Physical Experiences of the Nuclear Explosions in the Semipalatinsk Area: Radiation Exposure Level and Distance from the Hypocenter

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Abstract

The present paper has three aims related to important, direct experiences of the nuclear explosions among persons living near the Semipalatinsk Nuclear Test Site (SNTS). The first is to describe those experiences. The second is to examine their association with the radiation exposure. The third is to clarify their relationship with distance from the center of the nuclear test area. We examined responses to a questionnaire survey conducted from 2002 to 2005 and analyzed them using logistic regression analysis. The major results were: (1) approximately 94% of respondents reported having some direct experience from the nuclear tests; (2) approximately 66% of the respondents saw flashes, 50% felt the blasts, and 12% felt heat from the nuclear explosions; (3) the presence or absence of direct experiences from the nuclear explosions did not depend on radiation level but was associated with distance from the hypocenter of the SNTS.

This research is the first attempt to describe human experiences of the nuclear explosions at the SNTS. We briefly draw parallels between experiences near the SNTS and experiences among Hiroshima and Nagasaki A-bomb survivors. Our next goal in

this study is to examine the relationship between direct experiences and psychological consequences of the nuclear tests in view of the fact that epidemiologic studies in Hiroshima and Nagasaki have indicated that direct experiences of the atomic bombings induced psychological effects among the A-bomb survivors.

Introduction

The Semipalatinsk Nuclear Test Site (SNTS), in the present Republic of Kazakhstan, was the major site for nuclear weapons testing used by the former Soviet Union (USSR). The first nuclear test there was conducted on August 29, 1949. [1)] During the subsequent 40 years, 456 nuclear detonations were carried out between 1949 and 1989, including 86 above ground and 25 at ground level (111 atmospheric tests in total). [1, 2)] According to a speech before the United Nations (UN) by the Kazakh Ambassador to the UN on 19 October, 1998, approximately 1.6 million people were exposed to radiation from those nuclear explosions and 1.2 million inhabitants still suffer from their aftereffects.

Since 2002, our research team at Hiroshima University has conducted questionnaire surveys of persons exposed to radiation in the villages near the SNTS. We have already identified and discussed their direct experiences of the nuclear explosions, their health and psychological problems, and their impressions of the nuclear tests [3-5)], using data from the 2002 to 2004 surveys. Previous studies concerning the effects of radiation exposure in the Semipalatinsk area have been conducted from a medical and/or a physical point of view, producing results that include those on genetic mutations. [6-10)] However, there is no research on the psychological realities of radiation exposure focusing upon the voices of the victims themselves. Knowledge of their experiences of the nuclear test explosions can provide valuable medical information, especially because we have learned that the experiences of A-bomb survivors in Hiroshima and Nagasaki, Japan, influenced the occurrence of mental disorders. The present work will contribute towards a better understanding of radiation effects at Semipalatinsk, especially in terms of future work aimed at examining psychological effects among the Semipalatinsk residents caused by the nuclear tests.

Materials and Methods

We conducted a questionnaire survey in sixteen villages near the SNTS: Saryzhal,

Dolon, Karauyl, Kainar, Burus, Bodene, Mostik, Cheremushki, Znamenka, Grachi, Krasnyi Aul, Korosteli, Zenkovka, Kamyshenka, Boroduliha, and Novopokrovka (see Fig.1 at the end). Radiation levels varied among the villages as is shown in Table 1 at the end. The study subjects were selected from among persons approximately 50 years of age or older who experienced the nuclear tests on the ground between 1949 and 1962 in each village and who still resided there at the time of the survey. Medical doctors in each village and from the Kazakh Scientific Research Institute of Radiation Medicine and Ecology selected the research subjects from lists of names made up by the village hospitals, which maintain information on the movements of residents. We selected the subjects at random in proportion to street population size. We (primarily T.M. and the Japanese staff) collected the questionnaire responses and conducted interviews with selected residents in the field using an interpreter who was well-acquainted with both the Kazakh and Russian languages. The total number of respondents was 887; details of their demographics are shown in Table 1. In conducting the survey, we strictly upheld the respondents' privacy and obtained their informed consent to publish summary results of our analysis based on the information they provided. The appendix shows the subset of survey questions used in the present paper.

