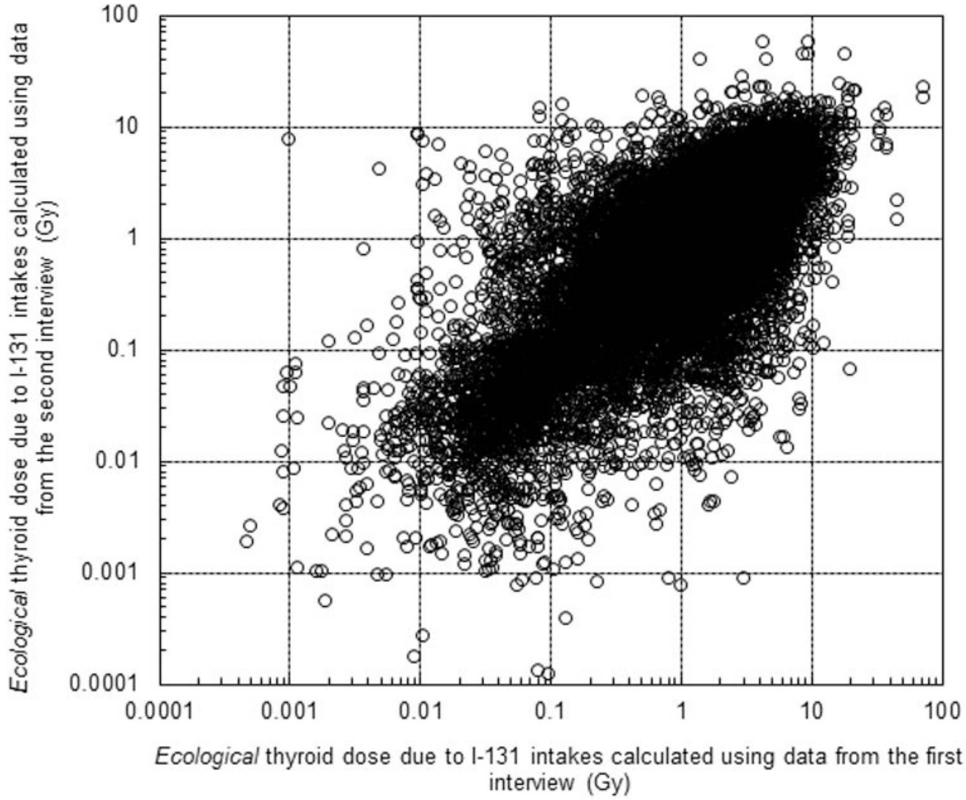

Fig. 3.
Comparison of *ecological* doses calculated using information from the first and second interviews.

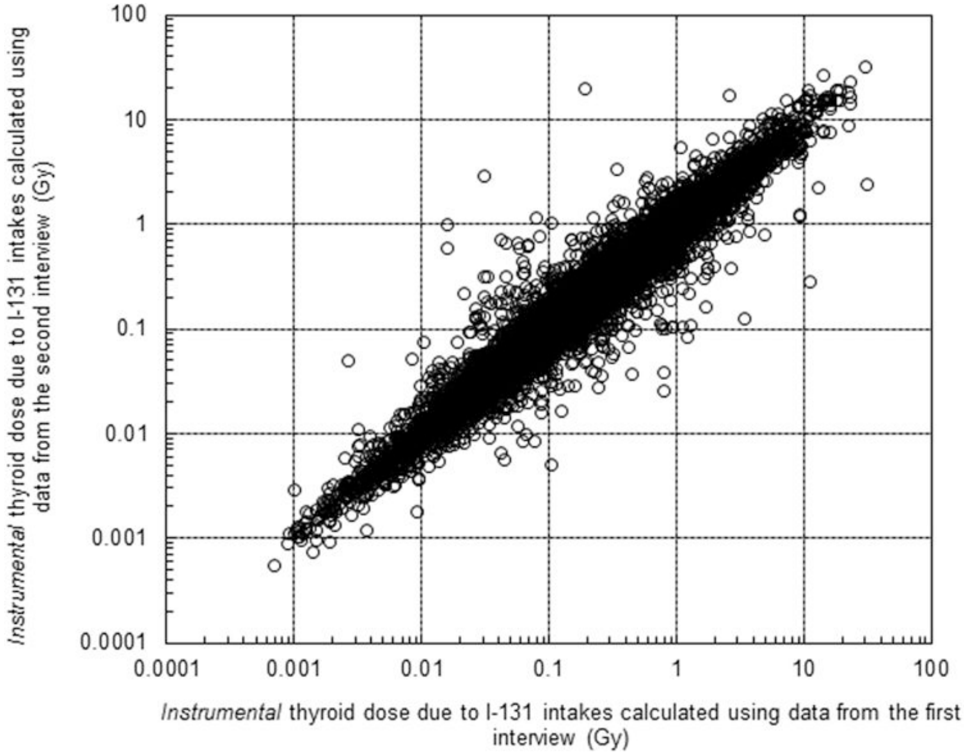

Fig. 4.

Comparison of *instrumental* doses calculated using information from the first and second interviews.

