Paper:

Effects of Radioactive Contamination from the Semipalatinsk Nuclear Test Site on Behavior Related to Food Choices: A Case Study of Kazakhstan

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[Received March 10, 2020; accepted May 19, 2020]

In this article, we analyzed the effects of radioactive contamination from the Semipalatinsk nuclear test site on food choices in Kazakhstan. Nearly 90% of citizens in Kazakhstan knew their health had been affected by radioactive material from the nuclear test site, with more than 50% of citizens still confirming the safety of foodstuffs regarding radioactive materials when purchasing food. However, citizens in the vicinity of the nuclear test site did not take countermeasures against internal exposure due to declining fear of radioactivity, despite refraining from purchasing food from near the nuclear test site. More than 80% of Kazakhstan understood that exposure to radioactive materials was both external and internal. Further, Kazakhs were more aware of the effects of internal exposure on the human body than either Ukrainians or Japanese. Elderly people who remembered the times when nuclear tests had been conducted were aware of radioactive materials in food. High-income individuals took measures to control radioactive contamination in consideration of their nutritional balance, while low-income individuals refrained from purchasing food from near the nuclear test site as a means of controlling potential contamination. In Kazakhstan, more than 60% of citizens did not take measures against internal exposure, but the number of citizens who were concerned about radioactive materials was much higher than in either Ukraine or Japan. In Kazakhstan, 30–40% of citizens, particularly women, would buy at least 20% more if foodstuffs with lower than the regulated level of radioactive materials were sold.

Keywords: the Republic of Kazakhstan, Semipalatinsk test site, radioactive contamination, ordered logistic regression analysis, tobit regression analysis

1. Subject

Kazakhstan is located at the center of the Eurasian Continent, has the 9th largest territorial area and is the largest landlocked country in the world [1]. The geographical features open to the all directions and the steppe of this country has caused the vulnerability to the disturbances of war and disasters [2]. Because there is vast semiarid area of steppe in Kazakhstan, the Government of the Soviet Union used Semipalatinsk in the north as the nuclear test site. After the status of Kazakh Autonomous Socialist Soviet Republic had been raised to Kazakh Socialist Soviet Republic on December 5, 1936, the country had been put under the control of the communist regime until December 16, 1991. Under the communist regime Semipalatinsk was selected as the nuclear test site by Lavrentiy Beria, a person with ultimate responsibility for the development of atomic bomb in the Soviet Union, in 1947 [3]. Two years later on August 29, 1949 Igor Kurchatov who was the general director of the project to develop atomic bomb in the Soviet Union and is called "father of atomic bomb" succeeded in the first nuclear test in the Soviet Union at the Semipalatinsk Test Site [4]. Since then 456 nuclear tests were conducted repeatedly over 40 years until October 19, 1989. Finally on August 29, 1991, 42 years after the first nuclear test the Semipalatinsk Test Site was closed officially, but the overall picture on the nuclear tests was not clarified until immediately before the closure.

The first study on the Semipalatinsk Test Site is the report to measure the radioactivity and identify the radiation dosage to which the residents on the lee side were exposed [4]. It is reported that acute radiation syndrome appeared under about 250,000 residents in Ust-Kamenogorsk located 402 km leeward in the middle of September, 1956 and 638 residents who were exposed to radiation were brought to the third clinic, the current Kazakh Scientific Research Institute of Radiology and Ecology [5–8]. It is also reported in this report [4] that the internal exposure dose caused by inhalation of radioactive material around Ust-Kamenogorsk could have reached to

140 mSv in a year, but this was explained as a result of "bacterial contamination" in 1957 [5, 8, 9]. After the independence of Kazakhstan, the residents who lived on the lee side of the nuclear test site were informed that the crops, etc., were contaminated in high concentration by radioactive material [5, 8, 9]. The Kazakh citizens did not know the influences caused by internal exposure to radiation, because the government of the Soviet Union concealed the information on the contamination. And they did not recognize in their ordinary life the danger brought by swimming and fishing in so-called "atomic lake," Lake Chagan, formed by the peaceful nuclear explosion (Chagan nuclear test) conducted around the water-scarce Chagan River [9].

Many previous studies on the Semipalatinsk Test Site are social and medical ones. Hirabayashi et al. [10, 11] conducted in cooperation with the Kazakh Scientific Research Institute of Radiology and Ecology the questionnaire survey for the residents living near the nuclear test site especially in terms of their health, route of radiation exposure and the contents and psychological influences from the experiences on the nuclear tests and collected their testimonies. Hirabayashi et al. [11] indicates that 17.3% of the residents living near the nuclear test site have been psychologically influenced and the psychological influences could affect their health disadvantageously. And Taira et al. [12] indicates that the artificial radioactive nuclide which was released in massive quantities still exists in the environment and there would be the risk of exposure to radiation, although the level of such artificial radioactive nuclide is lower compared to that in the past.

According to Pearce [8, 9], the residents living near the nuclear test site will not change their lifestyle in spite of their stress and fear, walk around in the steppe contaminated by radioactivity, grow the grass for their livestock and pick wild strawberries, ignoring the orders by the Government. Indeed as in the case of Kawano [13], there is a study which collects the testimonies on radiation exposure from the residents living near the nuclear test site, keep the records on the experiences and thoughts of the those exposed to radiation and clarify the actual situations of radiation exposure. And Hirabayashi [14] reports as a result of the survey on the correlation between disease or handicap and the nuclear tests that 61.9% of victims consider "the disease is caused by the nuclear tests." However, no survey can be found, which refers to the actual situation on food, that is whether the local residents took actually the contaminated food or not.

Takemine et al. [15] points out that the victims of the nuclear tests are socially protected in Kazakhstan and the comprehensive measures have been taken to recover the ecology in the areas contaminated by radioactivity. Taira et al. [16] analyses as a result of the analysis on the contaminated earth taken from around the Chernobyl nuclear power plant and the Semipalatinsk Test Site that the radiological dosage could be reduced by removing the surface soil. In the above country the food produced in the contaminated areas are always examined and the measures have been taken to recover the areas contaminated by radioactivity to be utilized economically [16]. Hirayama et al. [12] points out that the health impact assessment and the environmental monitoring should be followed up in a long term in the future and the unnecessary radiation exposure should be decreased in spite of the fact that the internal exposure to radiation caused by taking food is less compared to the external exposure. However, no study can be found, in which the local residents would evaluate whether the measures were taken not to take the radioactive material in eating food in the time when Kazakhstan was put under the control of the communist regime of the Soviet Union and the related information was concealed.

