Environmental disruption and human health: reduction of the Aral Sea and the residents' health problem

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Abstract

The Aral Sea has been getting smaller since late 1960s. Residents living nearby complain of health problems. We investigated the health status of school children living in two districts, close to the Sea; K-district and about 500 km east; Z-district in Kazakhstan in the summer of 2000. Total subjects were 383 in K-district and 432 in Z-districts. Socio-economic conditions were better in Z-district. Body mass index (BMI) was not significantly different between the two districts. Prevalence of anemia was higher in K (62.0%) than in Z (38.6%) ($p<0.001$). As to the general health status, the most prevalent recent symptom was headache (13.9% in K and 9.0% in Z) followed by diarrhea (11.3% in K and 5.6% in Z), cough (8.1% in K and 4.6% in Z) and abdominal pain (8.1% in K and 3.9% in Z). In renal function tests, prevalence of abnormal beta-2- microglobulin excretion (>660ug/g creatinine) was 16% in K and 9% in Z, and that of NAG (>13unit/g creatinine) was 4% in K and 3% in Z. Various kinds of element concentrations were determined. Mean values of sodium and chloride in plasma were significantly higher in K than in Z. Number of subjects having high value of sodium (>147 mEq/l) was 31.8% in K and 11.4% in Z.

1 Introduction

Shrinkage of the Aral Sea is called as the biggest environmental destruction in the 20th century. The Aral Sea receives water from Syrdarya River flowing through Kazakhstan

and Amudarya River flowing through Uzbekistan. There is no outlet. It is known that these areas produce rice and cotton. In order to increase crops much water was used for irrigation. In addition, a lot of agricultural chemicals, fertilizers, pesticides, insecticides, herbicides, especially defoliants immediately before harvesting cotton flowers, were applied. As there was no treating system of drainage, it was considered that these chemicals were deposited on land, and some parts were brought to the rivers and then to the Aral Sea. On the other hand, there are many underground resources such as metals in this area. After mining and refining they were discharged to the environments. Some of them were contaminated land, river water, and sediments like chemicals. Jensen et al [1] and Mazhitova et al [2] reported that higher rates of anemia were related to agricultural chemicals or heavy metals in the Aral Sea region.

Water usage of the upper streams further increased, and water volume into the Aral Sea decreased. Kazakhstan government designated that around the Aral Sea area was severely environmental destruction area. There have been increased local concerns of deteriorating conditions of public health for local residents. The actual prevalence of such health problems in this region had not been well documented. The causes which influence human health were also unclear. We investigated the health status of school children living in Kyzylorda State in Kazakhstan in summer, 2000.

2 Methods

2.1 Subjects

Two districts were selected for our servey; as severe and mild environmentally degraded area. Kazalinsk (K) was close to the Aral Sea, and Zhanacorgan (Z) was about 500km east from Kazalinsk (Figure 1). We investigated 9 villages in Kazalinsk and 4 villages in Zhanakorgan. Each village has the health center which keeps residents' records of all villagers. Each 486 school-age children born in 1985 to 1993 (6 to 15 years of age) in both districts were randomly selected from the list of residents' records. Interviewers visited the homes of the selected children. The parents were given a letter of the aim of this investigation and the form of informed consent. Those who accepted this investigation were asked to come to the health center at designated time of the date with the subjected childen and signed informed consent sheets. Total 815 children, 383 in Kazalinsk and 432 in Zhanakorgan, were responded to this survey. The response rate was 84%. Numbers of boys and girls, distribution of each age were not significant difference between two districts. These responded numbers were consisted of 18% of all the same age children in the area.

2.2 Questionnaire

Ten local nurses working at the regional central hospital were trained for one week as interviewers. Interviewers obtained answer from the parents or responsible adults of subject's family members in Kazakh language. Questionnaire contained socio- economic conditions, parents' education periods, general health status, and food frequency

questionnaire. The same interviewers worked in both districts.

2.3 Physique

Children were measured height and body weigh. Height was measured to the nearest 0.1 cm with a scale with steel tape. Children wore minimal cloth and measured weight to the nearest 0.1 kg on a battery-powered digital scale.

2.4 Blood

Subjects who visited the health center in the morning were drawn blood. Total 399 children, 193 in Kazalinsk and 206 Zhanakorgan, provided blood samples. An aliquot of whole blood was put into a glass tube containing EDTA, and then subjected anemia test. The remained blood was put heparin and was centrifuged. Supernatant samples were kept in clean tubes as plasma samples, which were kept in a freezer at -20 C, and brought to Japan.