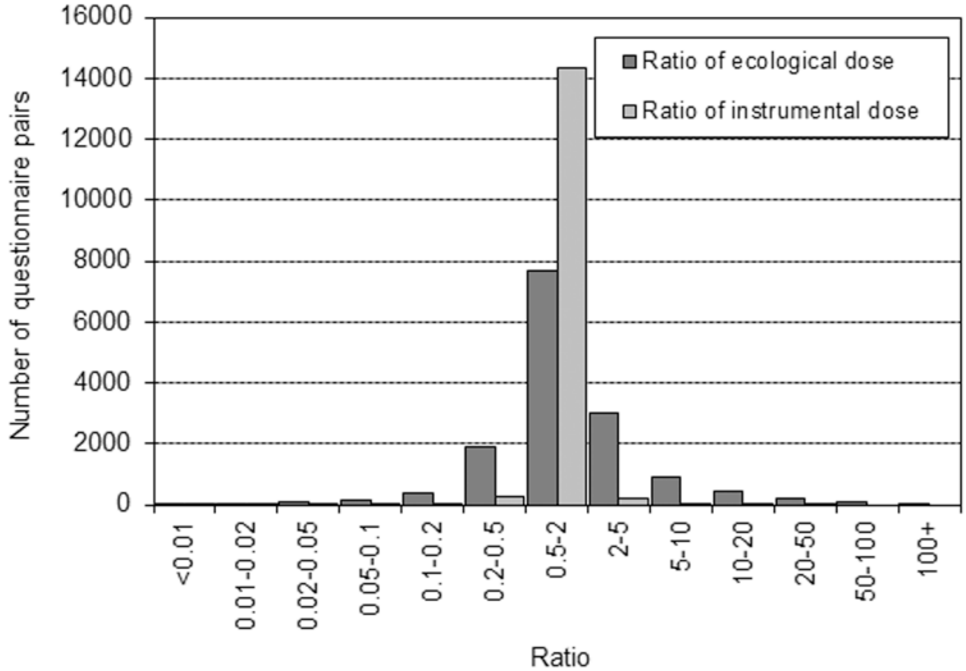

Fig. 5.

Distribution of the ratios of doses calculated using data from the first interview to those calculated using data from the second interview for *ecological* and *instrumental* doses.

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Table 1

Distribution of the number of questionnaires completed by the study subject during the first and second screenings.

Number of questionnaires completed for the study subject	Number of the study subjects for whom questionnaire was completed during	
	First screening	Second screening
1	9,631	8,899
2	1,235	2,005
3	94	60
4	5	2
5	1	-
Total	10,966	10,966

Table 2

Numbers of questionnaire pairs according to type of respondent in the two interviews.

Respondent #1	Respondent #2	Number of questionnaire pairs
Subject	Subject	5,662
Subject	Mother	4,294
Subject	Other relative	1,056
Mother	Mother	2,664
Mother	Other relative	1,062
Other relative	Other relative	244
Total		14,982

Table 3

Distribution of responses (N (%)) to questionnaires during the two interviews and thyroid doses due to ^{131}I intakes

Characteristics	Total	Pairs of respondents					
		Subject-subject	Subject-mother	Subject-other relative	Mother-to mother	Mother-other relative	Other relative-other relative
Residential history							
Name of settlement ATA[a]	14,982 (100)	5,662 (37.8)	4,294 (28.7)	1,056 (7.0)	2,664 (17.8)	1,062 (7.1)	244 (1.6)
< 10 y [b]	10,219 (100)	1,289 (12.6)	4,163 (40.7)	818 (8.0)	2,657 (26.0)	1,050 (10.3)	242 (2.4)
10-18 y [b]	4,763 (100)	4,373 (91.8)	131 (2.8)	238 (5.0)	7 (0.15)	12 (0.3)	2 (0.05)
Male [c]	7,120 (100)	2,610 (36.7)	2,053 (28.8)	516 (7.2)	1,296 (18.2)	502 (7.1)	143 (2.0)
Female [c]	7,862 (100)	3,052 (38.8)	2,241 (28.5)	540 (6.9)	1,368 (17.4)	560 (7.1)	101 (1.3)
Rural [d]	10,731 (100)	4,501 (41.9)	2,784 (25.9)	786 (7.3)	1,752 (16.3)	731 (6.8)	177 (1.6)
Urban [d]	3,897 (100)	1,093 (28.0)	1,381 (35.4)	235 (6.0)	836 (21.5)	293 (7.5)	59 (1.5)
Time between interviews < 2.1 y	4,092 (100)	2,432 (59.4)	760 (18.6)	167 (4.1)	552 (13.5)	136 (3.3)	45 (1.1)
Time between interviews ≥ 5.0 y	3,789 (100)	600 (15.8)	1,685 (44.5)	373 (9.8)	645 (17.0)	383 (10.1)	103 (2.7)
Number of settlements of residence	14,982 (100)	5,662 (37.8)	4,294 (28.7)	1,056 (7.0)	2,664 (17.8)	1,062 (7.1)	244 (1.6)
< 10 y	10,219 (100)	1,289 (12.6)	4,163 (40.7)	818 (8.0)	2,657 (26.0)	1,050 (10.3)	242 (2.4)
10-18 y	4,763 (100)	4,373 (91.8)	131 (2.8)	238 (5.0)	7 (0.15)	12 (0.3)	2 (0.05)
Male	7,120 (100)	2,610 (36.7)	2,053 (28.8)	516 (7.2)	1,296 (18.2)	502 (7.1)	143 (2.0)
Female	7,862 (100)	3,052 (38.8)	2,241 (28.5)	540 (6.9)	1,368 (17.4)	560 (7.1)	101 (1.3)
Rural	10,731 (100)	4,501 (41.9)	2,784 (25.9)	786 (7.3)	1,752 (16.3)	731 (6.8)	177 (1.6)
Urban	3,897 (100)	1,093 (28.0)	1,381 (35.4)	235 (6.0)	836 (21.5)	293 (7.5)	59 (1.5)
Time between interviews < 2.1 y	4,092 (100)	2,432 (59.4)	760 (18.6)	167 (4.1)	552 (13.5)	136 (3.3)	45 (1.1)
Time between interviews ≥ 5.0 y	3,789 (100)	600 (15.8)	1,685 (44.5)	373 (9.8)	645 (17.0)	383 (10.1)	103 (2.7)
Date of first relocation	8,958 (100)	3,595 (40.1)	2,091 (23.3)	534 (6.0)	1,899 (21.2)	694 (7.7)	145 (1.6)
< 10 y	5,683 (100)	607 (10.7)	2,003 (35.2)	353 (6.2)	1,892 (33.3)	684 (12.0)	144 (2.5)
10-18 y	3,275 (100)	2,988 (91.2)	88 (2.7)	181 (5.5)	7 (0.21)	10 (0.31)	1 (0.03)
Male	4,133 (100)	1,571 (38.0)	970 (23.5)	247 (6.0)	934 (22.6)	332 (8.0)	79 (1.9)