Stawkowski [17] mentions that many local residents have developed their own point of view such as "I have been muted to be adapted to radiation and the genes have evolved for the perfect adaptation," "I have been able to accept the ecology contaminated by radioactivity" or "I have evolved to survive the detrimental environment." Although there are the unique results of the folklore studies, no study can be found, which surveys which kind of knowledge in terms of the radioactive material the ordinary Kazakh citizens have and denies the above-mentioned peculiar point of view.

After the independence Kazakhstan has enacted the Republic Act 1788-XII (1992) to protect the victims suffering from the nuclear tests.[1] In Article 4 of Chapter 2 of the same Act the contaminated area are classified into 5 zones.[2] According to Article 11 of Chapter 3 of the same Act, the victims suffering from the nuclear tests are recognized as "victims of Semipalatinsk."[3] In Article 12 of Chapter 4 of the same Act, the temporary compensation for the damage suffering from the nuclear tests is guaranteed for the citizens who lived in 5 zones depending on each zone.[4] However, as the provisions in terms of the food only "implementation of regular inspection of the food produced locally" is stipulated in Article 16 of Chapter 5 of the same Act.[5] And in the policies on social protection the food inspection shall be carried out for the citizens and others who lived in 5 zones since the independence of Kazakhstan but not for the residents in other areas. The categories of the citizens to be protected socially under the same Act are further classified into the residents and immigrants in 5 zones and those recognized as "victims of Semipalatinsk," etc., depending on the time

1. The formal name is "On social protection of citizens who suffered from nuclear tests at the Semipalatinsk nuclear test site" [15, 18].
2. In Chapter 2 "Classification of areas exposed to nuclear testing," Article 4 "Classification of areas affected by radioactive fallout during nuclear testing," the contaminated areas are divided into five zones: "extraordinary radiation risk zone," "maximum radiation risk zone," "increased radiation risk zone," "minimum radiation risk zone," and "territory with preferential socioeconomic status" [15, 18].
3. According to Chapter 3 "The status of citizens affected by nuclear tests at the Semipalatinsk nuclear test site," Article 11 "Certificates of citizens affected by nuclear tests," the certificate recognizing the right to receive the preference and compensation is granted to the victims [15, 18].
4. In Chapter 4 "Social protection of citizens affected by nuclear tests at the Semipalatinsk nuclear test site," Article 12 "Benefits and compensations for citizens affected by nuclear tests," the temporary compensation for the damage suffering from the nuclear tests is guaranteed for the citizens who lived (or lives or works) in 5 zones referred to in Article 4 of Chapter 4 depending to the zone [15, 18].
5. See the provisions in Chapter 5 "Ecological improvement of territories and medical care to the population," Article 16 "Ecological improvement of territories exposed to nuclear testing" [15, 18].

and period of residence in the damaged areas. Therefore, the categories of the citizens could affect the choice action of the meal.

And Nakamura and Maruyama [19] takes the case in Japan and considers the measures against the contamination of food by radioactive material one year after the Fukushima Daiichi nuclear disaster on March 11, 2011 for the parents of the children with 12 years or under in Tokyo Metropolis. As a result the study shows that more than 60% of the parents are interested in radioactive material, more than 50% confirm the place of origin of food and purchase the agricultural and livestock products produced far from the nuclear plant, and women take the measures against the contamination [19]. And Yamamoto et al. [20] considers the internal exposure to radiation and the consumption behavior 5 years after the Fukushima Daiichi nuclear disaster for the pregnant women in Soma City the southern part of which had been designated as evacuation order zone. As a result of the survey, the study shows that more than 75% of the pregnant women consider the purchase of the local food as anxious [20]. The Consumer Affairs Agency in Japan [21] conducted the survey about the consumer consciousness on the damage caused by harmful rumors. Form this study it can be understood that the number of the consumers who answer that they want to purchase the food without radioactive material decreased, but 55.9% of the consumers purchase the food, paying attention to the origin of the food even in February, 2020.

As stated above the choice action of meal of the Japanese has changed since the Fukushima Daiichi nuclear disaster, but no study can be found, which surveys whether the choice action of meal of the Kazakh citizens has changed more than 40 years after the Semipalatinsk nuclear tests or not. Accordingly, this study takes the case of the Republic of Kazakhstan and analyses statistically and considers the influences of the radioactive contamination from the Semipalatinsk Test Site on the choice action of meal. And this study also analyses statistically whether the Kazakh citizens are concerned about radioactive material, whether they take the measures against oral internal exposure to radiation and whether there is any difference of the attitude according to the personal attributes or not.

2. Method of This Study

2.1. Structure of This Paper

This paper consists of the following structure.

In Section 2, the structure of this paper, the design of the questionnaire and the method of comparison are explained as the method of this study.

In Section 3, it is considered after grasping the location of the Semipalatinsk Test Site to what extent the citizens have the knowledge on radioactive material in food, to what extent they trust the information disclosed by the government of the former Soviet Union, to what extent they confirm the safety and to what extent they take the measures against radioactive material in food.

In Section 4, it is considered which measure would influences the measures against the contamination of radioactive material in food. And the correlations are estimated statistically.

In Section 5, the influences of the radioactive contamination from the Semipalatinsk Test Site on the choice action of meal are summarized.

2.2. Design of Survey, Method of Comparison, and Method of Estimation

2.2.1. Design of Survey

In this section, the design of the survey is explained. In the nuclear power plant accidents such as Chernobyl and Fukushima the Central Governments concealed the accident situation including the spread of radioactive material immediately after the accidents. However, the accident information is almost disclosed by the Central Governments in the end in the case of nuclear power plant accident. In Belarus, the actual situation of the contaminated areas after the Chernobyl nuclear power plant accident, the health risk by oral internal exposure to radiation, the social security for the victims and the policies to restore the agriculture in the contaminated areas have been reported by the Government Reports since the enactment of the Chernobyl Act [22]. In Belarus after the Chernobyl nuclear power plant accident, the contaminated areas have been controlled, the regulation values for radioactive material are set, the oral internal exposure to radiation has been prevented for the citizens by the Chernobyl Act, and the agriculture has been restored step by step by the national plan [23]. However, the residents on the lee side were not informed of the spread of radioactive material, because the government of the Soviet Union concealed the fact. In Kazakhstan different from the counties suffering from the nuclear power plant accidents such as Japan, Ukraine, and Belarus, the education on radiation is not carried out.[6] For this reason, it is examined in this paper whether two hypotheses that the Kazakh citizens "have poor knowledge on radioactive material in food" and they "don't take any measure against the oral internal exposure to radiation in purchasing food" could be rejected.

