Health Status of Radiation Exposed Residents Living Near the Semipalatinsk Nuclear Test Site Based on Health Assessment by Interview

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ABSTRACT

The purpose of the present paper is to examine the aftereffects of radiation exposure on residents of villages near the Semipalatinsk Nuclear Test Site (SNTS) in Kazakhstan. Our Hiroshima University (Japan) research team began field research in 2002 by means of health assessments conducted via interviews. We focus on persons who responded to questions concerning their medical conditions and symptoms.

In this paper, we summarize and analyze, using multiple linear logistic regression analysis, the answers obtained by questionnaire survey.

The results show: (1) 31% of the residents reported that they felt bad or were in very poor health. (2) Residents living in villages having higher radiation levels were more likely to report having poor or very poor health, minor complaints such as loss of sleep, headaches, nighttime sweating and swollen arms or legs, and the need for nursing care in performing activities of daily living. (3) Symptoms reported by over 40% of the respondents included high blood pressure, heart disease and arthralgia/ lower back pain/ arthritis.

Our results suggest that radiation exposure in the Semipalatinsk area is one of the causes of poor health in general among residents. There is also a possibility that radiation exposure has influenced the incidence of some specific medical conditions.

Key words: Health effects of radiation exposure, Semipalatinsk, Nuclear tests, Hiroshima and
Nagasaki

More than 450 nuclear explosions-including 111 atmospheric events-were carried out at the Semipalatinsk Nuclear Test Site (SNTS) between 1949 and 1989[8,23]. As a result of those nuclear explosions, many of the residents living around the SNTS were exposed to radiation. According to a speech delivered by the Kazakh Ambassador to the United Nations, 1.6 million people were exposed to radiation and 1.2 million people are still suffering from its aftereffects[2].

Our research team from Hiroshima University in Japan began interviewing the inhabitants of villages near the SNTS in 2002 to investigate their health status, their experiences of the nuclear explosions, psychological effects caused by those experiences, and the routes of exposure[12,13]. Previous studies by others undertaken to examine the effects of radiation exposure in the Semipalatinsk area have been conducted from a medical and/or physical point of view[1,4,7,8]. The present research focuses rather upon the inhabitants themselves, that is, we tried to clarify the realities of Semipalatinsk by listening to first-hand accounts from the victims. With the addition

of information about the victims' personal experiences, we expected to be able to provide a more complete picture of the radiation effects in and around Semipalatinsk. Our research is the first attempt at using this method, but we believe that the data includes important medical information demonstrating diverse psychological and social effects of radiation exposure similar to those observed in Hiroshima and Nagasaki, Japan.

The present paper focuses mainly upon medical conditions subsequent to radiation exposure among persons living near the SNTS based on their answers to our questionnaire (see Appendix 1).

MATERIALS AND METHODS

We began conducting health assessments by interview in 2002. To date we have conducted surveys on four occasions covering sixteen villages near the SNTS: Saryzhal, Dolon, Karauyl, Kainar, Burus, Bodene, Mostik, Cheremushki, Znamenka, Grachi and Krasnyi Aul, Korosteli, Zenkovka, Kamyshenka, Boroduliha and Novopokrovka (see Fig.1). Radiation levels vary widely among these villages. The study subjects comprise persons who experienced the nuclear tests on the ground between 1949 and 1962 (approximately 50 years of age or older) in each village and persons who currently reside there. Medical doctors in each village and from the Kazakh Scientific Research Institute of Radiation Medicine and Ecology listed the residents who satisfied the above requirements from lists of names drawn up by the village hospitals, according to the village street on which they lived. We selected the subjects at random in proportion with street population size. Our co-author, medical doctor Talgat Muldagaliyev, and Japanese staff conducted interviews with selected residents with the help of an interpreter who was well-acquainted with the Kazakh and the Russian languages. As we obtained appointment and informed consent prior to conducting interviews with the respondents, all subjects consented to be interviewed. The total number of replies was 887. Results of the survey are shown in Table 1. A question seeking more detailed information and another about minor health complaints were added to the questionnaire in 2003 to better understand the health status of persons with poor or very poor health. The results of these additional questions are limited to 763 respondents.

