

## Reconstruction of individual doses to the Semipalatinsk historical cohort subjects: preliminary results

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### Abstract

At present scientists from Russia, Japan, the U.S. and Kazakhstan take part in an international scientific research on reconstruction of individual doses for the population of 10 settlements: Dolon, Kanonerka, Mostik, Cheremushki, Znamenka, Kainar, Karaul, Sarzhal, Kaskabulak and Kundyzhdy, included in the so-called Semipalatinsk historical cohort. All the calculations are conducted in accordance with a U.S./Russian joint methodology. Individual input data, such as date of birth, ethnicity and so on, are obtained from the register of the residents who lived on the territory of local radioactive fallout due to the nuclear tests on the Semipalatinsk Nuclear Test Site. This register was created by the scientists in both Kazakhstan and Japan. The register contains data on 11,370 persons, lived in the above mentioned settlements at the time of the most significant nuclear tests. In addition, the register contains data on the persons who were born or arrived to the above mentioned settlements after the most significant tests. Individual whole body doses from external irradiation and internal doses to thyroid due to the ingestion of <sup>131</sup>I and <sup>133</sup>I for more than 11,000 persons included in the Semipalatinsk historical cohort have been estimated. According to the preliminary results of dose assessment, the maximum whole body dose (260 mGy) was received by adult non Kazakh residents of Dolon. In turn, the maximum thyroid dose (310 mGy) was received by 3-7 years old Kazakh residents of Kainar. Evacuation of the residents of villages Sarzhal and Karaul has been taken into account. Due to evacuation either whole body or thyroid dose to the residents of Sarzhal and Karaul were substantially less than they could have been without evacuation. Dose reduction factor in case of whole body dose was estimated to be equal to 4.6 (Sarzhal) and 2.8 (Karaul), while in case of thyroid dose – 10.6 (Sarzhal) and 4.6 (Karaul).

### INTRODUCTION

At present scientists from Russia, Japan, the U.S. and Kazakhstan take part in an international scientific research on reconstruction of individual doses to the subjects of the Semipalatinsk historical cohort. This cohort consists of about 20 thousand residents of 10 settlements located in the vicinity of the Semipalatinsk Nuclear Test Site (SNTS): Cheremushki, Dolon, Kanonerka, Mostik, Kainar, Sarzhal, Karaul, Kundyzhdy, Kaskabulak and Znamenka. The purpose of the research is to reconstruct individual whole body doses from external irradiation and individual doses to thyroid due to internal irradiation to <sup>131</sup>I and <sup>133</sup>I.

The most significant nuclear test, in terms of radioactive contamination and exposure to the residents, is chosen for every settlement listed above. Test #1 conducted on August 29, 1949 (22 kt) is chosen for Dolon, Mostik, Kanonerka and Cheremushki, test #2 conducted on September 24, 1951 (38 kt) – for Kainar, test #4 conducted on August 12, 1953 (400 kt) – for Sarzhal, Karaul and Kundyzhdy, test #18 conducted on October 30, 1954 (10 kt) – for Kaskabulak, test #28 conducted on August 24, 1956 (27 kt) – for Znamenka. The necessary data on these nuclear tests such as date, height above ground, maximum height of radioactive cloud, average wind speed, trace of the radioactive cloud are available in the published literature [1]. All the calculations, including assessment of dose to air, are conducted in accordance with a U.S./Russian joint methodology [2].

### **ANALYSIS OF AVAILABLE DATA**

The term “individualization” implies using individual data such as place of residence, age at the time of irradiation, gender, behavior pattern, dietary, etc. In order to obtain such information data available in the register of the residents who lived on the territory of local radioactive fallout due to the nuclear tests on the SNTS were analyzed. This register was created by the scientists in both Japan (Radiation Effects Research Foundation, Hiroshima) and Kazakhstan (Scientific Research Institute for Radiation Medicine and Ecology, Semipalatinsk). It’s based on individual interviewing of the residents, special questionnaires and official documents such as passport, birth certificate, etc.