We performed multiple logistic linear regression analysis to study the effects of village radiation level and respondent's age and sex to characterize each type of experience of the nuclear explosions. The presence/absence of individual direct experiences was analyzed using the LGReg program (Ver. 1.2) developed in the Department of Environmetrics and Biometics, Research Institute for Radiation Biology and Medicine, Hiroshima University. The logit of the probability p of a positive response (presence of an experience) is specified as:

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

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

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

As was done by Hirabayashi et al [11], instead of using actual radiation dose, we divided the sixteen villages into three groups having different radiation levels (high, moderate, and low) on the basis of two major studies [8, 9] and the latest results obtained by Shinkarev et al (personal communication) at the Institute of Biophysics of the Ministry of Health, Moscow, Russian Federation (Table 1). We also considered the trajectories of the radioactive clouds produced by the nuclear explosions. [8]

Results

Any Experience of the Nuclear Tests

Table 2 below shows the results for any (unspecified) experience of the nuclear tests. Overall 94% of respondents (835 of 887 persons) answered that they directly experienced something of the nuclear tests, with more than 80% of the respondents in each village reporting having had some experience. Unlike the Survivors of the A-bombs in Hiroshima and Nagasaki, Japan, the villages near the SNTS are located at great distances from the test area (called the technical area, the center of which is hereafter called the hypocenter) (Fig. 1). For instance, Krasniyi Aul village is located approximately 200 km from the hypocenter, yet 100% of respondents in Krasniyi Aul answered that they had some experience related to the nuclear tests.

There was a significantly higher frequency of reported experiences in villages with high radiation levels compared to villages with moderate or low radiation levels (P=0.01, odds ratio 2.65, 95% C.I.: 1.25 - 5.62; Table 3). In other words, if the respondents lived in villages having high radiation levels, the possibility of having some experience of the nuclear tests was greater. The results of logistic regression analysis on three specific types of experiences, also shown in Table 3, are summarized individually below.

"Seeing the Flash"

583 of the 887 respondents (65.7%) answered that they saw flashes of the nuclear explosions. As shown in Table 4, over 92% of the respondents in villages with high radiation levels saw flashes, compared with only 40% of those in villages with low radiation levels. Consequently, the odds of seeing flashes were significantly higher in

villages with high radiation levels (P<0.01, odds ratio 9.15, 95% C.I.: 5.59 - 14.99) and with moderate radiation levels (P<0.01, odds ratio 2.30, 95% C.I.: 1.63 - 3.25). In addition, the odds increased with age (P=0.01, odds ratio 1.29 for a 10-year difference in age, 95% C.I.: 1.05 - 1.57) and were significantly higher among males (P=0.01, odds ratio 1.50, 95% C.I.: 1.08 - 2.08).

"Feeling the Bomb Blast"

Approximately 50% of the respondents (443 persons) felt the blasts of the nuclear explosions and 301 respondents (34%) did not (Table 5). The frequency of feeling blasts increased with level of radiation exposure. There were significantly higher odds of feeling bomb blasts in villages with high radiation levels (P<0.01, odds ratio 6.04, 95% C.I.: 4.18 - 8.74) and moderate radiation levels (P<0.01, odds ratio 1.77, 95% C.I.: 1.23 - 2.55). The odds increased significantly with age (P<0.01, odds ratio 1.48 for a 10-year difference in age, 95% C.I.: 1.22 - 1.78) and were higher among males (P=0.01, odds ratio 1.50, 95% C.I.: 1.11 - 2.04).

"Feeling Heat"

Table 6 shows the results for feeling heat from the explosions. Among the 887 respondents, 109 persons (12.3%) felt heat from the nuclear explosions and 406 respondents (45.8%) did not; 372 persons (41.9%) answered that they did not know. 17.1% of the respondents in the villages with high radiation levels felt heat whereas only 3.2% of those in the villages with low radiation levels did. The odds of feeling heat were significantly higher in the villages with moderate or high radiation levels compared to villages with low radiation levels (P<0.01, odds ratio 5.66, 95% C.I.: 2.70 - 11.86).