We used a multiple linear logistic regression model to analyze the presence/absence of individual medical conditions, where radiation dose, respondent's age and sex were used as explanatory variables. The logit of the probability of a positive response is specified by the following formula:

$$\log\frac{p}{1-p} = \beta_0 + \beta_1 AGE + \beta_2 SEX_{M|F} + \beta_M D_M + \beta_H D_H,$$

where $SEX_{M|F} = \begin{cases} 1, & \text{if male,} \\ 0, & \text{if female,} \end{cases}$

$D_M = \begin{cases} 1, & \text{if radiation dose level is moderate or high,} \\ 0, & \text{otherwise,} \end{cases}$

$D_H = \begin{cases} 1, & \text{if radiation dose level is high,} \\ 0, & \text{otherwise.} \end{cases}$

We used the LGReg (ver.1.2) software developed in the Department of Environmetrics and Biometics of the Research Institute for Radiation Biology and Medicine, Hiroshima University[17]. In this analysis, information on radiation dose was obtained from previous studies. The estimated radiation doses of two representative studies are shown in Table 2. On the basis of these two results and the latest results obtained by Shinkarev et al (personal communication) at the Institute of Biophysics of the Ministry of Health, Moscow, Russian Federation, we divided the sixteen villages into three areas having different radiation levels (low, moderate, and high). We compensated missing values in Table 2 with the results estimated by Shinkarev et al. We classified estimated radiation dose of each village into the ordered categories of three levels on the assumption that the relationship between radiation dose and outcomes such as severity of health status and of medical conditions may have a threshold and a saturation value. For Korosteli village the dose estimated by Rosenson, Tchaijunusova, Gusev et al was extremely high compared with other results, so we used the doses estimated by Gordeev et al and Shinkarev et al. The three groups of villages are shown in Table 2.

RESULTS

1. Health effects among the inhabitants

1) Present general health status

We asked the inhabitants about their overall health status. Table 3 summarizes their responses. 273 people (30.8%) answered that their health was poor or very poor. Only 55 people (6.2%) answered that their health was excellent or good.

The logistic regression analysis showed that the odds of having poor or very poor health were significantly higher in villages with high radiation levels (odds ratio 1.49, 95% CI: 1.04 - 2.12) than in villages with moderate or low radiation levels, and increased with age (odds ratio 1.26 for a 10-year difference in age, 95% CI: 1.05 - 1.51).

2) More detailed information

Beginning in 2003, we added a question to obtain more detailed information from people who reported having poor or very poor health; Table 4 shows the results. 42.6% of 197 respondents who reported poor or very poor health complained that they needed nursing care or assistance from other people in performing the activities of daily living.

The logistic regression analysis revealed significantly higher odds of needing nursing care in the areas with high radiation levels (odds ratio 2.26, 95% CI: 1.24 - 4.11) than in areas with moderate or low radiation levels, and an increase with age (odds ratio 2.33, 95% CI: 1.72 - 3.16).

3) Minor complaints

We also asked the residents about minor health complaints to examine their health status in more detail. As shown in Table 5, more than 70% of the respondents answered that they had headaches, vertigo and general malaise. Over 50% had loss of sleep. We performed logistic regression analysis on the seven symptoms with prevalence greater than 20%; Table 6 shows the estimated regression coefficients for the explanatory variables. Loss of sleep, headaches, general malaise, nighttime sweating and swollen arms or legs were significantly associated with living areas having high radiation levels. General malaise also had a significantly higher prevalence in areas with low radiation levels. The reasons for this result are not clear at present. Lack of appetite, loss of sleep, headaches, vertigo and general malaise were significantly related to age.

2. *Current medical conditions*

We also asked the subjects about their current medical conditions. As shown in Table 7, 68.1% reported having arthralgia/lower back pain/arthritis, 50.1% had high blood pressure and 41.3% reported having some form of heart disease.

Table 8 shows the results of logistic regression analysis for each individual condition. Conditions showing a significantly higher prevalence in the areas with high radiation levels were: skin disorders, respiratory disease and thyroiditis. On the other hand, disorders of the eye and ear/ nose, digestive system disease, anemia and blood related disease occurred more frequently in villages with moderate dose levels. High blood pressure, heart disease, eye disorders, liver disease and arthralgia/lower back pain/arthritis showed significantly increasing frequency with age. High blood pressure, digestive system disease, anemia and blood related disease, arthralgia/lower back pain/arthritis and thyroiditis showed significantly higher prevalences among females.