For the survey the Web questionnaire was made using SurveyMonkey. And the questionnaire was sent to the consumer panel to conduct the survey. The questionnaire is written in Russian. The survey area is the whole of Kazakhstan. 351 respondents answered the questionnaire and 304 of them answered completely. The data collection period ranges from September 20 (Friday) to September 21 (Saturday), 2019 in Japan time zone.

In selecting the samples Quota Method may be used, in which the samples are classified by combining sex and

6. There is a report on the questions and answers in terms of how to educate the schoolchildren in terms of the knowledge on radiation, when the delegate from the House of the Councilors of Japan inspected the Second Astana Pediatric Hospital [24]. It is reported in this report that the news about radiation are covered and the children learn radiation actively around Semipalatinsk but the state does not carry out the education on radiation [24].

age, etc., and selected from each of the combinations in proportion to the population. In SurveyMonkey the samples cannot be extracted according to the state and region in Kazakhstan. Therefore, the sampling followed the distribution of the population in the consumer panel. However, the samples are expected to be biased due to the limitation of the internet survey, because the numbers of those who live in and around Almaty State with many population and range from twenties to forties are high, the number of the middle-aged and the elderly is low and many have high academic background such as university graduate and engineer.

2.2.2. Method of Comparison

In this survey, mainly three countries of Japan [19], Ukraine [25], and Kazakhstan (this paper) are compared for consideration in terms of the following evaluation items: (1) to what extent the citizens confirm the safety against radioactive material, (2) whether they take any measure against the contamination, (3) whether they have the related knowledge, what the reason is why they don't take the measures, and (4) which measures they take.

The almost same questions are asked in the evaluation items of (1), (2), and (3) among Japan, Ukraine, and Kazakhstan and in the evaluation items of (4) and (5) between Ukraine and Kazakhstan. The Ukrainian citizens have rich knowledge on radioactive material in food and more than 90% of them confirm the safety of radioactive material in food even today 30 years after the Chernobyl nuclear power plant accident [25]. As for the above evaluation items, it is examined by comparison to what extent there is a statistical difference between the citizens of the countries where the aggregate results have been obtained and the Kazakh citizens.

Furthermore, as for the item on (6) "whether the citizens will purchase the food with more money or not, if the food with lower than the regulated level of radioactive material is sold," mainly three countries of Ukraine [25], Sweden [26], and Kazakhstan are compared for consideration.

As the food to be eaten with the special attention to oral internal exposure to radiation edible mushroom, edible wild plants, wild grasses, fishes in lakes and marshes, potato, milk and dairy products etc. are mentioned in Ukraine [25] and fishes in sea, lakes and marshes, edible mushroom, meat and potato etc. in Sweden [26]. In this paper flour and mutton are taken up as the representative food which is eaten generally in Kazakhstan and it is examined by comparison whether any statistical difference would be recognized in the willingness to pay for both foods depending on the personal attributes.

2.3. Method of Estimation

In this section, the method of estimation is explained. As mentioned above on the method of comparison in the previous section to compare three countries of Japan, Ukraine and Kazakhstan in the ordinal logit model and to compare three countries of Ukraine, Sweden, and Kazakhstan in Tobit model the objective variables and the explanatory variables are unified for the estimation.

2.3.1. Analysis on Actual Situation of Knowledge in Terms of Nuclear Tests

First, "Damage caused by radioactive material from nuclear tests," "Reliability of information disclosure by the government of the former Soviet Union" and "Confirmation of safety of radioactive material in food," are set as the objective variables and estimated by the ordinal logit model. Taking "Damage caused by radioactive material from nuclear tests" as an example, estimation is made, supposing Don't know at all = 1, Don't know so much = 2, Neither know nor don't know = 3, Know a little = 4, and Know well = 5.

Next, "Knowledge on radioactive material in food" is set as the objective variable and estimated by the ordinal logit model. Taking "knowledge on external and internal exposure to radiation" as an example, estimation is made, supposing Don't know at all = 1, Don't know so much = 2, Neither know nor don't know = 3, Know a little = 4, and Know well = 5.

Only 7 kinds of personal attribute are introduced as the explanatory variables for the estimation. Ogiu et al. [27] conducted the epidemiological survey for the residents living around the Semipalatinsk Test Site. And as a result of the analysis using multivariate analysis, it is concluded that both of neoplasm and circulatory system disease are largely influenced by sex, age, and race. Therefore, the individual attributes are introduced in the estimation formula in this paper.[7] Three explanatory variables in terms of personal attributes, namely sex (male = 1, female = 0), region (East Kazakhstan State = 1, Other than East Kazakhstan State = 0) and child of 12 years or under (Have = 1, Don't have = 0) are introduced as the qualitative variables (dummy variables). East Kazakhstan State is introduced as dummy variable, because many residents who are recognized as "victims of Semipalatinsk" are expected to be included there.

Furthermore, age, number of members of household, education (career), and income (average earnings) are introduced as the continuous variables. In this paper, as for age and income, the class values of each class (for example, 45 years old in the class of age "40–50 years old" and 15,000 KZT in the class of income "10,001–20,000 KZT") are calculated and are introduced to the continuous variables as discrete variable. And as for education (career), the values are introduced to the explanatory variables as sored discrete variable such as "high school 1–postgraduate school 4."[8]

7. According to Ogiu et al. [27], the tendencies are recognized that circulatory system disease tends to increase in the group of high dose for male and circulatory system disease and ischemic heart disease tend to increase in the group of high dose for female.
8. As for education, there is a method for measurement by disassembling such as high school graduate, junior college graduate, university graduate, and postgraduate completion dummies, but the sored discrete variables are introduced as the proxy variable for education years in the estimation.

In the estimation, the categories of the dependent variables are integrated, if a difference between the classes is not statistically significant or if number of respondents is few. And in the estimation, only the optimal estimation results are shown, taking the values of AIC and likelihood ratio into consideration. Each explanatory variable is estimated by deleting the explanatory variables with the significant level of 20% or more and leaving the ones with the significant level of 1–10% by using Backward Selection method until the optimal estimation result can be obtained.

"cut" in tables below indicates the threshold variable and has the following relations: $Pr(y = 1) = Pr(\beta x < cut1)$, $Pr(y = 2) = Pr(cut1 < \beta x < cut2)$ (y is category of dependent variable, x is explanatory variable, and β is parameter).