2.4.1 Anemia test and plasma analysis

Immediately after collecting blood, hemoglobin (Hb), hematocrit (Ht), and red blood cell (RBC) were measured by an automated cell counter (MKE-5207, Hematology Analyzer, Nihon Koden, Tokyo). General clinical test of plasma was performed at the clinical laboratory in our university hospital in Tokyo.

2.5 Urine

Spot urine samples were collected from children who visited the health center in the morning. Total 369 children, 182 in Kazalinsk and 187 in Zhanakorgan, provided urine samples. These samples were kept in a freezer and brought to Japan. General clinical test was performed at the same laboratory which plasma samples were analyzed.

3 Results

3.1 Results of questionnaire

3.1.1 Socio-economic conditions

Fathers' unemployed rates were 49% in Kazalinsk and 42% in Zhanakorgan. Median value of annual cash income was US$ 18 (first quartile 0 and the third quartile 215) in Kazalinsk and US$ 28 (first quartile 0 and the third quartile 340). They were asked possession of electricity, television, radio, refrigerator, motorcycle, bicycle, car and telephone. All possession rates were higher in Zhanakorgan than in Kazalinsk except motorcycles.

3.1.2 General health status

Recent symptoms were defined as those occurred during the last 4 weeks. The results are

shown in Table 1. The most prevalent recent symptom was headache and followed by diarrhea, cough, and abdominal pain. These symptoms were significantly higher in Kazalinsk than in Zhanakorgan. However, prevalence rates of nausea, vomiting, sore through, sputum, dizziness, low back pain, easy fatigue, and fever were not statistically different.

Table 1: Recent symptoms

	Kazalinsk n=381(%)	Zhanakorgan n=428(%)	p
Headache	53 (13.9)	37 (8.6)	0.017
Diarrhea	43 (11.3)	24 (5.6)	0.003
Cough	31 (8.1)	20 (4.7)	0.043
Abdominal pain	31 (8.1)	17 (4.0)	0.012
Lack of appetite	29 (7.6)	14 (3.3)	0.006

3.1.3 Food consumption

Results of food frequency questionnaire were as followings: tea, main staples of breakfasts and lunches were slightly more frequent in Kazalinsk than in Zhanakorgan, but no statistical difference. Fish intake was 3.5 times frequently consumed in Kazalinsk. Nuts and rice were consumed about 2 times frequently in Kazalinsk ($p<0.01$ or 0.05). On the other hand vegetables, fruits, eggs, meets, and confectionaries were 2 to 6 times frequently consumed in Zhanakorgan. They were statistically different.

3.2 Physique

Their height and weight are summarized in Table 2. Body mass index (BMI) was calculated from height and body weight;

$$\text{BMI} = \text{weight (kg)} / \text{height squared (m}^2\text{)}$$

BIM was 16.3 +/- 2.01 in Kazalinsk and 16.6 +/- 2.17 in Zhanakorgan. These values were not statistical deference. (Table 2)

Table 2: Anthropometric valuables

		Kazalinsk		Zhanakorgan	
		n	Mean ± SD	n	Mean ± SD
Heights (cm)	Total	383	137.4 ±14.6	432	138.7 ±14.6
	Boys	190	137.7 ±14.7	217	137.8 ±14.1
	Girls	193	137.2 ±14.6	215	139.6 ±15.1
Body Weight (kg)	Total	383	31.6 ± 9.7	432	32.8 ±10.5
	Boys	190	31.6 ± 8.9	217	32.2 ±10.0
	Girls	193	31.6 ±10.4	215	33.5 ±11.0
BMI (kg/m^2)	Total	382	16.3 ± 2.0	432	16.6 ± 2.2
	Boys	190	16.4 ± 1.6	217	16.5 ± 1.9
	Girls	192	16.3 ± 2.4	215	16.7 ± 2.4

3.3 Anemia test

Analytical results of RBC, Hb, and Ht are shown in Table 3. Anemia was defined as a WHO's cut-off for age and sex; namely 12 g/dl for females and 6-14 years old males, and 13 g/dl for 15 hears old males [Gibson, 3]. Prevalence of anemia was significantly higher in Kazalinsk (62.0%) than in Zhanakorgan (38.6%) ($p<0.001$).

3.4 Plasma analyses

Mean values of sodium and chloride were significantly higher in Kazalinsk than in Zhanakorgan. Number of subjects having high value of sodium (>147 mEq/l) was 31.8% in Kazalinsk and 11.4% in Zhanakorgan.

Table 3: Blood analysis

	Kazalinsk n=379(%)	Zhanakorgan n=425(%)	p
RBC ($x10^4/mm^3$)	510 ±66	480 ±47	<0001
Hb (g/dl)	11.7 ±1.0	12.1 ±1.0	<0001
Ht (%)	43.8 ±5.8	42.4 ±4.3	<0001
Anemia (%)	235 (62.0)	164 (38.6)	<0001

3.5 Renal function

Prevalence of abnormal beta-2-microglobulin excretion (>660ug/g creatinine) was 16% in Kazalinsk and 9% in Zhanakorgan, and that of NAG (>13unit/g creatinine) was 4% in Kazalinsk and 3% in Zhanakorgan.