DISCUSSION

We observed statistically significant differences in regions with high radiation levels in terms of poor health, the need for nursing care or the assistance of other people in activities of daily living, some minor health complaints (Table 6) and current medical conditions (Table 8). In other words, if persons live in villages with higher radiation levels, it is more likely that they have poor health
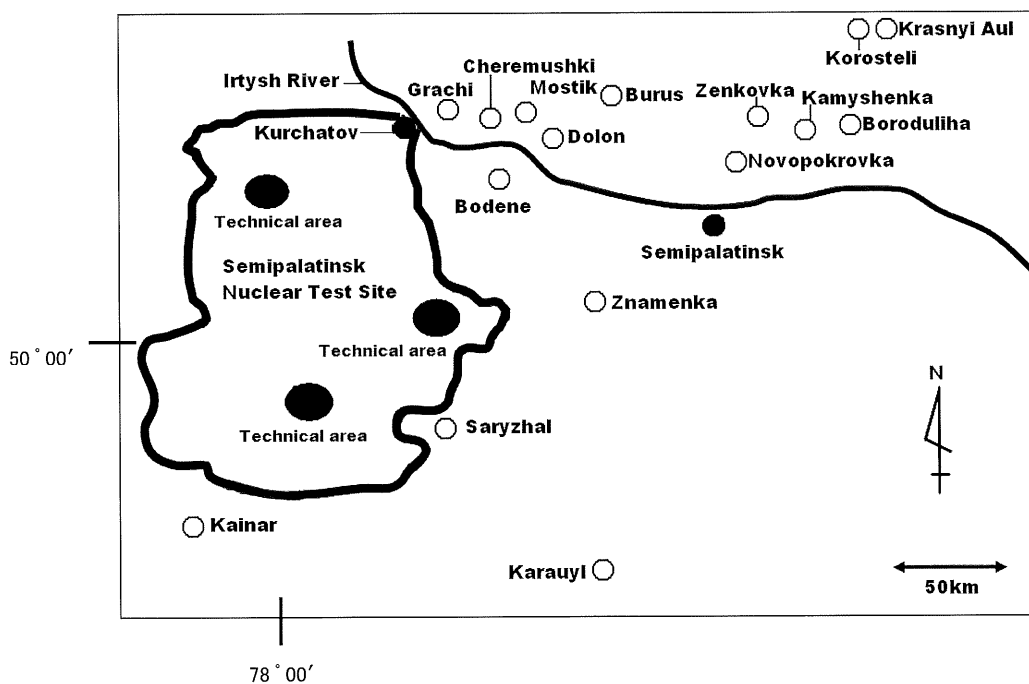
○ targeted villages

Fig. 1. Semipalatinsk Nuclear Test Site and the villages targeted by our survey

Table 1. Number of respondents classified by age and sex in each village

Village	45-54 Male	45-54 Female	55-64 Male	55-64 Female	65-74 Male	65-74 Female	75-84 Male	75-84 Female	85- Male	85- Female	Total by sex Male	Total by sex Female	No answer†	Total
High radiation levels														
Saryzhal	0	4	23	20	34	17	0	0	0	0	57	41	1	99
Dolon	7	9	8	11	11	18	5	9	0	0	31	47	1	79
Bodene	1	0	8	13	15	8	2	3	0	0	26	24	0	50
Mostik	5	6	12	6	5	9	1	4	1	1	24	26	0	50
Cheremushki	5	4	8	7	7	9	3	5	0	2	23	27	0	50
Subtotal	18	23	59	57	72	61	11	21	1	3	161	165	2	328
Moderate radiation levels														
Kainar	1	1	29	19	8	6	2	5	1	1	41	33	0	74
Karauyl	1	0	5	4	9	14	5	11	1	0	21	29	0	50
Znamenka	2	3	8	10	16	21	6	8	0	0	32	42	0	74
Krasnyi Aul	0	0	5	11	12	14	3	5	0	0	20	30	0	50
Korosteli	3	2	2	7	9	8	0	1	0	0	14	18	0	32
Subtotal	7	6	49	51	54	63	16	30	2	1	128	152	0	280
Low radiation levels														
Burus	0	0	8	11	7	13	2	8	0	1	17	33	0	50
Grachi	3	5	4	4	2	6	0	6	0	0	9	21	0	30
Zenkovka	1	2	5	7	5	20	4	5	0	0	15	34	0	49
Kamyshenka	1	1	0	1	15	18	0	13	0	1	16	34	0	50
Boroduliha	0	1	5	6	10	24	0	3	0	1	15	35	0	50
Novopokrovka	2	1	7	0	9	12	6	12	0	1	24	26	0	50
Subtotal	7	10	29	29	48	93	12	47	0	4	96	183	0	279
Total	32	39	137	137	174	217	39	98	3	8	385	500	2	887
	71		274		391		137		11					

*The median age of the respondents was 69 (range 45 - 94)
†No answer provided to the questions about age and sex

Table 2. Grouping of villages into high, moderate, and low radiation levels based on previously estimated radiation levels (Sv) in each village