Association between Direct Experiences and Distance from the SNTS Hypocenter

Distance from the hypocenter and geographical conditions in the Semipalatinsk area must have had significant influences on the presence or absence of individual direct experiences of the nuclear explosions. It is therefore not surprising that the number of persons who experienced flashes, blasts, or heat in villages closer to the hypocenter is

greater than in more distant villages. Fig. 2 shows the relationship between experiences of the nuclear explosions and distance from the hypocenter. Distances for some of the villages, as shown in Table 1 and Fig. 2, were obtained from Gordeev et al. [8] We ordered the villages by distance based on those results; villages with unknown distance were ordered based on reference to a detailed map [12]. Grachi is the village nearest to the hypocenter and Krasnyi Aul is the farthest. More than 80% of the respondents in each village experienced something of the nuclear explosions. Having some unspecified experience overall was not correlated with distance from the hypocenter, but the proportion of respondents with specific experiences of flashes or blasts decreased with distance from the hypocenter. The number of respondents who felt heat was small on average and showed no relationship with distance from the hypocenter, but respondents in villages at the greatest distances, such as Zenkovka, Booroduliha, and Krasnyi Aul, did not report feeling any heat whatsoever. Fig. 2 also suggests a paradox between the high percentage with some experience of the nuclear explosions and the percentages with specific experiences, such as seeing flashes. For example, most of the respondents from Kamyshenka in the Boroduliha region replied that they experienced something from the nuclear tests, but few of them answered that they had any specific experiences. We discuss this paradox below.

Discussion

Typical direct experiences of the Hiroshima or Nagasaki A-bombings in Japan were seeing the flash, feeling the bomb blast, and feeling heat. Among residents of villages in Semipalatinsk near the former Soviet Union's SNTS nuclear test area, approximately 94% of 887 respondents to our survey reported having had some experience related to the nuclear explosions there; those experiences were similar to those of the A-bomb survivors. Among those experiences, seeing the flash and feeling the blast in particular are remarkable and were typical among the Semipalatinsk residents. However, the respondents in the Boroduliha region (including the villages of Novopokrovka, Zenkovka, Kamyshenka, Boroduliha, Korosteli, and Krasnyi Aul) did not report having had these direct experiences of the nuclear explosions. Their experiences related to the nuclear explosions are not clear at present; however, they must have experienced something, because their distance from the hypocenter could not have entirely precluded

their being aware of the tests.

In addition to questions about specific experiences, our questionnaire survey also contained an open-ended question asking respondents to write freely about their nuclear test experiences. Many respondents who lived near the SNTS referred to other aspects of the nuclear tests in their testimonies; for example, out of 199 respondents who answered the open-ended question, 57 (28%) referred to the mushroom cloud and 32 (16%) mentioned a deafening roar. In addition, some described seeing hairless animals or mentioned their evacuation.[3)] It is probable that they saw the mushroom cloud because the atmospheric nuclear explosions reached to an altitude of several tens of thousands of meters or more. The mushroom cloud from the Hiroshima A-bomb (16 kilotons of TNT) reached an altitude of twelve thousand meters within 20-30 minutes after the explosion.[13)] There is a famous picture taken by Seizo Yamada who, at 8:15 A.M. on August 6, 1945, was fishing with a friend in Mikumari ravine located 7 km east-northeast of Hiroshima. Frightened by a flash and explosion, he looked up to find the surrounding trees shaking and see a huge cloud rising. [14)] The Semipalatinsk area is located in the steppe, so there is no obstruction to seeing a mushroom cloud at a height of more than several thousand meters. We continue to evaluate these and other experiences in addition to the typical direct ones through detailed examination of their testimonies.

In the previous paper we used 606 responses collected in the period 2002 – 2004[3)], 90% of which (546 persons) noted having seen flashes from the nuclear explosions. However, in the present analysis only 66% of respondents answered that they saw flashes. This decrease of 24% was greatly influenced by the addition of results of the 2005 survey of the Boroduliha region. Only 13% of respondents (37 of 281) in Boroduliha answered that they saw flashes from the nuclear explosions (Table 4). The primary reason must be the long distance—villages in the Boroduliha area are located more than 200 km from the hypocenter. Direct experience of the flash from a nuclear explosion should be closely correlated with distance from the hypocenter.