The register contains data on a great number of inhabitants of the Semipalatinsk region since the time of the nuclear tests till nowadays. The content of the register is as follows: ID number, full name, gender, ethnicity, date of birth, date and cause of death (for deceased), diseases (if any), close relatives, settlement and period of residence, occupation, work type (indoors, fieldwork, cattle management, etc.), harmful working conditions: petrochemicals, toxic substances, radioactivity, heavy metals, dust pollution, etc. (if any), date of interview. Regarding the Semipalatinsk historical cohort, data on 11,370 persons, lived in the above mentioned settlements at the time of the most significant nuclear tests, are available in the register. The distribution of them throughout the settlements under consideration is shown in Table 1. Among them 47 % are male and 53 % are female. In addition, the register contains data on the persons who were born or arrived to the settlements under consideration after the most significant tests. Unfortunately, information on the considered group of residents isn’t complete. For example, occupation is specified only for about 5 % of these 11,370 persons. So, the following types of data are chosen for calculations: place of residence, date of birth, date of arrival to the settlement, ethnicity. Statistical analysis was applied to these data.

The persons under consideration are divided into six groups according to their age at the start of irradiation. Age groups are chosen according to the ICRP recommendations. Therefore, age distribution of the residents of the settlements listed above at the time of the most significant nuclear tests is as follows: 0-12 m – 2.7 %; 1-2 y – 5.7 %; 3-7 y – 9.0 %; 8-12 y – 13.9 %; 13-17 y – 14.0 %; adult (18 years and older) – 54.9 %. In turn, distribution of the considered residents by ethnicity is as follows: 47 % - Kazakh; 38 % - Russian; 11 % - other ethnicities (more than 10 different ethnicities including German, Tatar, Chechen, Ukrainian, Pole and others); 4 % - ethnicity is not specified. So, the residents were predominantly Kazakh or Russian. Moreover, at the time of the nuclear tests on the SNTS five settlements

were inhabited mostly by Russians: Cheremushki (49%), Dolon (61%), Kanonerka (82%), Mostik (53%), and Znamenka (76%), and another five settlements – by Kazakhs: Kainar (95%), Sarzhal (74%), Karaul (73%), Kundyzhdy (97%) and Kaskabulak (94%).

Table 1. The distribution of the 11370 persons throughout the settlements under consideration.

Settlement	Number of persons	Settlement	Number of persons
Cheremushki	705	Sarzhal	988
Dolon	1687	Karaul	1995
Kanonerka	2929	Kundyzhdy	656
Mostik	830	Kaskabulak	536
Kainar	998	Znamenka	46

### INDIVIDUAL WHOLE BODY DOSE FROM EXTERNAL IRRADIATION

Two factors sufficiently affecting individual whole body dose are considered within this work: age and ethnicity. It is supposed that gender did not have a significant influence on whole body dose. The values of age-dependent conversion factors from absorbed dose to air to absorbed dose in body (Gy per Gy) were taken from [3]. Behavior pattern and number of hours spent outdoors per day do essentially depend either on age or on ethnicity. In case of the nuclear tests #1, #4 and #28 conducted at the end of August summer vacation of schoolchildren has been taken into account [4].

Building material of a house plays an important role in protection against external irradiation. At the time of nuclear tests in rural areas of Kazakhstan Russians traditionally used to live in wooden houses and Kazakhs – in adobe houses. It should be noticed that the Semipalatinsk region has specific landscape. The Irtysh river divides it into two parts crossing Semipalatinsk. There is a lot of forest on the right bank of the river, but practically no forest, only steppe – on the left bank. Within this work it is supposed that residents of the villages located on the left bank: Kainar, Sarzhal, Karaul, Kundyzhdy, Kaskabulak and Znamenka, used to live in adobe houses regardless of ethnicity because of lack of wood; in turn, in the villages located on the right bank of Irtysh: Cheremushki, Dolon, Kanonerka and Mostik, Kazakhs used to live in traditional adobe houses and residents of other ethnicities – in wooden houses. It is important to stress, that for the activity deposited on the ground a shielding factor of a wooden house is equal to 3, while shielding factor of an adobe house is equal to 13 [1].

As noted above, at the time of the nuclear tests there were a lot of people of a wide range of ethnicities. Unfortunately, only information on the behavior pattern of Kazakhs or Russians is available in the published literature. So, it seems reasonable to assume that behavior pattern of the inhabitants of ethnicity other than Russian or Kazakh were identical to the behavior pattern of Russians.

Individual whole body doses for more than 11,000 subjects of the Semipalatinsk historical cohort have been estimated. Individual whole body dose range depending on ethnicity for the residents of the settlements under consideration is shown in Table 2. According to the preliminary results of assessment the maximum whole body dose (260 mGy) was received by adult non Kazakh residents of Dolon.