2.3.2. Analysis on Situation of Measures Against Radioactive Material in Food

Furthermore, "Measures against radioactive material in food" is estimated by using the ordered logit model to grasp to what extent there would be the correlations with the reasons why the measures are not taken and the measures which are taken. And the marginal effects are also estimated.

"Measures against radioactive material in food" are set as the objective variables and estimated, supposing Don't take at all = 1, Don't take so considerably = 2, Neither take nor don't take = 3, Take in some degree = 4, and Take considerably.

"Reasons why no measure against oral internal exposure to radiation is taken" and "Measures to be taken not to take radioactive material in food" are also introduced as the explanatory variables in the estimation formula. And the results of each explanatory variable are shown by deleting the explanatory variables with the significant level of 20% or more.

2.3.3. Analysis on Situation of Responses to Oral Internal Exposure to Radiation

In addition, "Reasons why no measure against oral internal exposure to radiation is taken" and "Measures to be taken against oral internal exposure to radiation" are set as the objective variables and estimated using the binominal logit model on whether there are correlations with the personal attributes. 7 personal attributes mentioned above are introduced as the explanatory variables for the estimation. Also in the binominal logit model the results of each explanatory variable are shown by deleting the explanatory variables with the significant level of 20% or more.

2.3.4. Analysis on Willingness to Pay for Food with Lower than Regulated Level of Radioactive Material

Finally, the willingness to pay for flour and mutton with lower than regulated level of radioactive material is estimated using Tobit model for consideration.

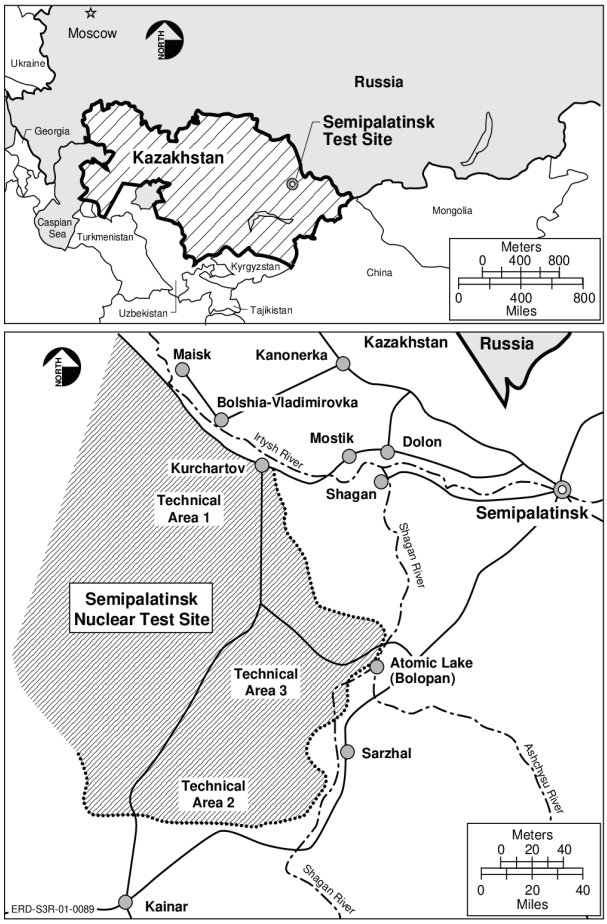

Fig. 1. Kazakhstan and Semipalatinsk Test Site.

"Willingness to pay for flour and mutton with lower than regulated level of radioactive material" is set as the objective variable and 7 personal attributes are introduced as the explanatory variables for the estimation. Also in the Tobit model the results of each explanatory variable are shown by deleting the explanatory variables with the significant level of 20% or more.

3. Outlines of Survey

3.1. Outlines of Survey Areas – Kazakhstan and Semipalatinsk Test Site

Before considering the survey results the survey areas are outlined. Former Semipalatinsk City is renamed Semey City [28]. Semipalatinsk was founded as one of the strongpoints for expansion to Siberia in the 18th century in the time of Czarist Russia [28]. Semipalatinsk is located near the birthplace of a poet Abai Qunanbaiuly who has been respected as father of Kazakh culture and has flourished as the gateway to the European culture such as literature and art since the 18th century [28]. And Semipalatinsk is also famous for the fact that novelist Fyodor Dostoevsky stayed there for nearly 5 years in the middle of the 19th century [28].

Figure 1 shows the location of Kazakhstan and Semi-

palatinsk. The nuclear test site is located in the steppe 150 km in westward direction from Semey (indicated as Semipalatinsk in **Fig. 1**) in the eastern part of Kazakhstan. And its area is 18,500 km^2 equivalent to that of Shikoku in Japan [29]. 60 km in westward direction from Semey is located a military secret city, Kurchatov [28]. In this nuclear test site, 126 atmospheric nuclear tests up to the class of 1,000 kt and 340 underground nuclear tests were conducted since the first nuclear test.[9] It was the top secret of the government of the former Soviet Union that the acute radiation syndrome caused by the nuclear tests developed 4 times as much as the number in the case of the Chernobyl nuclear power plant accident [32]. Because the nuclear tests themselves were treated as the top secret, the residents who lived on the lee side of the nuclear test site were never informed of the plan of the nuclear tests [4]. The residents there saw mushroom cloud rising, but nobody could ask what happened under the control of Stalin [8, 9]. However, the government of the Soviet Union knew that the damage was not limited to several farmers, but the radioactive material fell on the large cities such as Ust-Kamenogorsk (currently Oskemen) holding a closed city, Kurchatov [6].

In the top secret of Moscow, it is described at first after how long period the scientists of the former Soviet Union should disclose the health disorder and the concealed institute [32]. The radioactive fallout released when the former Soviet Union conducted the nuclear test on August 29, 1949 for the first time moved to Dolon village (see **Fig. 1**) 113 km in eastern direction from the nuclear test site by wind and hit the village directly [33]. Leonid Ilyin, director of the Russia Institute of Biophysics, remembers 40 years after the nuclear test that "because the nuclear test was the confidential matters, the villagers were not recommended to evacuate indoors, but were left as they were" [33]. He estimated also that 21,400 residents who lived in Uglovsky district, Altai Region of Russia bordering Kazakhstan would have been exposed to the radiological dosage of 800 mSv 40 times as much as 20 mSv for occupationally exposed personnel in a year [33]. The radioactivity released from the nuclear test on 12. August, 1953 moved from Sarzhal village (see **Fig. 1**) to Karaul village around Technical Area 3 in the air and many patients showing the clear symptoms of radiation syndrome were confirmed, but it is written in the report of Moscow that it was difficult for the surgeon to distinguish between brucellosis and radiation syndrome [6, 10]. In Kaninar village (see **Fig. 1**) in southern direction from Technical Area 2, the serious health damages have become clear beyond the generations even after the year of 2000 such as a series of births of babies with the various disabilities and the rapid increase of suicide of teenagers [34].