Radiation level	Village	Dosimetric study Gordeev et al[7]	Dosimetric study Rosenson, Tchaijunusova, Gusev et al[18]
High	Saryzhal	1.51	2.46
	Dolon	1.30	4.47
	Bodene	-*	3.47
	Mostik	-	2.25
	Cheremushki	-	2.25
Moderate	Kainar	0.12	0.68
	Karauyl	0.83	0.87
	Znamenka	-	0.62
	Krasnyi Aul	-	-
	Korosteli	0.4	2.42
Low	Burus	0.0058	-
	Grachi	-	-
	Zenkovka	-	-
	Kamyshenka	-	-
	Boroduliha	-	-
	Novopokrovka	0.003	-

*The symbol "-" denotes a missing value

overall and a greater prevalence of specific medical conditions. There is therefore some correlation between poor health and degree of radiation exposure. The increasing frequency with age of persons with various medical conditions may indicate the effects of aging. The age range of the respondents is that at which malignant tumors and many other diseases show increasingly high incidence. Conditions which showed statistically significant effects only in females, such as decreased reproductive capacity, anemia, collagen diseases and thyroid cancer, tend to be more prevalent among females, so this result is not surprising.

Concerning current medical conditions, dermatological disorders, respiratory disease, thyroiditis, eye disorders, digestive system disease, anemia and blood related disease and ear/nose disorders increased significantly with radiation exposure as demonstrated by logistic regression analysis. According to previous studies in Hiroshima and Nagasaki, thyroid cancer[5,6,21], atomic bomb (radiation) cataracts[15,16,24] and leukemia[9,10] show causal relationships with radiation exposure. There is also the possibility that skin cancer[19,20,24], lung cancer[3,14,21], gastric cancer[11,21] and multiple myeloma/malignant lymphoma or other blood related diseases[24] were induced by radiation exposure. We cannot pinpoint specific medical diagnoses from our questionnaire survey in Semipalatinsk. However, our results based on self-reported medical conditions suggest that diseases which were associated with radiation exposure in Hiroshima and Nagasaki are also radiation-dose dependent in Semipalatinsk. A relationship between ear/nose disorders and radiation exposure is as yet not well established in the studies of atomic bomb effects in Hiroshima and Nagasaki.

In summary, we suggest that poor health among residents in Semipalatinsk may be the result of radiation exposure caused by nuclear explosions.

Table 3. Frequency (%) of respondents by self-reported general health status

Radiation level / village	Excellent n	Good n	Fair n	Poor n	Poor (%)	Very poor n	Very poor (%)	No answer n	Total n
High radiation levels									
Saryzhal	0	11	45	39	(39.4)	2	(2.0)	2	99
Dolon	1	2	46	28	(35.4)	2	(2.5)	0	79
Bodene	0	5	32	13	(24.0)	0	(0.0)	0	50
Mostik	1	2	35	12	(30.0)	0	(2.0)	0	50
Cheremushki	0	3	30	15	(31.1)	1	(1.4)	1	50
Subtotal	2	23	188	107	(32.6)	5	(1.5)	3	328
Moderate radiation levels									
Kainar	1	9	33	28	(18.0)	2	(0.0)	1	74
Karauyl	0	2	39	9	(37.8)	0	(2.7)	0	50
Znamenka	0	2	48	23	(28.0)	1	(2.0)	0	74
Krasnyi Aul	0	0	40	10	(20.0)	0	(0.0)	0	50
Korosteli	0	1	29	2	(6.3)	0	(0.0)	0	32
Subtotal	1	14	189	72	(25.7)	3	(1.1)	1	280
Low radiation levels									
Burus	0	2	32	14	(26.0)	1	(0.0)	1	50
Grachi	0	4	18	8	(26.7)	0	(0.0)	0	30
Zenkovka	0	3	22	19	(38.8)	1	(2.0)	4	49
Kamyshenka	0	3	35	11	(22.0)	0	(0.0)	1	50
Boroduliha	0	0	34	13	(26.0)	3	(6.0)	0	50
Novopokrovka	0	3	31	16	(32.0)	0	(0.0)	0	50
Subtotal	0	15	172	81	(29.0)	5	(1.8)	6	279
Total n (%)	3 (0.3)	52 (5.9)	549 (61.9)	260 (29.3)		13 (1.5)		10 (1.1)	887

Table 4. Frequency (%) of persons who require nursing care or assistance with activities of daily living among 197 respondents who reported having poor or very poor health (2003-2005)