Logistic regression analysis showed that the odds of seeing flashes increased significantly with age. As reporting of experiences is based on recall, this is not surprising. The reason for the higher frequency in males, however, is not obvious. This result may indicate that males were more likely than females to be outside of their

houses at times of nuclear explosions. The analysis also showed a significant and very high frequency of seeing flashes in villages with high radiation levels. The possibility of seeing the flash from a nuclear test explosion would be greater if a respondent lived in one of the villages with high radiation level, because most of those villages, such as Cheremushki, Dolon, or Saryzhal, are located near the SNTS (Table 1). It is not clear whether this result is due to radiation level or distance from the hypocenter. Therefore, we compared the responses in Grachi—which is nearest to the hypocenter but in the low radiation group—to those in the distal villages of Zenkovka, Kamyshenka, Boroduliha, and Novopokrovka, which also belong to the low radiation group; 93% (28 of 30) of respondents in Grachi answered that they saw flashes but, on average only 17.6% (35 of 199) of respondents in the four distal villages answered that they saw flashes. It is therefore likely that the presence or absence of seeing flashes depends more on distance from the hypocenter than on radiation level.

The frequency of feeling the bomb blasts in the present analysis (50%) was considerably lower than that in the surveys of 2002 – 2004 (70%).[3)] The reason for this decrease is also due to the Boroduliha region. Only 7% (19 of 281) of respondents in the Boroduliha region answered that they felt the blasts of the nuclear explosions. This result is probably because of the long distance; it might be difficult for residents to feel the bomb blast at a distance on the order of 200 km. However, approximately half of the respondents in Karauyl (at a distance of 191 km) answered that they felt the blasts. The reason for this high frequency in Karauyl is not known at present.

In the case of the Hiroshima A-bomb, there were testimonies attesting to the experience of the bomb blast in the Eba district, which is approximately 4 km from the hypocenter.[3, 15)] Assuming that the shock wave is proportional to the explosion energy, it would be possible for inhabitants at approximately 100 km, such as those in Saryzhal, Cheremushki, or Dolon, to feel the blast of a 400 kiloton nuclear explosion.[3)] Our analysis showed a significantly higher frequency of feeling the blasts with high radiation level, older age, and male sex. The reasons for these results should be the same as the reasons in the case of seeing the flashes.

Only 12.3% of respondents answered that they felt heat from the nuclear test explosions. The frequency of feeling heat was lower than that of seeing flashes or feeling the blasts. This is probably because thermal radiation energy per unit area

attenuates with distance from the burst point, which is an entirely different phenomenon from that of a shock wave. There are two kinds of attenuations: one is inversely proportional to the square of the distance, the other is brought about by absorption and scattering as radiation passes through air.[14] Therefore, the more frequent occurrence of feeling heat in villages with high radiation levels would be due to distance from the hypocenter.

The temperature of the Hiroshima A-bomb reached a maximum of approximately one million degrees centigrade an instant after detonation. Within three seconds of the explosion, 99% of the thermal radiation emitted by the fireball had reached the surface of the ground. The heat caused scorching of wood and other effects as far as 3 km from the hypocenter, and at a distance of 3.5 km, caused the burning of any human flesh that was not covered with clothes. Burns resulting from exposure to the thermal radiation proved fatal to unprotected people who were within about 1.2 km of the blast; estimates attribute 20-30% of total acute deaths to these burns.[13, 16] In the case of the SNTS, it is unlikely that inhabitants of villages at a distance of approximately 100 km succumbed to burns caused by the bombs. However, there is testimony in Hiroshima attesting to feeling heat at a distance of approximately 9 km from the hypocenter.[17] Considering this and the greater magnitude of the SNTS tests compared to the Hiroshima A-bomb, it might be not surprising that 17 of 50 respondents of Karauyl, at approximately 200 km, felt heat. Nevertheless, it is likely that the great majority of residents in the area approximately 200 km from the hypocenter did not feel heat from the explosions, because 267 of 281 respondents (95%) in the Boroduliha region answered that they did not feel heat.

Conclusion

The present paper focuses on three direct experiences of nuclear test explosions at the SNTS. We found that 94% (835) of 887 respondents directly experienced something from the nuclear explosions. We investigated in detail three direct experiences of the nuclear explosions: 66% saw flashes and 50% felt the blasts, but only 12% felt heat. The presence or absence of direct experiences of the nuclear explosions was dependent on distance from the hypocenter. We found that frequency of experiences was significantly related to radiation level, age, and sex. It is likely that the association with

age is due to memory. We also suggest the possibility that males were more likely than females to have been out of their homes at times of nuclear explosions, and thus more likely to have experiences of the explosions. The frequency of experiences was significantly higher with higher radiation level, but this is probably attributable to distance from the hypocenter owing to the fact that radiation level is correlated with distance.