Characteristics	Total	Pairs of respondents					
		Subject-subject	Subject-mother	Subject-other relative	Mother-to mother	Mother-other relative	Other relative-other relative
Female	4,825 (100)	2,024 (41.9)	1,121 (23.2)	287 (5.9)	965 (20.0)	362 (7.5)	66 (1.4)
Rural	6,468 (100)	2,955 (45.7)	1,258 (19.4)	398 (6.2)	1,282 (19.8)	467 (7.2)	108 (1.7)
Urban	2,266 (100)	589 (26.0)	772 (34.1)	122 (5.4)	555 (24.5)	198 (8.7)	30 (1.3)
Time between interviews < 2.1 y	2,355 (100)	1,453 (61.7)	333 (14.1)	83 (3.5)	371 (15.8)	84 (3.6)	31 (1.3)
Time between interviews ≥ 5.0 y	2,213 (100)	426 (19.2)	837 (37.8)	179 (8.1)	460 (20.8)	253 (11.4)	58 (2.6)
Name of settlement of first relocation	9,361 (100)	3,719 (39.7)	2,292 (24.5)	574 (6.1)	1,916 (20.5)	709 (7.6)	151 (1.6)
< 10 y	6,020 (100)	671 (11.1)	2,201 (36.6)	390 (6.5)	1,909 (31.7)	699 (11.6)	150 (2.5)
10-18 y	3,341 (100)	3048 (91.2)	91 (2.7)	184 (5.5)	7 (0.21)	10 (0.31)	1 (0.03)
Male	4,323 (100)	1632 (37.8)	1057 (24.5)	268 (6.2)	943 (21.8)	339 (7.8)	84 (1.9)
Female	5,038 (100)	2087 (41.4)	1235 (24.5)	306 (6.1)	973 (19.3)	370 (7.3)	67 (1.3)
Rural	6,790 (100)	3,062 (45.1)	1,416 (20.9)	429 (6.3)	1,290 (19.0)	479 (7.1)	114 (1.7)
Urban	2,334 (100)	605 (25.9)	808 (34.6)	128 (5.5)	562 (24.1)	201 (8.6)	30 (1.3)
Time between interviews < 2.1 y	2,447 (100)	1,502 (61.4)	367 (15.0)	86 (3.5)	371 (15.2)	90 (3.7)	31 (1.3)
Time between interviews ≥ 5.0 y	2,331 (100)	434 (18.6)	923 (39.6)	196 (8.4)	464 (19.9)	254 (10.9)	60 (2.6)
Residential history for evacuees							
Name of settlement ATA	944 (100)	393 (41.6)	198 (21.0)	115 (12.2)	117 (12.4)	100 (10.6)	21 (2.2)
Number of settlements	944 (100)	393 (41.6)	198 (21.0)	115 (12.2)	117 (12.4)	100 (10.6)	21 (2.2)
Date of evacuation	853 (100)	367 (43.0)	165 (19.3)	100 (11.7)	112 (13.1)	90 (10.6)	19 (2.2)
Name of settlement after evacuation	853 (100)	367 (43.0)	165 (19.3)	100 (11.7)	112 (13.1)	90 (10.6)	19 (2.2)
Cow milk consumption							
Source of milk	14,982 (100)	5,662 (37.8)	4,294 (28.7)	1,056 (7.0)	2,664 (17.8)	1,062 (7.1)	244 (1.6)
< 10 y	10,219 (100)	1,289 (12.6)	4,163 (40.7)	818 (8.0)	2,657 (26.0)	1,050 (10.3)	242 (2.4)
10-18 y	4,763 (100)	4,373 (91.8)	131 (2.8)	238 (5.0)	7 (0.15)	12 (0.25)	2 (0.04)
Male	7,120 (100)	2,610 (36.7)	2,053 (28.8)	516 (7.2)	1,296 (18.2)	502 (7.1)	143 (2.0)
Female	7,862 (100)	3,052 (38.8)	2,241 (28.5)	540 (6.9)	1,368 (17.4)	560 (7.1)	101 (1.3)
Rural	10,731 (100)	4,501 (41.9)	2,784 (25.9)	786 (7.3)	1,752 (16.3)	731 (6.8)	177 (1.6)