4 Discussion

Health status of children living in two districts of east side of the Aral Sea was investigated. Kazalinsk locates at the mouth of Syrdarya River, and Zhanakorgan locates about 500 km far from Kazalinsk. The former one is severely destructed environmental area, and the latter one is slightly destructed environmental area. As the background of children's living conditions, economical situation was interviewed. Fathers' unemployed rates were not different. Annual cash income was not statistical difference, and the minimum income was zero in both districts, however the third quartile was more than US$ 100 higher in Zhanakorgan. The usage rates of electricity and telephone were higher in Zhanakorgan. Kazalinsk is step area and inconvenient to reach to the other cities, while Zhanakorgan has the advantage of geographical situation. Those who live in Zhanakorgan can obtain fruits and vegetables not only by their own garden due to better weather in comparison with Kazalinsk but also by supplying from southern Kazakhstan state or others. It is estimated, therefore, children living in Zhanakorgan have more convenient lives.

As shown in Table 2, children's physique in both districts was not different. This fact means that energy intake was adequate.

As to anemia, prevalence rate was high in both districts; especially more than 60% of children tested were anemia in Kazalinsk. But more than 95% of them were mild anemia, of which Hb concentrations were between 10.0 and 12 g/dl for 6-14 years old and 15 years old females or 13 g/dl for 15 years old males. It is considered that iron intake was not inadequate, but iron-absorption in intestine was inhibited.

In the renal function, there was extremely high percentage of abnormality of bete-2-microgloblin excretion [Kaneko, 4]. This is also higher in Kazalinsk than in Zhanakorgan. It is clear that renal tubular impairment occurred. The cause of disorder of the renal function will have to be investigated.

In the general health status, complaining rate of diarrhea had the largest different between two districts. It may cause drinking water or an extent of general cleanliness. They live with domestic animals closely.

About 10% children complained headache. About 5 % of children had cough, abdominal pain, or lack of appetite. It is considered that one of the causes might be lowered resistance of physical ability, and it might depend of nutritional conditions.

Relationship between health status and environmental condition must be considered. The Aral Sea has saline water, therefore, salt concentration increased after shrinkage. They use salty drinking water. Some times sodium concentration in drinking water was over 800 mg/l. As described above, sodium and chloride concentrations in plasma were higher

in some residents. This may reflect environmental problem.
Besides, large scale of previous sediments, which might be contained with agricultural chemicals and heavy metals having reversed effects to organisms, are now exposed under the Sun.
It is needed to build strong bodies. In order to do so, it is needed nutrition education and environmental protection.

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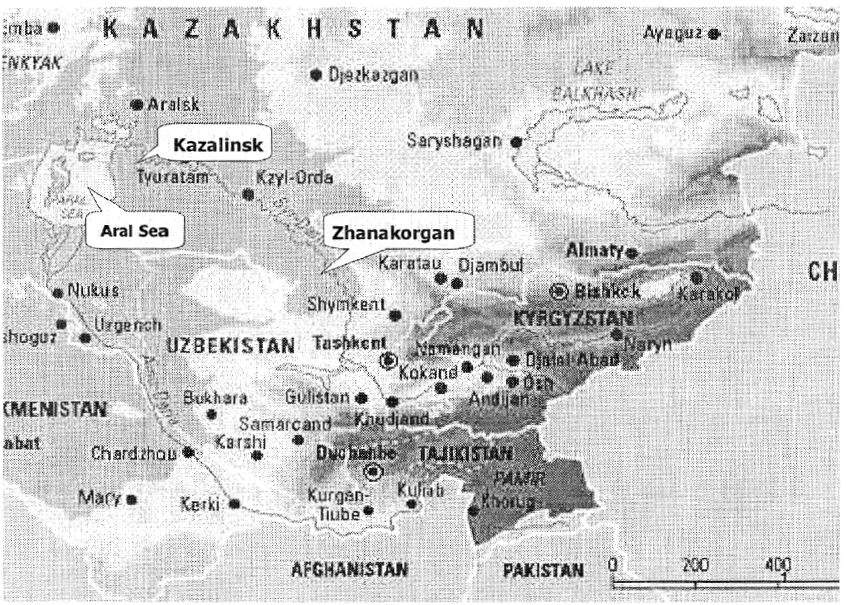

Figure 1: Location of the Aral Sea, Kazalinsk and Zhanakorgan