Village	No difficulty n	No difficulty (%)	Some difficulty with labor intensive tasks n	Some difficulty with labor intensive tasks (%)	Occasionally require nursing care n	Occasionally require nursing care (%)	Require nursing care most of the day n	Require nursing care most of the day (%)	Require nursing care all day n	Require nursing care all day (%)	No answer n	No answer (%)	Total n
High radiation levels													
Saryzhal	1	(7.1)	1	(7.1)	6	(42.9)	3	(21.4)	1	(7.1)	2	(14.3)	14
Dolon	0	(0.0)	3	(33.3)	5	(55.6)	0	(0.0)	1	(11.1)	0	(0.0)	9
Bodene	3	(23.1)	3	(23.1)	7	(53.8)	0	(0.0)	0	(0.0)	0	(0.0)	13
Mostik	1	(8.3)	1	(8.3)	6	(50.0)	2	(16.7)	0	(0.0)	2	(16.7)	12
Cheremushki	4	(25.0)	5	(31.3)	3	(18.8)	3	(18.8)	1	(6.3)	0	(0.0)	16
Subtotal	9	(14.1)	13	(20.3)	27	(42.2)	8	(12.5)	3	(4.7)	4	(6.3)	64
Moderate radiation levels													
Kainar	0	(0.0)	1	(50.0)	0	(0.0)	1	(50.0)	0	(0.0)	0	(0.0)	2
Karauyl	0	(0.0)	0	(0.0)	2	(22.2)	1	(11.1)	0	(0.0)	6	(66.7)	9
Znamenka	0	(0.0)	11	(45.8)	6	(25.0)	6	(25.0)	0	(0.0)	1	(4.2)	24
Krasnyi Aul	1	(10.0)	2	(20.0)	1	(10.0)	0	(0.0)	0	(0.0)	6	(60.0)	10
Korosteli	0	(0.0)	2	(100.0)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	2
Subtotal	1	(2.1)	16	(34.0)	9	(19.1)	8	(17.0)	0	(0.0)	13	(27.7)	47
Low radiation levels													
Burus	1	(6.7)	8	(53.3)	3	(20.0)	3	(20.0)	0	(0.0)	0	(0.0)	15
Grachi	1	(12.5)	4	(50.0)	1	(12.5)	0	(0.0)	1	(12.5)	1	(12.5)	8
Zenkovka	3	(15.0)	9	(45.0)	5	(25.0)	0	(0.0)	1	(5.0)	2	(10.0)	20
Kamyshenka	0	(0.0)	4	(36.4)	1	(9.1)	3	(27.3)	0	(0.0)	3	(27.3)	11
Boroduliha	0	(0.0)	11	(68.8)	2	(12.5)	0	(0.0)	3	(18.8)	0	(0.0)	16
Novopokrovka	0	(0.0)	9	(56.3)	2	(12.5)	3	(18.8)	1	(6.3)	1	(6.3)	16
Subtotal	5	(5.8)	45	(52.3)	14	(16.3)	9	(10.5)	6	(7.0)	7	(8.1)	86
Total	15	(7.6)	74	(37.6)	50	(25.4)	25	(12.7)	9	(4.6)	24	(12.2)	197

Table 5. Frequency (%) of persons who mentioned minor health complaints among 197 respondents who reported poor or very poor health (2003-2005) (respondents could report more than one condition)