Characteristics	Total	Pairs of respondents					
		Subject-subject	Subject-mother	Subject-other relative	Mother-to mother	Mother-other relative	Other relative-other relative
Urban	3,897 (100)	1,093 (28.0)	1,381 (35.4)	235 (6.0)	836 (21.5)	293 (7.5)	59 (1.5)
Time between interviews < 2.1 y	4,092 (100)	2,432 (59.4)	760 (18.6)	167 (4.1)	552 (13.5)	136 (3.3)	45 (1.1)
Time between interviews ≥ 5.0 y	3,789 (100)	600 (15.8)	1,685 (44.5)	373 (9.8)	645 (17.0)	383 (10.1)	103 (2.7)
Consumption rate ATA of privately owned cow milk	14,627 (100)	5,541 (37.9)	4,189 (28.6)	1,006 (6.9)	2,637 (18.0)	1,023 (7.0)	231 (1.6)
< 10 y	9,914 (100)	1,211 (12.2)	4,059 (40.9)	774 (7.8)	2,630 (26.5)	1,011 (10.2)	229 (2.3)
10-18 y	4,713 (100)	4,330 (91.9)	130 (2.8)	232 (4.9)	7 (0.15)	12 (0.25)	2 (0.04)
Male	6,955 (100)	2,557 (36.8)	2,004 (28.8)	489 (7.0)	1,287 (18.5)	483 (6.9)	135(1.9)
Female	7,672 (100)	2,984 (38.9)	2,185 (28.5)	517 (6.7)	1,350 (17.6)	540 (7.0)	96 (1.3)
Rural	10,420 (100)	4,389 (42.1)	2,689 (25.8)	744 (7.1)	1,735 (16.7)	697 (6.7)	166 (1.6)
Urban	3,862 (100)	1,086 (28.1)	1,373 (35.6)	228 (5.9)	829 (21.5)	289 (7.5)	57 (1.5)
Time between interviews < 2.1 y	4,003 (100)	2,382 (59.5)	742 (18.5)	157 (3.9)	549 (13.7)	128 (3.2)	45 (1.1)
Time between interviews ≥ 5.0 y	3,700 (100)	595 (16.1)	1,636 (44.2)	359 (9.7)	638 (17.2)	374 (10.1)	98 (2.7)
Consumption rate of privately owned cow milk[e]	14,496 (100)	5,506 (38.0)	4,140 (28.6)	993 (6.9)	2,611 (18.0)	1016 (7.0)	230 (1.6)
< 10 y	9,805 (100)	1,197 (12.2)	4,010 (40.9)	762 (7.8)	2,604 (26.6)	1,004 (10.2)	228 (2.3)
10-18 y	4,691 (100)	4,309 (91.9)	130 (2.8)	231 (4.9)	7 (0.15)	12 (0.25)	2 (0.04)
Male	6,900 (100)	2,536 (36.8)	1,984 (28.8)	484 (7.0)	1,279 (18.5)	482 (7.0)	135 (2.0)
Female	7,596 (100)	2,970 (39.1)	2,156 (28.4)	509 (6.7)	1,332 (17.5)	534 (7.0)	95 (1.3)
Rural	10,317 (100)	4,357 (42.2)	2,649 (25.7)	737 (7.1)	1,715 (16.6)	693 (6.7)	166 (1.6)
Urban	3,836 (100)	1,083 (28.2)	1,365 (35.6)	222 (5.8)	824 (21.5)	286 (7.5)	56 (1.5)
Time between interviews < 2.1 y	5,310 (100)	3,089 (58.2)	1,026 (19.3)	211 (4.0)	746 (14.0)	188 (3.5)	50 (0.9)
Time between interviews ≥ 5.0 y	4,432 (100)	766 (17.3)	1,922 (43.4)	437 (9.9)	772 (17.4)	426 (9.6)	109 (2.5)
Consumption rate ATA of milk from a commercial trade network	14,804 (100)	5,597 (37.8)	4,231 (28.6)	1,034 (7.0)	2,655 (17.9)	1,052 (7.1)	235 (1.6)
< 10 y	10,058 (100)	1,240 (12.3)	4,100 (40.8)	797 (7.9)	2,648 (26.3)	1,040 (10.3)	233 (2.3)
10-18 y	4,746 (100)	4,357 (91.8)	131 (2.8)	237 (5.0)	7 (0.15)	12 (0.25)	2 (0.04)
Male	7,021 (100)	2,575 (36.7)	2,015 (28.7)	505 (7.2)	1,291 (18.4)	497 (7.1)	138 (2.0)