This research is the first attempt to describe experiences of the nuclear explosions at the SNTS. Our next goal is to further this research to describe psychological effects caused by the nuclear test explosions. Our final goal is to bring together all of these elements to paint the entire picture of effects of nuclear test explosions on inhabitants of villages near the SNTS. The present research is just one step towards reaching that goal, but a necessary and important step.

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○ targeted villages

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

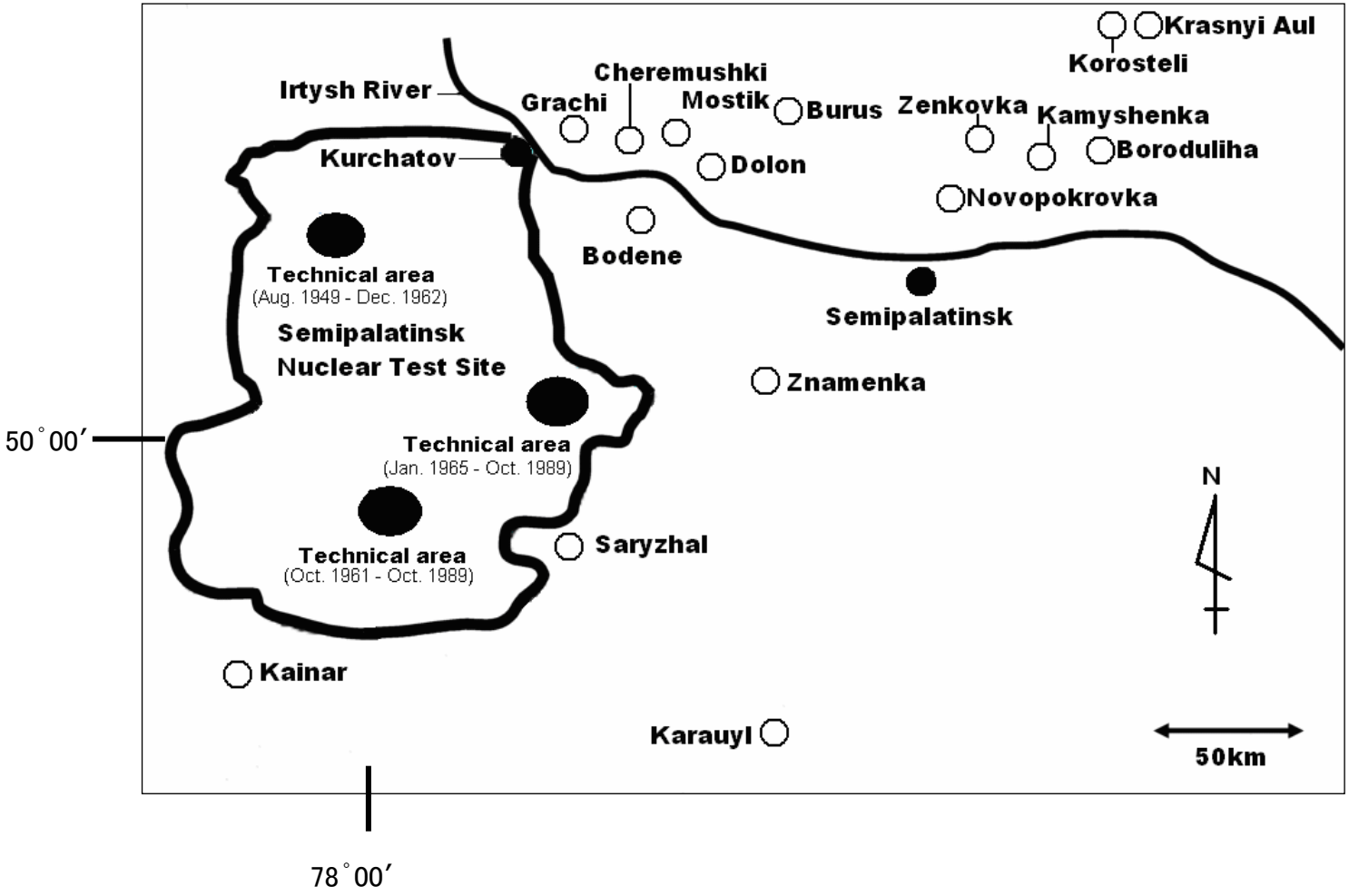
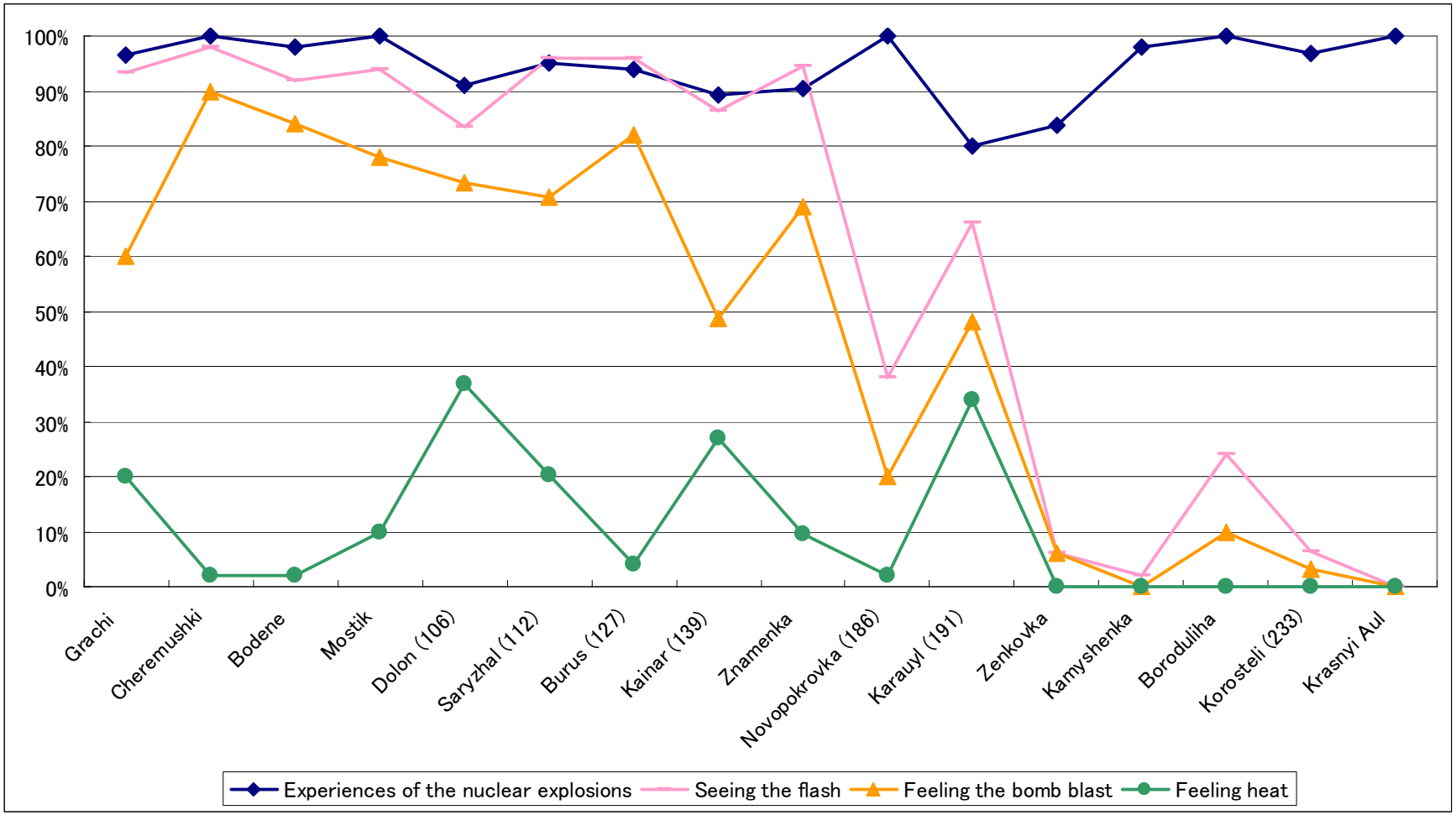