3.2. Sample Attributes

Kazakhstan is still contaminated in a wide area by radioactive material caused by the nuclear tests. Accordingly, this study conducts the questionnaire explained in the previous chapter to analyze the influences of the radioactive contamination from the Semipalatinsk Test Site on the food selection behavior statistically.

Table 1 shows the sample attitudes. First as for sex, male accounts for 37.2% and female 62.8%. The respondents who have child or grandchild with 12 years or under in their families account for 62.8%. As for the residential area, Almaty State bordering East Kazakhstan State southward accounts for 36.2% and Akmola State holding the capital Nur-Sultan 13.5%. And East Kazakhstan State where the nuclear test site is located accounts for 7.9%, Karagandy State adjoining East Kazakhstan State westward 7.9% and Pavlodar State adjoining East Kazakhstan State northwestward 7.2%. It is expected for the data in this paper that the respondents would be concentrated in Almaty State with the most population, but East Kazakhstan State and three states adjoining it, Almaty, Karagandy and Pavlodar States account for 59.2%. As for occupation, the percentage of general office work (33.2%) is the highest and those of engineer/specialist (16.1%) and self-employment (13.2%) are also high. And housewife/househusband accounts for 7.9%, person seeking employment 4.6%, retired person 3.0%, and recuperating patient, etc., 1.0% and others, that is those who don't have occupation account for 18.5%. The average age is 37.4 years old. And the percentage of 30–39 years old (37.8%), that of 40–49 years old (27.0%), that of 20–29 years old (24.7%) and that of 50–59 years old (6.3%) are high.[10] The year when the nuclear test was finished is 1989 and just 30 years have passed since then on the day of survey. It is expected that the difference between those who know the nuclear tests and those who don't know them would be reflected in the estimation results according to the average age. As for academic background, the percentage of university (59.9%) is the highest and junior college and vocational school account for 16.8% and postgraduate school 15.1.%[11] The average monthly income is 133,926 KZT which is converted to 346.7 USD with the rate of 1 KZT = 0.00257637 USD. The monthly income in Kazakhstan in September, 2019 is 487 USD and the income level of the data of this paper is lower in some degree. As for the income class, the percentage of 100,001–120,000 KZT is 10.9%, the highest and 120,001–140,000 KZT accounts for 9.2%. According to the United Nations (2009–2017) the Gini coefficient of Kazakhstan of 27.5 is small and ranked 9th among 152 countries with such statistics. However, larger income differentials than those of the statistics of the United

9. Because the information on the Semipalatinsk Test Site had been concealed for a long time, there are differences in terms of the official information [30]. Doctor Mikhailov who served as the Minster of Nuclear Energy of the Russian Federation from 1992 to 1998 reports 30 aboveground nuclear tests, 86 nuclear tests in the air and 340 underground nuclear tests [31]. President Nursultan Nazarbayev, the Kazakhstan National Nuclear Center, the Ministry of Defense of the Russian Federation and the Agency of Nuclear Energy of the Russian Federation also claim 456 nuclear tests. Accordingly, this paper adopts 456 nuclear tests as the official number.

10. The average age in Kazakhstan is 30.68 years old (the United Nations, 2020), the population rate of 15 years old or under 28.46% (the World Bank, 2018), that of 15–64 years old 64.15%, that of 65 years old or over 7.39%. The average age of the samples of this paper is a little higher.

11. The rate of 4-year university graduate is 51.46% (UNESCO, 2018) which is not so different from the rate in this paper.

Table 1. Sample attributes ($n = 304$).

Personal attributes		Frequency	Rate	Personal attributes		Frequency	Rate
Sex	Male	113	37.2%	Occupation	General office work	101	33.2%
	Female	191	62.8%		Public employee	27	8.9%
Age	19 years old or under	3	1.0%		Factory worker	19	6.3%
	20~29 years old	75	24.7%		Engineer/specialist	49	16.1%
	30~39 years old	115	37.8%		Self-employment	40	13.2%
	40~49 years old	82	27.0%		Housewife / househusband	24	7.9%
	50~59 years old	19	6.3%		Retired person	9	3.0%
	60~69 years old	7	2.3%		Person seeking employment	14	4.6%
	70 years or over	3	1.0%		Student	6	2.0%
	Average, SD	37.4	10.6		Recuperating patient / on leave / maternity leave	3	1.0%
Academic background	Junior high school	4	1.3%		Others (farmer 1 / teacher 3 / others)	12	3.9%
	High school	21	6.9%	Monthly income	10,000 KZT or less	12	3.9%
	Junior college and vocational school	51	16.8%		10,001-20,000 KZT	4	1.3%
	University	182	59.9%		20,001-30,000 KZT	6	2.0%
	Postgraduate school	46	15.1%		30,001-40,000 KZT	2	0.7%
State	Almaty	110	36.2%		40,001-50,000 KZT	8	2.6%
	Aqmola	41	13.5%		50,001-60,001 KZT	14	4.6%
	Aqtobe	7	2.3%		60,001-70,000 KZT	16	5.3%
	Atyrauy	7	2.3%		70,001-80,000 KZT	22	7.2%
	East Kazakhstan	24	7.9%		80,001-90,000 KZT	18	5.9%
	Mangystau	7	2.3%		90,001-100,000 KZT	24	7.9%
	North Kazakhstan	13	4.3%		100,001-120,000 KZT	33	10.9%
	Pavlodar	22	7.2%		120,001-140,000 KZT	28	9.2%
	Karagandy	24	7.9%		140,001-160,000 KZT	21	6.9%
	Kostanay	16	5.3%		160,001-180,000 KZT	19	6.3%
	Kyzylorda	3	1.0%		180,001-200,000 KZT	16	5.3%
	Turkistan	15	4.9%		200,001-225,000 KZT	13	4.3%
	West Kazakhstan	7	2.3%		225,001-250,000 KZT	11	3.6%
	South Kazakhstan	8	2.6%		250,001-275,000 KZT	5	1.6%
Child	Have child with 12 years or under	191	62.8%		275,001-300,000 KZT	10	3.3%
	Don't have child with 12 years or under	113	37.2%		300,001 KZT or more	22	7.2%
Average and SD of number of household members		3.68	1.3		Average, SD	133,926	80,960

Source: made from the survey results by SurveyMonkey
Note 1: "Child" indicates those who are junior high school student or younger.
Note 2: The average and SD (standard deviation) of age and income are calculated using the class value.
Note 3: "Others" include one farmer and three teachers.
Note 4: Although Nur-Sultan is ordinance-designated city (capital), this is included in Aqmola State. And although the largest city, Almaty is ordinance-designated city, this is included in Almaty State.