Characteristics	Total	Pairs of respondents					
		Subject-subject	Subject-mother	Subject-other relative	Mother-to mother	Mother-other relative	Other relative-other relative
Female	7,783 (100)	3,022 (38.8)	2,216 (28.5)	529 (6.8)	1,364 (17.5)	555 (7.1)	97 (1.2)
Rural	10,639 (100)	4,466 (42.0)	2,750 (25.8)	778 (7.3)	1,748 (16.4)	726 (6.8)	171 (1.6)
Urban	3,816 (100)	1,065 (27.9)	1,355 (35.5)	221 (5.8)	831 (21.8)	288 (7.5)	56 (1.5)
Time between interviews < 2.1 y	4,041 (100)	2,400 (59.4)	752 (18.6)	161 (4.0)	552 (13.7)	134 (3.3)	42 (1.0)
Time between interviews ≥ 5.0 y	3,740 (100)	598 (16.0)	1,656 (44.3)	366 (9.8)	638 (17.1)	381 (10.2)	101 (2.7)
Consumption rate of milk from a commercial trade network[e]	14,615 (100)	5,521 (37.8)	4,180 (28.6)	1,022 (7.0)	2,630 (18.0)	1,030 (7.0)	232 (1.6)
< 10 y	9,936 (100)	1,226 (12.3)	4,050 (40.8)	789 (7.9)	2,623 (26.4)	1,018 (10.2)	230 (2.3)
10-18 y	4,679 (100)	4,295 (91.8)	130 (2.8)	233 (5.0)	7 (0.15)	12 (0.25)	2 (0.04)
Male	6,927 (100)	2,537 (36.6)	1,990 (28.7)	498 (7.2)	1,279 (18.5)	488 (7.0)	135 (1.9)
Female	7,688 (100)	2,984 (38.8)	2,190 (28.5)	524 (6.8)	1,351 (17.6)	542 (7.0)	97 (1.3)
Rural	10,336 (100)	4,313 (41.7)	2,693 (26.1)	756 (7.3)	1,703 (16.5)	703 (6.8)	168 (1.6)
Urban	3,785 (100)	1,060 (28.0)	1,354 (35.8)	216 (5.7)	816 (21.6)	286 (7.6)	53 (1.4)
Time between interviews < 2.1 y	3,488 (100)	2,136 (61.2)	590 (16.9)	142 (4.1)	475 (13.6)	114 (3.3)	31 (0.9)
Time between interviews ≥ 5.0 y	2,527 (100)	446 (17.6)	1,055 (41.7)	268 (10.6)	458 (18.1)	240 (9.5)	60 (2.4)
Milk products consumption							
Consumption rate of milk products	10,267 (100)	4,223 (41.1)	2,680 (26.1)	674 (6.6)	1,837 (17.9)	700 (6.8)	153 (1.5)
Leafy vegetables consumption							
Date of beginning of consumption	5,523 (100)	2,812 (50.9)	1,218 (22.1)	332 (6.0)	834 (15.1)	272 (4.9)	55 (1.0)
Date of ending of consumption	664 (100)	299 (45.0)	131 (19.7)	45 (6.8)	129 (19.4)	49 (7.4)	11 (1.7)
Consumption rate	10,013 (100)	3,459 (34.5)	3,147 (31.4)	648 (6.5)	1,900 (19.0)	697 (7.0)	162 (1.6)
Stable iodine administration							
Yes/No	11,274 (100)	4,502 (39.9)	2,742 (24.3)	666 (5.9)	2,401 (21.3)	793 (7.1)	170 (1.5)
Date of beginning	2,835 (100)	1,321 (46.6)	547 (19.3)	139 (4.9)	614 (21.7)	185 (6.5)	29 (1.0)
Duration	2,605 (100)	1,226 (47.1)	498 (19.1)	127 (4.9)	570 (21.9)	158 (6.1)	26 (1.0)
Thyroid dose from ^{131}I intakes							

Characteristics	Total	Pairs of respondents					
		Subject-subject	Subject-mother	Subject-other relative	Mother-to mother	Mother-other relative	Other relative-other relative
Ecological or instrumental thyroid dose	14,982 (100)	5,662 (37.8)	4,294 (28.7)	1,056 (7.0)	2,664 (17.8)	1,062 (7.1)	244 (1.6)

[a] ATA = at the time of the accident.

[b] Age of the study subject at the time of the accident.

[c] Gender of the study subject.

[d] Type of residence of respondent at the time of the accident. Some respondents reported rural type of residence during one interview and urban – during another interview. They are not shown in the table.

[e] Consumption rate averaged over the period from 26 April through 10 May 1986.

Table 4

Consistency of answers between two interviews and thyroid doses due to ^{131}I intakes.

Characteristics	Total		Pairs of respondents											
			Subject-subject		Subject-mother		Subject-other relative		Mother-to mother		Mother-other relative		Other relative-other relative	
	Agreed (%)	$\kappa (r_s)$[a]	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$
Residential history														
Name of settlement ATA [b]	88	-	91	-	85	-	86	-	89	-	87	-	84	-
< 10 y [c]	87	-	88	-	85	-	84	-	89	-	87	-	84	-
10-18 y [c]	92	-	92	-	79	-	90	-	100	-	92	-	100	-
Male [d]	88	-	91	-	85	-	86	-	88	-	88	-	84	-
Female [d]	88	-	91	-	85	-	85	-	89	-	87	-	85	-
Rural [e]	91	-	93	-	88	-	89	-	91	-	89	-	89	-
Urban [e]	82	-	83	-	81	-	75	-	85	-	85	-	85	-
Time between interviews < 2.1 y	90	-	92	-	85	-	86	-	90	-	88	-	81	-
Time between interviews ≥ 5.0 y	87	-	90	-	86	-	86	-	88	-	86	-	79	-
Number of settlements of residence	48	*0.55*	51	*0.64*	42	*0.40*	44	*0.47*	55	*0.65*	46	*0.50*	50	*0.59*
< 10 y	47	*0.50*	52	*0.58*	42	*0.39*	42	*0.41*	55	*0.65*	46	*0.50*	50	0.59
10-18 y	51	*0.64*	51	*0.65*	42	*0.53*	49	*0.56*	54	*0.86*	42	*0.36*	50	NA [f]
Male	48	*0.54*	52	*0.63*	41	*0.36*	41	*0.43*	55	*0.65*	44	*0.51*	46	0.55
Female	49	*0.56*	51	*0.65*	43	*0.43*	46	*0.50*	55	*0.65*	49	*0.49*	55	0.66
Rural	49	*0.56*	53	*0.67*	41	*0.37*	45	*0.49*	54	*0.66*	46	*0.52*	50	*0.58*
Urban	48	*0.52*	46	*0.55*	45	*0.48*	43	*0.40*	57	*0.60*	47	*0.46*	54	*0.61*
Time between interviews < 2.1 y	51	*0.60*	54	*0.67*	40	*0.37*	48	*0.57*	59	*0.70*	42	*0.46*	47	*0.45*
Time between interviews ≥ 5.0 y	44	*0.46*	49	*0.58*	41	*0.38*	39	*0.34*	52	*0.60*	43	*0.48*	52	*0.64*