Fig. 2. Relationship of direct experiences to distance from the hypocenter



* ( ) shows distance from the hypocenter

Table 1. Number of respondents classified by age, sex, radiation exposure level, and distance from technical area

	Age (years)*														
	45-54		55-64		65-74		75-84		85-		Total by sex		No answer†	Total	Distance from technical area (km)
Village	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female			
High radiation levels															
Cheremushki	5	4	8	7	7	9	3	5	0	2	23	27	0	50	
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	
Dolon	7	9	8	11	11	18	5	9	0	0	31	47	1	79	106
Saryzhal	0	4	23	20	34	17	0	0	0	0	57	41	1	99	112
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	139
Znamenka	2	3	8	10	16	21	6	8	0	0	32	42	0	74	
Karauyl	1	0	5	4	9	14	5	11	1	0	21	29	0	50	191
Korosteli	3	2	2	7	9	8	0	1	0	0	14	18	0	32	233
Krasnyi Aul	0	0	5	11	12	14	3	5	0	0	20	30	0	50	
Subtotal	7	6	49	51	54	63	16	30	2	1	128	152	0	280	
Low radiation levels															
Grachi	3	5	4	4	2	6	0	6	0	0	9	21	0	30	
Burus	0	0	8	11	7	13	2	8	0	1	17	33	0	50	127
Novopokrovka	2	1	7	0	9	12	6	12	0	1	24	26	0	50	186
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	
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 respondents was 69 (range 45 - 94)

†No answer provided to the questions about age and sex

Table 2. Experiences of the nuclear tests.

Village	Experience *n* (%)	No Experience	No Answer	Total
Cheremushki	50 (100 %)	0	0	50
Bodene	49 (98.0 %)	0	1	50
Mostik	50 (100 %)	0	0	50
Dolon	72 (91.1 %)	5	2	79
Saryzhal	94 (94.9 %)	0	5	99
Subtotal	315 (96.0 %)	5	8	328
Kainar	66 (89.2 %)	6	2	74
Znamenka	67 (90.5 %)	1	6	74
Karauyl	40 (80.0 %)	5	5	50
Korosteli	31 (96.9 %)	1	0	32
Krasnyi Aul	50 (100 %)	0	0	50
Subtotal	254 (90.7 %)	13	13	280
Grachi	29 (96.7 %)	0	1	30
Burus	47 (94.0 %)	1	2	50
Novopokrovka	50 (100 %)	0	0	50
Zenkovka	41 (83.7 %)	0	8	49
Kamyshenka	49 (98.0 %)	0	1	50
Boroduliha	50 (100 %)	0	0	50
Subtotal	266 (95.3 %)	1	12	279
Total	835 (94.1 %)	19	33	887

Table 3. Estimated odds ratios and 95% confidence intervals for direct experiences of the nuclear explosions according to age, sex, and radiation level

Variable	Odds ratio	95% C.I.		Variable	Odds ratio	95% C.I.	
[Some experience]				**[Seeing the flash]**			
Age*	1.41	(0.96	2.06)	Age	1.29	(1.05	1.57)
Male vs. Female	1.40	(0.75	2.62)	Male vs. Female	1.50	(1.08	2.08)
Radiation level				Radiation level			
High†	2.65	(1.25	5.62)	High	9.15	(5.59	15.00)
Moderate‡	0.57	(0.28	1.15)	Moderate	2.30	(1.63	3.25)
[Feeling the bomb blast]				**[Feeling heat]**			
Age	1.48	(1.22	1.78)	Age	1.29	(0.99	1.66)
Male vs. Female	1.51	(1.11	2.04)	Male vs. Female	1.21	(0.80	1.83)
Radiation level				Radiation level			
High	6.04	(4.18	8.74)	High	1.18	(0.76	1.83)
Moderate	1.77	(1.23	2.55)	Moderate	5.66	(2.70	11.86)

*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 4. Frequency of respondents who answered that they saw flashes, classified by radiation exposure level and frequency in the Boroduliha Region