Nations can be recognized from the income classification of this paper.

3.3. Damage Caused by Radioactive Material from Nuclear Tests, Reliability of Governmental Information Disclosure by Government of the Former Soviet Union, Safety Confirmation of Radioactive Material in Food, Measures Against Radioactive Material in Food

Table 2 shows the results of evaluation on whether the Kazakh citizens could trust the information disclosure by the government of the former Soviet Union, whether they would confirm radioactive material in food and whether they would take the measures against radioactive material in food or not.

3.3.1. Damage Caused by Radioactive Material from Nuclear Tests

First the evaluation item of "Knowledge on damage caused by radioactive material from nuclear tests" is treated. In this item, it is asked whether the respondents know that the citizens suffered from radioactive material or not. As a result, the percentage of "Know a little" (47.7%) is the highest and adding "Know well" (40.5%) together, as much as 88.2% of the respondents know that the citizens suffered from radioactive material.

3.3.2. Reliability of Governmental Information Disclosure by Government of the Former Soviet Union

Next, the evaluation item of "Reliability of governmental information disclosure by government of the former Soviet Union" is treated. It is after the independence of Kazakhstan from the former Soviet Union when the actual situations on the radioactive contamination from the Semipalatinsk Test Site have been revealed. At the time in 2019 when the survey was conducted, the Kazakhstan Government is responsible for the information disclosure on the damage caused by the nuclear tests to the Kazakh nationals. However, the country concerned at the time of the nuclear tests is the government of the former Soviet Union which had not disclosed the information on the nuclear tests. Accordingly, it is asked whether the Kazakh citizens trust the information disclosure by the government of the former Soviet Union or not. As a result the percentage of "Trust a little" (40.5%) is the highest, but that of "Don't trust so much" (23.4%) is also high.

Table 2. Reliability of governmental information disclosure by government of the former Soviet Union, safety confirmation of radioactive material, measures against radioactive material in food.

Evaluation item	Question / Evaluation	Know well	Know a little	Neither know nor don't know	Don't know so much	Don't know at all	Average / Standard Deviation
Damage by radioactive material from nuclear tests	Do you know that 200,000 residents around the Semipalatinsk Test Site suffered from heath damage caused directly by radioactive fallout from the test site?	40.5%	47.7%	2.6%	6.9%	2.3%	4.171
		123	145	8	21	7	0.942
Evaluation item	Question / Evaluation	Trust much	Trust a little	Neither trust nor don't trust	Don't trust so much	Don't trust at all	Average / Standard Deviation
Reliability of governmental information disclosure by government of the former Soviet Union	Do you trust the information disclosure by the government of the former Soviet Union?	14.1%	40.5%	13.2%	23.4%	8.9%	3.276
		43	123	40	71	27	1.220
Evaluation item	Question / Evaluation	Confirm often	Confirm a little	Neither confirm nor don't	Don't confirm so much	Don't confirm at all	Average / Standard Deviation
Safety confirmation of radioactive material in food	Do you confirm the safety of radioactive material in purchasing food still today when 28 years have passed since the closure of the Semipalatinsk Test Site?	11.5%	45.4%	10.2%	18.1%	14.8%	3.207
		35	138	31	55	45	1.285
Evaluation item	Question / Evaluation	Take significantly	Take to some degree	Neither take nor don't take	Don't take so much	Don't take at all	Average / Standard Deviation
Measures against radioactive material in food	Do you take any measure against oral internal exposure to radiation?	13.5%	12.8%	9.9%	25.3%	38.5%	2.375
		41	39	30	77	117	1.441

Notes: The mean represents the average when the responses were scored using a 5-level Likert scale (the same is for Table3).

As for the reliability of the information disclosure by the government of the former Soviet Union, in France and German the percentage of "Don't trust at all" (each 48.9%, 39.0%) is the highest [35, 36], while in Belarus and Russia the percentage of "Trust a little" (each 31.7%, 30.8%) is the highest [37, 38]. In West European countries, the reliability of the information disclosure by the government of the former Soviet Union is low, but in CIS member countries the reliability is higher compared to the West European countries. It can be seen that the reliability of the information disclosure by the government of the former Soviet Union is also high in Kazakhstan.

3.3.3. Safety Confirmation of Radioactive Material in Food

It is asked whether the citizens would "confirm the safety of radioactive material in food" even today 28 years after the closure of the Semipalatinsk Test Site. As a result, the percentage of "Confirm a little" (45.4%) is the highest and adding "Confirm often" (11.5%) together, 56.9% of the respondents confirm the safety of radioactive material even today.

For the reference there are the survey results on whether the citizens would confirm the safety of radioactive material in food even today 30 years after the Chernobyl nuclear power plant accident [25, 37]. In Belarus and Ukraine, the percentage of "Confirm often" (each 55.3%, 56.4%) is the highest even 30 years after the nuclear disaster [25, 37]. Although the safety confirmation of radioactive contamination cannot be simply compared between the case of the Chernobyl nuclear power plant accident and that of the Semipalatinsk nuclear tests, many citizens still confirm the safety of radioactive material in food today.

3.3.4. Measures Against Radioactive Material in Food

Furthermore, it is asked whether the citizens take any measure against the oral internal exposure to radiation or not. As a result, as for the evaluation item "Measures against radioactive material in food," the percentage of "Don't take at all" (38.5%) is the highest and that of "Don't take so much" (25.3%) the next highest. On the other hand adding "Take significantly" (13.5%) and "Take in some degree" (12.8%) together, 26.3% of the respondents take the measures.

3.4. Knowledge on Radioactive Material in Food in Kazakhstan and Comparison Among Three Countries

In this section, after it is outlined to what degree the Kazakh citizens have the knowledge on radioactive material in food, the survey results are compared for examination between Japan and Ukraine, taking the measures against radioactive material in food also into consideration.