Characteristics	Total		Pairs of respondents											
			Subject-subject		Subject-mother		Subject-other relative		Mother-to mother		Mother-other relative		Other relative-other relative	
	Agreed (%)	$\kappa (r_s)^a$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$
Date of first relocation [g]	42	0.329	44	0.326	37	0.283	35	0.268	50	0.411	39	0.295	36	0.327
< 10 y	40	0.299	36	0.282	36	0.281	30	0.226	50	0.411	40	0.330	35	0.325
10-18 y	46	0.325	46	0.333	41	0.349	46	0.342	43	0.500	10	-0.268	100	NA
Male	43	0.323	44	0.295	38	0.306	34	0.239	51	0.435	39	0.273	33	0.263
Female	42	0.333	45	0.349	35	0.264	36	0.290	49	0.388	40	0.307	39	0.401
Rural	43	0.279	45	0.301	36	0.186	37	0.240	50	0.358	41	0.242	37	0.285
Urban	39	0.318	37	0.269	37	0.272	30	0.167	48	0.448	38	0.329	38	0.249
Time between interviews < 2.1 y	44	0.338	44	0.335	37	0.267	40	0.303	51	0.456	31	0.225	42	0.278
Time between interviews ≥ 5.0 y	40	0.246	44	0.224	38	0.228	30	0.182	48	0.331	41	0.253	37	0.232
Name of settlement of first relocation	49	-	47	-	46	-	41	-	61	-	47	-	47	-
< 10 y	51	-	47	-	46	-	40	-	61	-	47	-	47	-
10-18 y	47	-	47	-	46	-	44	-	43	-	50	-	100	-
Male	48	-	44	-	48	-	40	-	59	-	47	-	48	-
Female	50	-	49	-	45	-	42	-	63	-	48	-	46	-
Rural	46	-	45	-	37	-	38	-	55	-	39	-	46	-
Urban	57	-	57	-	65	-	52	-	73	-	67	-	57	-
Time between interviews < 2.1 y	51	-	47	-	51	-	52	-	68	-	43	-	45	-
Time between interviews ≥ 5.0 y	43	-	41	-	41	-	29	-	55	-	45	-	37	-
Residential history for evacuees														
Name of settlement ATA	85	-	89	-	78	-	85	-	85	-	90	-	76	-
Number of settlements	36	0.336	39	0.371	29	0.198	27	0.220	52	0.643	30	0.389	33	-0.182
Date of evacuation [e]	49	0.292	45	0.236	45	0.195	48	0.222	66	0.472	51	NA	53	NA
Name of settlement after evacuation	46	-	49	-	41	-	41	-	59	-	40	-	37	-

Characteristics	Total		Pairs of respondents											
			Subject-subject		Subject-mother		Subject-other relative		Mother-to mother		Mother-other relative		Other relative-other relative	
	Agreed (%)	$\kappa\,(r_s)$[a]	Agreed (%)	$\kappa\,(r_s)$	Agreed (%)	$\kappa\,(r_s)$	Agreed (%)	$\kappa\,(r_s)$	Agreed (%)	$\kappa\,(r_s)$	Agreed (%)	$\kappa\,(r_s)$	Agreed (%)	$\kappa\,(r_s)$
Cow milk consumption														
Source of milk	56	0.381	62	0.447	45	0.271	53	0.330	60	0.449	53	0.352	53	0.337
< 10 y	51	0.337	54	0.362	45	0.267	48	0.276	60	0.450	52	0.346	52	0.341
10-18 y	65	0.476	65	0.472	57	0.402	71	0.527	86	0.811	92	0.875	50	NA
Male	55	0.370	60	0.397	45	0.274	51	0.299	62	0.481	55	0.370	55	0.353
Female	56	0.392	65	0.488	45	0.269	56	0.359	58	0.422	51	0.338	50	0.319
Rural	55	0.323	63	0.389	42	0.194	56	0.283	59	0.405	52	0.286	52	0.284
Urban	57	0.371	61	0.365	53	0.318	49	0.278	62	0.470	53	0.339	52	0.348
Time between interviews < 2.1 y	60	0.427	64	0.456	49	0.324	53	0.318	61	0.468	52	0.347	56	0.370
Time between interviews ≥ 5.0 y	50	0.312	59	0.401	42	0.235	50	0.294	60	0.431	54	0.352	48	0.256
Consumption rate ATA of privately owned cow milk	54	0.334	56	0.395	49	0.218	49	0.271	59	0.393	53	0.304	55	0.313
< 10 y	52	0.288	52	0.316	49	0.214	46	0.230	59	0.393	53	0.304	55	0.318
10-18 y	56	0.409	56	0.411	61	0.374	52	0.371	57	0.323	58	0.259	0	NA
Male	51	0.314	52	0.351	48	0.204	46	0.240	59	0.392	52	0.299	56	0.347
Female	55	0.349	60	0.425	50	0.231	50	0.295	59	0.394	55	0.306	53	0.250
Rural	47	0.277	51	0.344	40	0.157	43	0.222	52	0.322	45	0.223	45	0.228
Urban	73	0.310	77	0.267	70	0.251	70	0.142	74	0.443	71	0.303	84	0.462
Time between interviews < 2.1 y	54	0.353	55	0.388	49	0.194	47	0.253	62	0.420	49	0.239	64	0.420
Time between interviews ≥ 5.0 y	49	0.278	53	0.373	47	0.212	45	0.234	53	0.329	53	0.309	45	0.237
Consumption rate of privately owned cow milk [h]	53	0.327	56	0.382	47	0.215	47	0.248	58	0.410	51	0.308	52	0.303
< 10 y	51	0.287	52	0.289	47	0.211	46	0.228	59	0.408	52	0.305	52	0.300
10-18 y	56	0.399	57	0.403	57	0.350	48	0.291	86	0.774	75	0.561	50	NA

