

Iodine prophylaxis around the Semipalatinsk Nuclear Testing Site, Republic of Kazakhstan

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Abstract

Objective: This study aimed to clarify the iodine deficiency status in the Semipalatinsk region that has been contaminated by radioactive fallout from nuclear testing during the period of the former USSR.

Design: Based on the Japan–Kazakhstan joint project of adult cancer screening around the Semipalatinsk Nuclear Testing Site (SNTS), from May to October 2002 spot urine specimens were collected at random in each village. Separately, children aged 5–15 years from around the SNTS were chosen at random and spot urine specimens were collected from them.

Setting: Area contaminated by radioactive fallout around the SNTS, Republic of Kazakhstan.

Subjects: A total of 2609 adults aged >40 years from 16 settlements in three regions and one city, and 298 children aged 5–15 years from two regions and one city.

Results: Median urinary iodine concentrations of adults and children in all regions were in the range of 116.0–381.7 and 127.7–183.0 $\mu\text{g l}^{-1}$, respectively. The highest prevalence of values <50 $\mu\text{g l}^{-1}$ (14.1%) did not exceed 20%. Distributions within each group, adults and children, showed almost the same pattern, except for one region where more than 50% of adults had urinary iodine concentration >100 $\mu\text{g l}^{-1}$.

Conclusions: In agreement with our previous studies, the urinary iodine concentration data showed no clear evidence of iodine deficiency around the SNTS. Kazakhstan is geographically and nutritionally at moderate risk of iodine deficiency disorders without fortification or iodine replacement by iodised salt. The socio-medical prophylaxis against iodine deficiency has been successfully maintained in East Kazakhstan.

Keywords
Iodine deficiency disorders
Urinary iodine
Universal salt iodisation
Semipalatinsk

'Radiation and human health' is a major research topic; the consequences for health from the effects of radioactive fallout are a social and political problem in a world that now must bear negative effects from the Cold War¹. The increased risk of particular cancers among the survivors of the atomic bombing of Hiroshima and Nagasaki, Japan, is well known^{2,3}. Recent data also suggest an increased risk of thyroid cancer after the Nevada Nuclear Testing, probably due to the repetitive nature of the radioactive fallout^{1,4}. A similar situation can be speculated regarding areas in the former USSR, especially around nuclear testing sites.

Over a period of 13 years from 1949, 26 nuclear tests above ground and 87 in the atmosphere were conducted within the Semipalatinsk Nuclear Testing Site (SNTS),

Kazakhstan⁵. There are many small villages, with a population of several hundreds of thousands, scattered in the vast steppe around the site, in an area extremely far from established social and medical infrastructures. Since May 2002, adult cancer screening using a mobile examination vehicle donated by the Japan International Cooperation Agency (JICA) has been undertaken around the SNTS, which is located in the north-eastern part of the Republic of Kazakhstan. This screening is a part of a joint project between Japan and Kazakhstan to improve healthcare services in the region affected by radioactive fallout as the result of nuclear bomb tests; this was undertaken following an official appeal at the 54th UNDP Congress in New York, 1998. Primary medical screening has been performed for early detection of thyroid, breast

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and lung cancers and leukaemia around the SNTS. Subjects were residents >40 years old, who had been indirectly affected by irradiation⁶. Questionnaires including radiation exposure history were taken from all persons who received screening. Blood and urinary analysis, a chest X-ray and ultrasound examination of the thyroid gland and breast were performed in the mobile examination vehicle.

It has been suggested that iodine deficiency might promote the intake of radioactive iodine released from nuclear accidents and nuclear bomb explosions. A dramatic increase in childhood thyroid cancer about 5 years after the nuclear accident in Chernobyl has been reported⁷. This increase might have been due to direct external or internal exposure to short-lived radioactive isotopes such as ¹³¹I and ¹³³I as occurred just after the Chernobyl nuclear accident⁸. However, there are no reliable data concerning the iodine status of the population and the prevalence of goitre at the time of the accident; a national programme to prevent iodine deficiency had not functioned well in this area during the 1970s and 1980s⁹.