3.4.1. Knowledge on Radioactive Material in Food in Kazakhstan

Table 3 shows the results of aggregate of the knowledge on radioactive material in food in Kazakhstan.

First, "Knowledge on external and internal exposure to radiation" is treated. As for the knowledge that there is external and internal exposure in radiation exposure,

Table 3. Knowledge on radioactive material in food in Kazakhstan ($n = 304$).

Evaluation item	Question / Evaluation	Know well	Know a little	Neither known nor not known	Don't know so much	Don't know at all	Average Standard Deviation
Knowledge on external and internal exposure to radiation	Do you know there is external and internal exposure in radiation exposure?	68.8%	17.1%	2.3%	9.9%	2.0%	4.408
		209	52	7	30	6	1.058
Influences of oral internal exposure to radiation on human body	Do you know oral internal exposure to radiation influences human body the most among internal exposures?	52.6%	28.0%	3.3%	12.2%	3.9%	4.132
		160	85	10	37	12	1.178
Knowledge on physical and biological half-life	Do you know there is physical and biological half-life in radiative lifetime?	37.8%	36.5%	3.6%	16.1%	5.9%	3.842
		115	111	11	49	18	1.254
Knowledge on influence on human body after biological half-life	Do you know even if radiation reaches half-time but a human suffers from oral internal exposure to radiation, the cells in the body are harmed?	53.6%	26.3%	3.6%	12.5%	3.9%	4.132
		163	80	11	38	12	1.190
Influence of radiation on child	Do you know the influence of radiation on child is more significant, because the growth hormone is more secreted in child?	31.3%	47.7%	2.3%	9.9%	8.9%	3.826
		95	145	7	30	27	1.226
Late effect of radiation	Do you know the influence of radiation on human body is not exerted immediately (acute effect) but after several years (late effect)?	62.2%	23.0%	2.6%	9.2%	3.0%	4.322
		189	70	8	28	9	1.088
Knowledge on stable iodine	Do you know stable iodine is provided to child in the time of nuclear power plant accident to prevent childhood thyroid cancer which is most concerned as health damage?	35.2%	45.4%	2.3%	8.2%	8.9%	3.898
		107	138	7	25	27	1.224

adding "Know well" (68.8%) and "Know a little" (17.1%) together, 85.9% of the respondents have the knowledge. Among the knowledge on radioactive material in food the citizens have the knowledge on external and internal exposure to radiation to the highest degree.

Next, "Influences of oral internal exposure to radiation on human body" is treated. As for the knowledge that oral internal exposure to radiation influences human body the most among the internal exposures, adding "Know well" (52.6%) and "Know a little" (28.0%) together, 80.6% of the respondents have the knowledge.

Then "Knowledge on physical and biological half-life" is treated. As for the knowledge that there is physical and biological half-life in radioactive lifetime, adding "Know well" (37.8%) and "Know a little" (36.5%) together, 74.3% of the respondents have the knowledge. Among the knowledge on radioactive material in food the citizens have the knowledge on physical and biological half-life to the lowest degree.

Furthermore, "Knowledge on influence on human body after biological half-life" is treated. As for the knowledge that even if radiation reaches half-time but a human suffers from oral internal exposure to radiation, the cells in the body are harmed, adding "Know well" (53.6%) and "Know a little" (26.3%) together, 79.9% of the respondents have the knowledge.

Additionally, "Influence of radiation on child" is treated. As for the knowledge that the influence of radiation on child is more significant, because the growth hormone is more secreted in child, adding "Know well" (31.3%) and "Know a little" (47.7%) together, 78.9% of the respondents have the knowledge.

And "Late effect of radiation" is treated. As for the knowledge that the influence of radiation on human body is not exerted immediately (acute effect) but after several years (late effect), adding "Know well" (62.2%) and "Know a little" (23.0%) together, 85.2% of the respondents have the knowledge.

Lastly, "Knowledge on stable iodine" is treated. As for the knowledge that stable iodine is provided to child in the time of nuclear power plant accident to prevent childhood thyroid cancer which is most concerned as health damage, adding "Know well" (35.2%) and "Know a little" (45.4%) together, 80.6% of the respondents have the knowledge.

3.5. Comparison Among Japan, Ukraine, and Kazakhstan in Terms of Knowledge on Radioactive Material in Food, Confirmation of Safety, and Measures Against Radioactive Material in Food

In this section, it is considered to what degree there are statistical differences among Japan, Ukraine, and Kazakhstan in terms of knowledge on radioactive material in food, confirmation of safety and measures against radioactive material in food.

Figure 2 shows the comparison of the average values in Japan, Ukraine, and Kazakhstan in terms of knowledge on radioactive material in food, confirmation of safety and measures against radioactive material in food.[12]

And **Table 4** shows the estimation results of multiple comparison (Tukey's test) in terms of knowledge on radioactive material in food, confirmation of safety, and measures against radioactive material in food.[13]

3.5.1. Comparison Among Japan, Ukraine and Kazakhstan in Terms of Knowledge on Radioactive Material in Food

First, as for "Knowledge on external and internal exposure to radiation," there is no statistically significant difference between Kazakh citizens (4.408) and Ukrainian

12. The values in **Tables 2** and **3** in this paper are used as the values of Kazakhstan, the values in **Table 3** of [19] as the values of Japan and the values in **Table 3** of [25] as the values of Ukraine.
13. As for the values in **Table 4**, same as the values in Footnote 12.

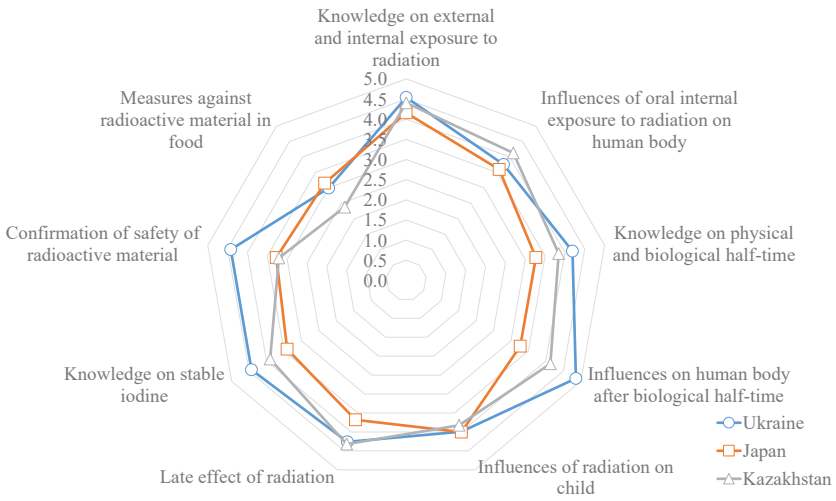

Fig. 2. Comparison among average values in Japan, Ukraine and Kazakhstan in terms of knowledge on radioactive material in food, confirmation of safety and measures against radioactive material in food.