Characteristics	Total		Pairs of respondents											
			Subject-subject		Subject-mother		Subject-other relative		Mother-to mother		Mother-other relative		Other relative-other relative	
	Agreed (%)	$\kappa (r_s)$[a]	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$
Male	51	0.303	50	0.327	45	0.198	43	0.210	61	0.426	52	0.309	51	0.298
Female	55	0.347	60	0.427	48	0.230	49	0.280	58	0.393	52	0.304	54	0.302
Rural	48	0.279	52	0.341	40	0.163	42	0.200	55	0.350	46	0.229	46	NA
Urban	66	0.373	70	0.365	61	0.306	64	0.331	69	0.474	66	0.395	68	0.332
Time between interviews < 2.1 y	54	0.345	56	0.385	47	0.190	45	0.222	62	0.430	45	0.174	58	0.365
Time between interviews ≥ 5.0 y	49	0.279	55	0.389	46	0.209	46	0.254	53	0.328	52	0.309	44	0.225
Consumption rate ATA of milk from a commercial trade network	75	0.427	80	0.500	70	0.372	77	0.373	75	0.417	74	0.356	77	0.384
< 10 y	72	0.388	77	0.435	70	0.372	75	0.323	75	0.417	74	0.351	77	0.381
10-18 y	80	0.515	81	0.519	59	0.330	85	0.554	57	0.344	75	0.571	100	NA
Male	75	0.410	79	0.472	68	0.365	76	0.326	74	0.415	75	0.354	77	0.306
Female	76	0.442	80	0.522	71	0.378	79	0.419	75	0.419	73	0.355	78	0.469
Rural	83	0.381	87	0.465	77	0.294	86	0.313	81	0.375	84	0.324	87	0.422
Urban	53	0.283	52	0.246	53	0.281	48	0.188	60	0.351	48	0.194	50	0.198
Time between interviews < 2.1 y	78	0.474	82	0.536	69	0.385	79	0.356	75	0.424	75	0.399	77	0.313
Time between interviews ≥ 5.0 y	74	0.386	78	0.460	71	0.362	77	0.348	76	0.438	73	0.308	78	0.336
Consumption rate of milk from a commercial trade network[h]	61	0.308	66	0.368	54	0.240	62	0.262	61	0.331	57	0.267	60	0.227
< 10 y	59	0.282	68	0.366	55	0.241	61	0.217	61	0.331	59	0.261	62	0.231
10-18 y	66	0.367	67	0.368	47	0.181	70	0.419	57	0.417	75	0.532	50	NA
Male	59	0.280	62	0.300	53	0.232	61	0.263	61	0.330	58	0.258	63	0.215
Female	63	0.333	70	0.425	56	0.246	63	0.259	62	0.332	59	0.237	61	0.239
Rural	65	0.257	70	0.310	57	0.154	67	0.037	64	0.314	62	0.238	64	0.217
Urban	50	0.214	52	0.197	49	0.201	45	0.212	55	0.282	45	0.131	47	0.206

Characteristics	Total		Pairs of respondents											
			Subject-subject		Subject-mother		Subject-other relative		Mother-to mother		Mother-other relative		Other relative-other relative	
	Agreed (%)	$\kappa (r_s)$[a]	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$	Agreed (%)	$\kappa (r_s)$
Time between interviews < 2.1 y	66	0.370	70	0.405	57	0.221	66	0.315	64	0.380	60	0.310	66	0.219
Time between interviews ≥ 5.0 y	57	0.248	59	0.268	54	0.315	60	0.218	60	0.323	56	0.249	54	0.136
Milk products consumption														
Consumption rate of milk products	34	0.099	38	0.131	26	0.043	30	0.090	41	0.149	27	0.016	25	0.059
Leafy vegetables consumption														
Date of beginning of consumption	31	0.051	34	0.052	28	0.045	33	0.083	27	0.061	22	-0.002	29	-0.019
Date of ending of consumption	31	0.066	32	0.073	34	0.099	27	0.053	28	0.013	27	0.089	18	-0.088
Consumption rate	41	0.142	30	0.104	39	0.072	38	0.079	60	0.241	51	0.109	55	0.160
Stable iodine administration														
Yes/No	75	0.487	77	0.539	71	0.389	68	0.553	79	0.433	73	0.433	75	0.420
Date of beginning	26	0.208	26	0.181	24	0.165	26	0.267	28	0.298	21	0.153	31	0.343
Duration	43	0.203	44	0.223	42	0.168	37	0.129	45	0.210	41	0.134	54	0.351
Thyroid dose from ^{131}I intakes [i]														
Ecological dose	51	0.260	51	0.254	48	0.244	50	0.220	58	0.281	51	0.233	54	0.304
Inhalation of ^{131}I	93	0.855	93	0.866	92	0.836	90	0.829	93	0.871	91	0.853	89	0.826
Intake of ^{131}I in milk	42	0.243	43	0.244	36	0.206	38	0.174	51	0.300	41	0.224	40	0.185
Intake of ^{131}I in milk products	25	0.172	31	0.198	18	0.131	23	0.130	29	0.203	22	0.108	19	NA
Intake of ^{131}I in leafy vegetables	10	0.124	15	0.109	6	0.078	8	0.105	8	0.173	6	0.082	9	0.215
Instrumental dose	96	0.809	97	0.826	95	0.788	96	0.808	95	0.812	96	0.778	97	0.813

[a] κ-coefficient or Spearman's rank-correlation coefficient, which is shown in Italic, provide measure of agreement.