	Weight loss		Slight fever		Lack of appetite		Loss of sleep		Headache		Vertigo		General malaise		Nighttime sweating		Swollen arms or legs	
	n	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)
High radiation levels																		
Saryzhal	1	(2.4)	3	(7.3)	5	(12.2)	8	(19.5)	13	(31.7)	12	(29.3)	10	(24.4)	7	(17.1)	11	(26.8)
Dolon	1	(3.3)	5	(16.7)	4	(13.3)	6	(20.0)	8	(26.7)	8	(26.7)	7	(23.3)	4	(13.3)	5	(16.7)
Bodene	1	(7.7)	0	(0.0)	2	(15.4)	7	(53.8)	11	(84.6)	11	(84.6)	12	(92.3)	5	(38.5)	5	(38.5)
Mostik	4	(33.3)	1	(8.3)	5	(41.7)	6	(50.0)	7	(58.3)	10	(83.3)	12	(100.0)	8	(66.7)	6	(50.0)
Cheremushki	0	(0.0)	1	(6.3)	4	(25.0)	11	(68.8)	12	(75.0)	10	(62.5)	12	(75.0)	4	(25.0)	5	(31.3)
Subtotal	7	(10.9)	10	(15.6)	20	(31.3)	38	(59.4)	51	(79.7)	51	(79.7)	53	(82.8)	28	(43.8)	32	(50.0)
Moderate radiation levels																		
Kainar	0	(0.0)	0	(0.0)	2	(22.2)	1	(11.1)	2	(22.2)	1	(11.1)	2	(22.2)	2	(22.2)	1	(11.1)
Karauyl	2	(6.7)	3	(10.0)	3	(10.0)	2	(6.7)	2	(6.7)	3	(10.0)	3	(10.0)	1	(3.3)	2	(6.7)
Znamenka	1	(4.2)	4	(16.7)	5	(20.8)	17	(70.8)	15	(62.5)	22	(91.7)	15	(62.5)	8	(33.3)	7	(29.2)
Krasnyi Aul	2	(20.0)	0	(0.0)	2	(20.0)	2	(20.0)	7	(70.0)	8	(80.0)	8	(80.0)	2	(20.0)	2	(20.0)
Korosteli	0	(0.0)	0	(0.0)	0	(0.0)	1	(50.0)	2	(100.0)	2	(100.0)	2	(100.0)	0	(0.0)	0	(0.0)
Subtotal	5	(10.6)	7	(14.9)	12	(25.5)	23	(48.9)	28	(59.6)	36	(76.6)	30	(63.8)	13	(27.7)	12	(25.5)
Low radiation levels																		
Burus	1	(6.7)	0	(0.0)	6	(40.0)	11	(73.3)	9	(60.0)	12	(80.0)	10	(66.7)	3	(20.0)	4	(26.7)
Grachi	1	(12.5)	1	(12.5)	2	(25.0)	5	(62.5)	4	(50.0)	5	(62.5)	6	(75.0)	0	(0.0)	3	(37.5)
Zenkovka	1	(5.0)	0	(0.0)	3	(15.0)	6	(30.0)	16	(80.0)	14	(70.0)	17	(85.0)	4	(20.0)	5	(25.0)
Kamyshenka	1	(9.1)	0	(0.0)	3	(27.3)	4	(36.4)	7	(63.6)	8	(72.7)	8	(72.7)	4	(36.4)	2	(18.2)
Boroduliha	3	(18.8)	2	(12.5)	6	(37.5)	3	(18.8)	9	(56.3)	10	(62.5)	11	(68.8)	0	(0.0)	4	(25.0)
Novopokrovka	3	(18.8)	1	(6.3)	3	(18.8)	14	(87.5)	16	(100.0)	15	(93.8)	16	(100.0)	5	(31.3)	9	(56.3)
Subtotal	10	(11.6)	4	(4.7)	23	(26.7)	43	(50.0)	61	(70.9)	64	(74.4)	68	(79.1)	16	(18.6)	27	(31.4)
Total	22	(11.2)	21	(10.7)	55	(27.9)	104	(52.8)	140	(71.1)	151	(76.6)	151	(76.6)	57	(28.9)	71	(36.0)

Table 6. Estimated odds ratios and 95% confidence intervals for minor health complaints according to age, sex, and radiation level

Variable	Odds ratio	95% C.I.	
[Lack of appetite]			
Age*	1.49	(1.06	2.09)
Male vs. Female	0.71	(0.39	1.28)
Radiation level			
High†	1.74	(0.83	3.65)
Moderate‡	0.66	(0.32	1.37)
[Loss of sleep]			
Age	1.51	(1.16	1.96)
Male vs. Female	0.68	(0.43	1.06)
Radiation level			
High	1.80	(1.03	3.15)
Moderate	0.66	(0.38	1.14)
[Headache]			
Age	1.37	(1.08	1.74)
Male vs. Female	0.67	(0.45	1.01)
Radiation level			
High	2.05	(1.23	3.40)
Moderate	0.69	(0.42	1.15)

Variable	Odds ratio	95% C.I.	
[Vertigo]			
Age	1.55	(1.24	1.95)
Male vs. Female	0.85	(0.59	1.25)
Radiation level			
High	1.53	(0.95	2.47)
Moderate	0.66	(0.42	1.04)
[General malaise]			
Age	1.42	(1.14	1.78)
Male vs. Female	0.76	(0.52	1.11)
Radiation level			
High	1.98	(1.21	3.25)
Moderate	0.49	(0.31	0.79)

Variable	Odds ratio	95% C.I.	
[Nighttime sweating]			
Age	1.08	(0.78	1.51)
Male vs. Female	1.29	(0.75	2.24)
Radiation level			
High	2.14	(1.08	4.25)
Moderate	0.97	(0.45	2.06)
[Swollen arms or legs]			
Age	1.31	(0.97	1.77)
Male vs. Female	0.74	(0.44	1.25)
Radiation level			
High	2.88	(1.44	5.76)
Moderate	0.55	(0.27	1.10)

*The odds ratio for age represents an increase of 10 years of age
†High radiation levels vs. moderate and low radiation levels
‡High and moderate radiation levels vs. low radiation levels