In contrast, Kazakhstan, part of the former USSR, is classified as an iodine-deficient country¹⁰. Median urinary iodine concentration < 100 µg l⁻¹ was found in 65% of 494 samples, and only 29% of households consumed iodised salt in 1999¹¹. In 2001 we undertook a preliminary investigation of urinary iodine concentrations and thyroid abnormalities of schoolchildren in areas around the SNTS, where no iodine deficiency and a rate of less than 1.0% for goitre were ascertained¹². We have since attempted to confirm this result on a larger scale by performing urinary iodine measurements as part of an adult cancer-screening programme around the SNTS.

Subjects and methods

Subjects

Subjects came from eight settlements in the Abai district (Karaaul, Kockbay, Kunduz, Arhat, Kaskabulak, Sarjar, Toktams, Medeo) and six settlements in the Abralay district (Kainar, Abralay, Ackbulack, Dogolan, Aynabulak, Tanat), two settlements in the Jana-Semey district (Checkoman, Novo-Pokrov) and from Semipalatinsk City. Any resident aged >40 years could partake of medical screening for this study.

Medical screening was performed from May to October 2002, as a JICA project between Japan and Kazakhstan, in highly radio-contaminated areas within 100 km of the SNTS. To minimise evaluation errors, we followed a recommended sampling protocol¹³. A minimum of 50, and optimally more than 100, casual spot urine samples for general urine examination were collected at random in each village. However, in Tanat village, fewer than 50 samples were collected. The sampling time was during the morning, and there was no restriction of food before

sampling. All samples were kept at 4°C until assay. We analysed a total of 2609 spot adult urine samples at the Regional Diagnostic Center in Semipalatinsk.

Independent of this medical screening, a total of 298 children aged 5–15 years were chosen at random in three regions (Semipalatinsk City, Beskaragay and Kokpekty districts) and spot urine specimens collected from them. Beskaragay district is on the north-east border of the SNTS; Kokpekty, an area known to be uncontaminated by radioactive fallout, is located 250 km away on the south-east of the SNTS.

Measurement of urinary iodine

The urinary iodine concentration was measured by a modified 'simple microplate method'¹⁴, based on the Sandell–Kolthoff reaction, which incorporates both the digestion and the reaction into a microplate format. Briefly, using a specially designed sealing cassette (Atom Kousan Co. Ltd, Tokyo) to prevent loss of vapour and cross-contamination among plates, ammonium persulphate digestion was performed in a 96-well microplate in a standard oven at 90°C for 90 min. Samples were then transferred to another microplate and the reduction reaction of ceric ammonium sulphate carried out at 25°C for 30 min, with results being read on a microplate reader at 405 nm. The sensitivity of this method was > 10 µg l⁻¹.

We expressed urinary iodine concentrations in µg l⁻¹, not related to creatinine, because the urinary iodine excretion of individuals can show day-to-day and within-day variation; however, spot urinary iodine concentrations give useful information in population samples of appropriate size for cross-sectional epidemiological survey¹⁵.

As epidemiological criteria for assessing the severity of iodine deficiency, we adopted the proposals by the World Health Organization, the United Nations Children's Fund and the International Council for the Control of Iodine Deficiency Disorders based on median urinary iodine concentration. Median urinary iodine concentration of < 20 µg l⁻¹ is defined as indicative of severe iodine deficiency disorders (IDD), 20–49 µg l⁻¹ as moderate IDD, 50–99 µg l⁻¹ as mild IDD and ≥ 100 µg l⁻¹ as no IDD¹⁶.

Results

Table 1 summarises median urinary iodine concentrations and presents the percentages of the samples showing values < 50 and < 20 µg l⁻¹. Median urinary iodine concentrations of adults and children in all villages were in the range of 116.0–381.7 and 127.7–183.0 µg l⁻¹, respectively. Even the highest prevalence of median urinary iodine concentration < 50 µg l⁻¹, observed in children in the Beskaragay district (14.1%), did not exceed 20%. Distributions of urinary iodine concentration, in both adults and children, showed almost same patterns, except for adults in one village (Kaskabulak) (Figs 1 and 2).