[b] ATA = at the time of the accident.

[c] Age of the study subject at the time of the accident.

[d] Gender of the study subject.

[e] Type of place of residence at the time of the accident.

[f] κ-coefficient cannot be calculated because of different number of categories of responses.

[g] Exact date, date ± 1 day, or period.

[h] Consumption rate averaged over the period from 26 April through 10 May 1986.

[i] Two values of doses were considered to agree if they differ less than 50%.

Table 5

Distribution of dates of first relocation and evacuation reported during the first and secondinterviews.

Dates of relocation / evacuation in 1986	First interview				Second interview			
	Relocation		Evacuation from 30-km zone		Relocation		Evacuation from 30-km zone	
	Number of respondents	%	Number of respondents	%	Number of respondents	%	Number of respondents	%
April 26	291	2.3	42	5.8	104	0.8	17	2.3
April 27	503	4.1	68	9.3	545	4.2	65	8.7
April 28	244	2.0	47	6.4	490	3.7	61	8.1
April 29	384	3.1	53	7.3	258	2.0	51	6.8
April 30	1,084	8.7	120	16.5	516	3.9	80	10.7
May 1	231	1.9	33	4.5	527	4.0	60	8.0
May 2	282	2.3	25	3.4	223	1.7	20	2.7
May 3	438	3.5	112	15.4	374	2.9	68	9.1
May 4	708	5.7	86	11.8	874	6.7	200	26.6
May 5	325	2.6	15	2.1	1,308	10.0	45	6.0
May 6-7	982	7.9	28	3.8	746	5.7	14	1.9
May 8-10	810	6.5	24	3.3	600	4.6	21	2.8
May 11-15	415	3.3	9	1.2	786	6.0	19	2.5
May 16-31	1,277	10.3	7	1.0	985	7.5	9	1.2
June 1-30	491	4.0	1	0.1	1,219	9.3	1	0.1
No relocation	3,626	29.2	41	5.6	3,358	25.6	15	2.0
Don't remember	317	2.6	18	2.5	184	1.4	5	0.7
Total	12,408	100	729	100	13,097	100	751	100

Table 6

Consumption rates reported during the first and second interviews.

Parameter	First interview		Second interview		*p*-value
	Number of respondents	Consumption rate (L(kg) d^{-1})	Number of respondents	Consumption rate (L(kg) d^{-1})	
Privately owned cow milk					
Mean ± SD	7,245	0.51±0.48	8,046	0.44±0.38	<0.001
Median		0.40		0.33	
Range		0.0005 – 6.4		0.0024 – 7.0	
Milk from a commercial trade network					
Mean ± SD	4,720	0.23±0.24	5,850	0.21±0.21	0.842
Median		0.15		0.13	
Range		0.0005 – 3.4		0.0012 – 3.0	
Milk products					
Mean ± SD	7,531	0.23±0.17	8,514	0.20±0.18	<0.001
Median		0.19		0.15	
Range		0.0014 – 2.4		0.0021 – 2.8	
Leafy vegetables					
Mean ± SD	5,801	0.047±0.057	5,240	0.031±0.033	<0.001
Median		0.025		0.025	
Range		0.0003 – 0.71		0.0001 – 0.3	

Table 7

Distribution of dates of stable iodine administration reported during the first and second interviews.

Dates of stable iodine administration in 1986	First interview		Second interview	
	Number of respondents	%	Number of respondents	%
April 26	11	0.1	22	0.2
April 27	39	0.3	80	0.6
April 28	378	3.0	653	5.0
April 29	72	0.6	87	0.7
April 30	90	0.7	71	0.5
May 1	145	1.2	161	1.2
May 2	86	0.7	73	0.6
May 3	94	0.8	81	0.6
May 4	52	0.4	68	0.5
May 5	1,049	8.5	1,953	14.9
May 6-7	173	1.4	137	1.0
May 8-10	216	1.7	228	1.7
May 11-15	793	6.4	1,009	7.7
May 16-31	264	2.1	410	3.1
No stable iodine administration	6,466	52.1	6,702	51.2
Do not remember	2,480	20.0	1,362	10.4
Total	12,408	100	13,097	100

Table 8

Thyroid doses (Gy) calculated using individual behavior and consumption data reported during the two interviews.

Parameter	Thyroid doses (Gy) calculated using individual data reported during		*p*-value	r_s
	First interview	Second interview		
Ecological dose due to intake of ^{131}I in milk				
Mean ± SD	1.1±1.9	1.2±2.0	<0.001	0.46
Median	0.54	0.58		
Range	0–71	0–59		
Ecological dose due to intake of ^{131}I in milk products				
Mean ± SD	0.42±0.79	0.19±0.45	<0.001	0.26
Median	0.14	0.04		
Range	0–9	0–11		
Ecological dose due to intake of ^{131}I in leafy vegetables				
Mean ± SD	0.28±0.70	0.16±0.36	<0.001[a]	0.25
Median	0.007	0.013		
Range	0–17	0–14		
Ecological dose due to inhalation of ^{131}I				
Mean ± SD	0.097±0.27	0.097±0.28	0.105	0.88
Median	0.031	0.030		
Range	0–5.5	0–5.5		
Ecological dose (total)				
Mean ± SD	1.9±2.4	1.7±2.4	<0.001	0.66
Median	1.2	0.93		
Range	0–71	0–59		
Instrumental dose				
Mean ± SD	0.61±1.3	0.60±1.3	0.367	0.97
Median	0.25	0.24		
Range	0–31	0–33		

[a]For non-zero doses