Table 7. Frequency (%) of self-reported medical conditions (respondents could report more than one condition)

	Arthralgia, lower back pain, arthritis	High blood pressure	Heart disease	Digestive system diseases	Neuralgia	Eye disorders	Thyroiditis	Liver disease	Respiratory disease	Ear, nose disorders	Skin disorders	Anemia and blood related diseases	Diabetes	Bone fracture and bone related disease	Others
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
High radiation levels															
Saryzhal	68	66	48	38	16	35	26	16	26	22	25	15	1	2	17
Dolon	50	38	37	21	14	21	17	18	22	6	12	6	2	0	5
Bodene	36	16	19	17	12	4	7	4	0	9	8	0	0	4	16
Mostik	35	20	12	13	7	6	10	3	5	4	1	0	1	2	16
Cheremushki	33	15	14	17	12	9	3	3	3	1	1	1	0	1	10
Subtotal	222 (67.7)	155 (47.3)	130 (39.6)	106 (32.3)	61 (18.6)	75 (22.9)	63 (19.2)	44 (13.4)	56 (17.1)	42 (12.8)	47 (14.3)	22 (6.7)	4 (1.2)	9 (2.7)	64 (19.5)
Moderate radiation levels															
Kainar	60	40	32	30	17	23	11	12	14	24	10	8	2	4	1
Karauyl	17	25	36	19	4	21	6	14	2	6	2	3	4	1	0
Znamenka	54	32	32	26	12	9	8	10	6	11	1	0	2	0	19
Krasnyi Aul	41	31	16	10	19	3	5	1	2	2	0	0	1	0	4
Korosteli	27	16	11	10	13	2	5	4	3	0	2	1	0	1	12
Subtotal	199 (71.1)	144 (51.4)	127 (45.4)	95 (33.9)	65 (23.2)	58 (20.7)	35 (12.5)	41 (14.6)	27 (9.6)	43 (15.4)	15 (5.4)	12 (4.3)	9 (3.2)	6 (2.1)	36 (12.9)
Low radiation levels															
Burus	27	14	19	14	14	2	4	8	4	9	1	0	2	0	25
Grachi	13	14	11	5	6	7	2	2	1	1	0	0	0	1	7
Zenkovka	31	32	24	7	17	1	7	4	9	0	2	0	2	1	12
Kamyshenka	35	28	13	6	12	3	2	3	7	2	1	0	2	0	9
Boroduliha	36	33	22	16	10	3	12	9	3	3	1	1	2	1	16
Novopokrovka	41	24	20	9	19	4	10	4	3	6	3	1	2	3	15
Subtotal	183 (65.6)	145 (52.0)	109 (39.1)	57 (20.4)	78 (28.0)	20 (7.2)	37 (13.3)	30 (10.8)	27 (9.7)	21 (7.5)	8 (2.9)	2 (0.7)	10 (3.6)	6 (2.2)	84 (30.1)
Total	604 (68.1)	444 (50.1)	366 (41.3)	258 (29.1)	204 (23.0)	153 (17.2)	135 (15.2)	115 (13.0)	110 (12.4)	106 (12.0)	70 (7.9)	36 (4.1)	23 (2.6)	21 (2.4)	184 (20.7)

Table 8. Estimated odds ratios and 95% confidence intervals for presence/absence of current medical conditions according to age, sex, and radiation level

Variable	Odds ratio	95% C.I.	
[High blood pressure]			
Age*	1.19	(1.01	1.41)
Male vs. Female	0.53	(0.40	0.69)
Radiation level			
High†	0.89	(0.64	1.24)
Moderate‡	1.07	(0.76	1.51)
[Heart disease]			
Age	1.27	(1.07	1.50)
Male vs. Female	0.87	(0.66	1.14)
Radiation level			
High	0.82	(0.59	1.13)
Moderate	1.35	(0.96	1.90)
[Eye disorders]			
Age	1.77	(1.41	2.22)
Male vs. Female	0.86	(0.59	1.24)
Radiation level			
High	1.30	(0.87	1.93)
Moderate	3.97	(2.29	6.88)
[Skin disorders]			
Age	0.90	(0.67	1.23)
Male vs. Female	1.36	(0.82	2.24)
Radiation level			
High	2.90	(1.58	5.34)
Moderate	1.83	(0.76	4.40)