Table 2. Individual whole body dose range depending on ethnicity: K – Kazakh, O – other ethnicities.

Settlement	Dose range, mGy			
	K		O	
	Min	Max	Min	Max
Cheremushki	28	140	86	160
Dolon	47	240	140	<b>260</b>
Kanonerka	24	120	73	140
Mostik	15	76	46	86
Kainar	13	66	11	66
Sarzhah	21	110	18	110
Karaul	35	130	31	130
Kundyzhdy	1.1	5.5	3.6	5.5
Kaskabulak	0.55	2.7	0.78	2.7
Znamenka	21	21	23	38

#### INDIVIDUAL THYROID DOSE DUE TO INTAKE OF RADIOIODINES

Consumption of locally produced milk products is supposed to be the main path of intake of radioiodines. Consumption of leafy vegetables is assumed to be negligible at the time of the nuclear tests. By analogy with the whole body dose, two factors sufficiently affecting individual thyroid dose are considered within this work: age and ethnicity. It is also supposed that gender did not have a significant influence on internal thyroid dose. Age-dependent thyroid dose coefficients for  $^{131}\text{I}$  and  $^{133}\text{I}$  were taken from [3].

According to the published literature dietary substantially depends on age and ethnicity. Firstly, consumption rate of milk products depends on age. Secondly, it is assumed that only Kazakhs used to consume koumiss (horse milk product), persons of other ethnicities used to consume cow's milk. Moreover, consumption rate of cow's milk substantially depends on ethnicity: Russians consumed much more cow's milk than Kazakhs did [4]. For calculations the dietary of the inhabitants of ethnicity other than Russian or Kazakh is supposed to be identical to the dietary of Russians. Individual thyroid doses due to ingestion of radioiodines for more than 11,000 subjects of the Semipalatinsk historical cohort have been estimated. Individual thyroid dose range depending on ethnicity of the residents of the settlements under consideration is shown in Table 3. According to the preliminary results of assessment the maximum thyroid dose (310 mGy) was received by 3-7 years old Kazakh residents of Kainar.

#### EFFECTIVENESS OF EVACUATION

Evacuation took place in two of the considered settlements: Sarzhah and Karaul. The residents of Sarzhah were evacuated to non-exposed areas before the nuclear test #4. They returned to Sarzhah 16 days after the event. In turn, the residents of Karaul were hurriedly evacuated during about 5 hours after the nuclear test #4, because of arrival of the radioactive cloud in the settlement. They returned to Karaul 10 days after the date of the nuclear test. It's supposed that the cattle were also evacuated from both villages.

Either whole body or thyroid doses, which could be received by the residents of Sarzhal and Karaul without evacuation, have been calculated. Dose reduction factor due to evacuation in case of whole body dose was estimated to be equal to 4.6 (Sarzhal) and 2.8 (Karaul), while in case of thyroid dose – 10.6 (Sarzhal) and 4.6 (Karaul).

Table 3. Individual thyroid dose range depending on ethnicity: K – Kazakh, O – other ethnicities.

Settlement	Dose range, mGy			
	K		O	
	Min	Max	Min	Max
Cheremushki	4.2	24	2.03	12
Dolon	14	83	6.9	42
Kanonerka	14	79	6.6	40
Mostik	2.8	16	1.4	8.1
Kainar	53	310	26	150
Sarzhal	0.11	0.70	0.055	0.32
Karaul	1.5	10	0.79	4.5
Kundyzhdy	0.23	1.4	0.11	0.68
Kaskabulak	11	63	5.2	31
Znamenka	2.5	2.5	0.21	1.3

## CONCLUSIONS

Individual whole body doses from external irradiation and internal doses to thyroid due to the ingestion of  $^{131}\text{I}$  and  $^{133}\text{I}$  for more than 11,000 persons included in the Semipalatinsk historical cohort have been estimated. According to the preliminary results of dose assessment, the maximum whole body dose (260 mGy) was received by adult non Kazakh residents of Dolon. In turn, the maximum thyroid dose (310 mGy) was received by 3-7 years old Kazakh residents of Kainar.

Due to evacuation either whole body or thyroid dose to the residents of Sarzhal and Karaul were substantially less than they could have been without evacuation. Dose reduction factor in case of whole body dose was estimated to be equal to 4.6 (Sarzhal) and 2.8 (Karaul), while in case of thyroid dose – 10.6 (Sarzhal) and 4.6 (Karaul).

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