Table 1 Median urinary iodine concentrations and percentage of the samples showing values <50 and <20 µg l⁻¹

Region	Village	Number	Median urinary iodine concentration (µg l ⁻¹)	Median urinary iodine concentration < 50 µg l ⁻¹ (%)	Median urinary iodine concentration < 20 µg l ⁻¹ (%)	
ADULTS (n = 2609)						
Abai	Karaaul (including Kingirbay)	72	234.0	0.0	0.0	
	Kockbay	156	181.7	6.4	2.6	
	Kunduz	200	171.9	8.0	0.5	
	Arhat	246	197.2	4.7	0.0	
	Kaskabulak	215	381.7	0.0	0.0	
	Sarjar	151	246.9	1.3	0.0	
	Toktams	194	207.3	2.6	0.0	
	Medeo	66	250.9	3.0	1.5	
	Abraly	Kainar	148	202.5	2.7	0.0
		Abraly	170	191.1	2.9	0.0
		Ackbulack	118	232.6	4.2	0.9
		Dogolan	201	196.7	2.5	0.5
		Aynabulak	58	172.5	1.7	0.0
	Jana-Semey	Tanat	42	173.7	11.9	0.0
Checkoman		294	197.0	4.7	0.6	
Novo-Pokrov		79	201.7	3.8	2.5	
		199	116.0	6.5	0.0	
Average			209.1	3.9	0.5	
CHILDREN (n = 298)						
Semipalatinsk City		99	127.7	8.1	1.0	
Beskaragay		99	149.4	14.1	2.0	
Kokpekty		100	183.0	5.0	3.0	
Average			153.4	9.6	2.5	

Comparison with data from Gomel, Belarus¹⁷, where the median urinary iodine concentration is 47.3 µg l⁻¹, reveals good iodine status of the population in the area of iodine prophylaxis around the SNTS (Fig. 3). More than 50% of the population in each group had median urinary iodine concentration ≥ 100 µg l⁻¹.

Discussion

IDD include all illnesses related to iodine deficiency, such as goitre, abortion, stillbirth, neonatal and other types of hypothyroidism, foetal brain damage of varying degrees and cretinism, which can be prevented by a sufficient