Village	Saw it *n* (%)	Did not see it	Do not know or No answer	Total
Cheremushki	49 (98.0 %)	1	0	50
Bodene	46 (92.0 %)	3	1	50
Mostik	47 (94.0 %)	2	1	50
Dolon	66 (83.5 %)	3	10	79
Saryzhal	95 (96.0 %)	0	4	99
Subtotal	303 (92.4 %)	9	16	328
Kainar	64 (86.5 %)	5	5	74
Znamenka	70 (94.6 %)	4	0	74
Karauyl	33 (66.0 %)	1	16	50
Korosteli	2 (6.3%)	29	1	32
Krasnyi Aul	0 (0 %)	50	0	50
Subtotal	169 (60.4 %)	89	22	280
Grachi	28 (93.3 %)	1	1	30
Burus	48 (96.0 %)	2	0	50
Novopokrovka	19 (38.0 %)	31	0	50
Zenkovka	3 (6.1 %)	36	10	49
Kamyshenka	1 (2.0 %)	48	1	50
Boroduliha	12 (24.0 %)	38	0	50
Subtotal	111 (39.8 %)	156	12	279
Total	583 (65.7 %)	254	50	887
Boroduliha Region	37 (13.2 %)	232	12	281

Table 5. Frequency of respondents who answered that they felt the bomb blasts, classified by radiation exposure level and frequency in the Boroduliha Region

Village	Felt it *n* (%)	Did not feel it	Do not know or No answer	Total
Cheremushki	45 (90.0 %)	1	4	50
Bodene	42 (84.0 %)	5	3	50
Mostik	39 (78.0 %)	3	8	50
Dolon	58 (73.4 %)	2	19	79
Saryzhal	70 (70.7 %)	8	21	99
Subtotal	254 (77.4 %)	19	55	328
Kainar	36 (48.6 %)	16	22	74
Znamenka	51 (68.9 %)	9	14	74
Karauyl	24 (48.0 %)	3	23	50
Korosteli	1 (3.1 %)	30	1	32
Krasnyi Aul	0 (0 %)	50	0	50
Subtotal	112 (40.0 %)	108	60	280
Grachi	18 (60.0 %)	1	11	30
Burus	41 (82.0 %)	7	2	50
Novopokrovka	10 (20.0%)	39	1	50
Zenkovka	3 (6.1%)	36	10	49
Kamyshenka	0 (0.0%)	49	1	50
Boroduliha	5 (10.0%)	42	3	50
Subtotal	77 (27.6 %)	174	28	279
Total	443 (49.9 %)	301	143	887
Boroduliha Region	19 (6.8 %)	246	16	281

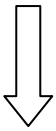
Table 6. Frequency of respondents who answered that they felt heat, classified by radiation exposure level and frequency in the Boroduliha Region

Village	Felt it	Did not feel it	Do not know or No answer	Total
Cheremushki	1 (2.0 %)	29	20	50
Bodene	1 (2.0 %)	26	23	50
Mostik	5 (10.0 %)	16	29	50
Dolon	29 (36.7 %)	12	38	79
Saryzhal	20 (20.2 %)	6	73	99
Subtotal	56 (17.1 %)	89	183	328
Kainar	20 (27.0 %)	14	40	74
Znamenka	7 (9.5 %)	9	58	74
Karauyl	17 (34.0 %)	8	25	50
Korosteli	0 (0 %)	31	1	32
Krasnyi Aul	0 (0 %)	50	0	50
Subtotal	44 (15.7 %)	112	124	280
Grachi	6 (20.0 %)	3	21	30
Burus	2 (4.0 %)	16	32	50
Novopokrovka	1 (2.0 %)	49	0	50
Zenkovka	0 (0 %)	38	11	49
Kamyshenka	0 (0 %)	49	1	50
Boroduliha	0 (0 %)	50	0	50
Subtotal	9 (3.2 %)	205	65	279
Total	109 (12.3 %)	406	372	887
Boroduliha Region	1 (0.36 %)	267	13	281

Appendix.

Question 16: Did you experience something from the nuclear tests?

1. Yes 2. No



For those who selected 1, please answer question 17.

Question 17: What did you experience? Circle the appropriate number from the following choices.

Flash	1. Saw it 2. Did not see it 3. Do not know
For those who saw the light, when did you see it? [Year Month]	
Bomb blast	1. Felt it 2. Did not feel it 3. Do not know
For those who felt the bomb blast, when did you feel it? [Year Month]	
Heat	1. Felt it 2. Did not feel it 3. Do not know
For those who felt the heat, when did you feel it? [Year Month]	