Variable	Odds ratio	95% C.I.	
[Digesitive system disease]			
Age	1.02	(0.85	1.22)
Male vs. Female	0.51	(0.37	0.70)
Radiation level			
High	0.95	(0.67	1.35)
Moderate	2.16	(1.47	3.20)
[Liver disease]			
Age	1.31	(1.03	1.67)
Male vs. Female	0.72	(0.48	1.09)
Radiation level			
High	0.96	(0.60	1.53)
Moderate	1.55	(0.93	2.58)
[Respiratory disease]			
Age	1.16	(0.90	1.49)
Male vs. Female	1.15	(0.76	1.75)
Radiation level			
High	2.20	(1.31	3.68)
Moderate	0.88	(0.50	1.58)
[Anemia and blood related diseases]			
Age	0.66	(0.43	1.03)
Male vs. Female	0.31	(0.14	0.70)
Radiation level			
High	1.62	(0.75	3.48)
Moderate	5.76	(1.29	25.8)

Variable	Odds ratio	95% C.I.	
[Arthralgia, lower back pain, arthritis]			
Age	1.20	(1.00	1.43)
Male vs. Female	0.57	(0.43	0.77)
Radiation level			
High	0.91	(0.64	1.30)
Moderate	1.43	(1.00	2.07)
[Ear, nose disorders]			
Age	1.28	(0.99	1.65)
Male vs. Female	1.09	(0.72	1.66)
Radiation level			
High	0.80	(0.50	1.28)
Moderate	2.18	(1.26	3.78)
[Thyroiditis]			
Age	0.80	(0.64	1.01)
Male vs. Female	0.31	(0.20	0.47)
Radiation level			
High	1.75	(1.10	2.78)
Moderate	0.98	(0.59	1.64)

*The odds ratio for age represents an increase of 10 years of age
†High radiation levels vs. moderate and low radiation levels
‡High and moderate radiation levels vs. low radiation levels

We also conclude that radiation exposure might be one of the causes of the incidence of some specific medical conditions.

The objective of our research was to portray in full and in detail the health status of persons exposed to radiation in the Semipalatinsk area. Our research method of performing health assessment by interview is only a first step, but it provides valuable medical information that could be important in terms of seeing the full picture. To clarify the relationship between radiation exposure and various medical conditions, further information is required. In the future we will attempt to evaluate other possible confounding factors in addition to age and sex, such as tobacco and alcohol use. Health screening and genetic mutation research in the population living around the SNTS have been conducted[1,4,22]. We need to consider not only the results of our survey but also the findings of these other investigations to deepen our understanding of the effects of radiation exposure in the Semipalatinsk area.

Appendix 1. Summary of survey questions

Question 1: What is your current health condition? Please circle the appropriate numbers from the following choices.

1. Excellent	2. Good	3. Fair	4. Poor	5. Very poor

For those who selected 4 or 5, proceed to the questions below.

About your recent physical condition, (1. you have no difficulty performing labor-intensive tasks or activities of daily living 2. you have difficulty performing labor-intensive tasks but no difficulty with activities of daily living 3. you sometimes need help of other people but are usually out of bed 4. you need nursing care or assistance with activities of daily living most of the time and are confined to bed more than half of the day 5. you require constant nursing care and are bedridden)

Please choose the appropriate numbers from the following symptoms.

(1. weight loss 2. slight fever (more than 37.0℃) 3.lack of appetite (you eat less than half the normal amount of food) 4. loss of sleep 5. headache 6. vertigo 7. general malaise 8.nighttime sweating 9. swollen arms or legs)

Question 2: Please note any of the medical conditions below that apply to you.

1.	High blood pressure (blood pressure is 140/90 or more)	8.	Respiratory disease (you have been diagnosed with asthma, pulmonary emphysema, chronic bronchitis etc.)
2.	Heart disease (you have been diagnosed with angina pectoris, myocardial infarction, cardiovalvulitis etc.)	9.	Diabetes (fasting blood sugar level is at least 126 or casual blood sugar level is at least 200)
3.	Eye disorders (except myopia and presbyopia)	10.	Anemia and blood related diseases (you have been diagnosed by means of a blood test)
4.	Dermatological disorders (you currently have skin eruptions)	11.	Arthralgia, lower back pain, arthritis (you have pain or deformation of articulation at present)
5.	Digestive system diseases (gastrointestinal tract, gallbladder, pancreas) (A doctor has diagnosed your abnormality using an imaging procedure, such as x-ray etc.)	12.	Neuralgia (you have numbness, pain, lowering sensibility etc.)
6.	Liver disease (you have been diagnosed with abnormal liver function by blood test or an imaging procedure)	13.	Ear, nose disorders (you have symptoms at present)
7.	Bone fracture and bone related disease (A doctor has diagnosed your abnormality using an imaging procedure, such as x-ray etc.)	14.	Thyroiditis (you have been diagnosed by blood test or ultrasound)
		15.	Others ( )

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