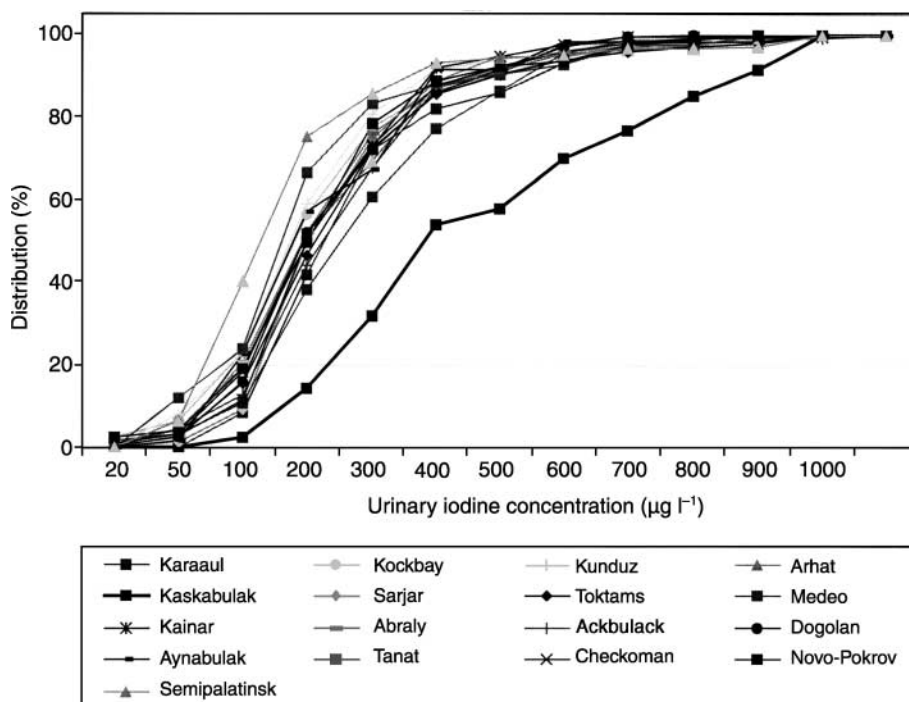


Fig. 1 Distribution of urinary iodine concentration in adults aged >40 years

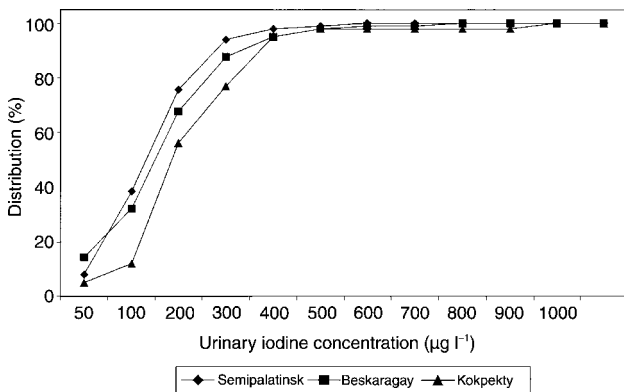


Fig. 2 Distribution of urinary iodine concentration in children aged 5–15 years

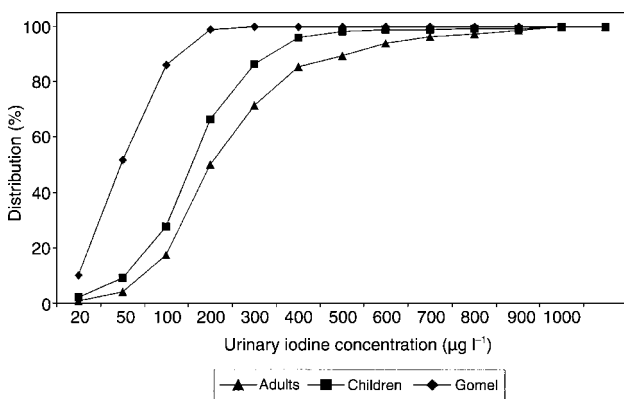


Fig. 3 Distribution of urinary iodine concentration in adults and children around the Semipalatinsk Nuclear Testing Site, Republic of Kazakhstan, compared with that in Gomel, Belarus¹⁷

intake of iodine. Recognition of IDD has resurfaced since the 1990s, and many programmes to eliminate IDD have been initiated around the world, especially after the catastrophe in the former USSR at Chernobyl. Universal salt iodisation is the main strategy of these programmes. Iodine control programmes were undertaken throughout the country with highly successful results¹⁸.

In the former USSR, scientists since the 1940s have suggested a strategy to eradicate endemic goitre by compulsory iodine prophylaxis. Prevention and control of endemic goitre were carried out except for a few years during and after World War II, and iodine deficiency had been almost eliminated by the 1970s. The prevalence of goitre decreased dramatically, and the most serious complications, such as cretinism and large nodular goitre, had almost disappeared⁹. However, the political changes and social upheaval following the break-up of the former Soviet block must be held responsible for the subsequent failure of iodine prophylaxis. The lack of a continuous monitoring system caused a dramatic drop in salt iodisation rates. Iodine nutritional status at the time of exposure to radioactive iodine strongly affects the thyroid radiation dose, because of its effects on thyroid iodine

uptake and thyroid volume. Iodine deficiency may increase the risk of radiation-induced thyroid tumourigenesis. Indeed, we previously reported data suggesting an incompleteness of the iodine supply for iodine prophylaxis around Chernobyl¹⁹. In universal salt iodisation programmes, the importance of monitoring and evaluation is now well recognised^{20,21}.

There are many small villages scattered in the vast territory of Kazakhstan, which covers steppe, desert and forest, far from any ocean. The climate is severe for residents and the soil shows low iodine levels in most areas¹⁰. Without proper fortification of iodine, Kazakhstan would have a moderate risk of iodine deficiency. Because of its vast size and poor accessibility, monitoring of iodine deficiency is extremely difficult to undertake. Regarding iodine deficiency in adults, the thyroid status of pregnant and lactating women aged 15–44 years is of greatest concern²². Although we could not examine this population group in particular, a sufficient number of adult urine samples in this study gives us useful information about the general iodine status around the SNTS.

Our JICA project to improve healthcare services in this area contaminated by radioactive fallout will continue for another 2 years. Furthermore, establishment of a database system of medical screening will give us more direct information on the relationship between radiation exposure and health.

In conclusion, the current situation of iodine nutrition around the SNTS indicates good supplementation. However, continuing attention to iodine nutrition in long-term studies is essential, and there is a need to monitor the potential influence of iodine status on the development of benign and malignant thyroid tumours in response to irradiation or other insults.

Acknowledgements

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