Table 4. Multiple comparison in terms of knowledge on radioactive material in food, confirmation of safety and measures against radioactive material in food (Tukey's test).

Evaluation item	Country for comparison 1	Country for comparison 2	Level 1	Level 2	Difference (1-2)	p value
Knowledge on external and internal exposure to radiation	Kazakhstan	Japan	4.408	4.159	0.249	0.004 ***
	Ukraine	Japan	4.541	4.159	0.382	0.000 ***
Influences of oral internal exposure to radiation on human body	Kazakhstan	Ukraine	4.132	3.757	0.374	0.000 ***
	Kazakhstan	Japan	4.132	3.592	0.539	0.000 ***
Knowledge on physical and biological half-time	Kazakhstan	Ukraine	3.842	4.190	-0.348	0.001 ***
	Kazakhstan	Japan	3.842	3.267	0.575	0.000 ***
	Ukraine	Japan	4.190	3.267	0.923	0.000 ***
Influences on human body after biological half-time	Kazakhstan	Ukraine	4.132	4.862	-0.731	0.000 ***
	Kazakhstan	Japan	4.132	3.266	0.865	0.000 ***
	Ukraine	Japan	4.862	3.266	1.596	0.000 ***
Late effect of radiation	Kazakhstan	Japan	4.322	4.003	0.319	0.001 ***
	Ukraine	Japan	4.262	4.003	0.259	0.007 ***
Knowledge on stable iodine	Kazakhstan	Ukraine	3.898	4.433	-0.535	0.000 ***
	Kazakhstan	Japan	3.898	3.322	0.576	0.000 ***
	Ukraine	Japan	4.433	3.322	1.110	0.000 ***
Confirmation of safety of radioactive material in food	Kazakhstan	Ukraine	3.207	4.420	1.212	0.000 ***
	Ukraine	Japan	4.420	3.272	1.148	0.000 ***
Measures against radioactive material in food	Kazakhstan	Ukraine	2.375	2.993	0.618	0.000 ***
	Kazakhstan	Japan	2.375	3.148	0.773	0.000 ***

Note 1: *** indicates that the difference between the average values has a statistical significance with the significant level of 1%.

Note 2: Only the estimations with statistically significant difference are listed in the Table.

citizens (4.541) as a result of the multiple comparison. On the other hand Kazakh citizens (4.408) have more knowledge than Japanese citizens (4.159) with the significant level of 1%. Similarly Ukrainian citizens (4.541) have more knowledge than Japanese citizens (4.159) with the significant level of 1%. Kazakh and Ukrainian citizens have more knowledge on external and internal exposure to radiation than Japanese citizens.

Next, as for "Influences of oral internal exposure to radiation on human body," there is no statistically significant difference between Ukrainian citizens (3.757) and Japanese citizens (3.592) as a result of the multiple comparison. As for "Influences of oral internal exposure to radiation on human body," Kazakh citizens (4.134) have more knowledge than Japanese citizens (3.592) and Ukrainian citizens (3.757) with the significant level of 1%.

Then, as for "Knowledge on physical and biological half-time," the citizens have more knowledge in the order of Ukraine (4.190), Kazakhstan (3.843), and Japan (3.267). Similarly, as for "Influences on human body after biological half-time" and "Knowledge on stable iodine," the citizens have more knowledge in the order of Ukraine (each 4.862, 4.433), Kazakhstan (4.132, 3.898), and Japan (3.266, 3.322).

Furthermore, as for "Influences of radiation on child," Japanese citizens (4.003) have more knowledge than Kazakh citizens (3.826) and Ukrainian citizens (3.993), but there is no statistically significant difference.

Additionally, as for "Late effect of radiation," there is no statistically significant difference between Kazakh citizens (4.332) and Ukrainian citizens (4.262). Regarding this evaluation item Kazakh citizens (4.322) and Ukrainian citizens (4.262) have more knowledge than Japanese citizens (4.003) with the significant level of 1%.

Summing up, in terms of the influences of oral internal exposure to radiation, Kazakh citizens have more knowledge than Ukrainian and Japanese citizens. Because, in Ukraine, the citizens have many opportunities to touch the device for measurement of radioactive material in food and the access to the education on this subject, they have more knowledge than Japanese citizens [25]. In Kazakhstan in the late 1980s, the health damage by radiation has begun to be suspected and the health damage was reported by the press in the areas concerned [26]. In Kazakhstan the children learn about radiation actively, but the state has not provided the education of the knowledge on radiation [26]. Under the circumstances it is revealed that the citizens have relatively rich knowledge on radioactive material in food in this country.

3.5.2. Comparison Among Japan, Ukraine, and Kazakhstan in Terms of Confirmation of Safety on Radioactive Material in Food and Measures Against It

In this section, it is compared among three counties whether the citizens confirm the safety of radioactive material in food and whether they take any measure against oral internal exposure to radiation in purchasing food (see **Table 4**).

First, as for "Confirmation of safety of radioactive material," there is no statistically significant difference between Kazakh citizens (3.207) and Japanese citizens (3.272). Ukrainian citizens (4.420) confirm the safety of radioactive material in food more than Kazakh citizens (3.207) and Japanese citizens (3.272) with the significant level of 1%.

Lastly, as for "Measures against radioactive material in food," there is no statistically significant difference between Japanese citizens (3.148) and Ukrainian citizens (2.993). Kazakh citizens (2.375) don't take the measures against radioactive material in food with the significant level of 1% compared to Japanese citizens (3.148) and Ukrainian citizens (2.993).

Summing up, although many citizens confirm the safety of radioactive material in food even today when 30 years have passed since the Chernobyl nuclear power plant accident in Ukraine, less residents confirm it in Kazakhstan and Japan. And although the citizens have relatively rich knowledge on the influences of oral internal exposure to radiation on human body in Ukraine, less residents take the measures against radioactive material in food.

3.6. Measures Against Contamination by Radioactive Material in Food

3.6.1. Reasons Why Measures Are Not Taken Against Oral Internal Exposure to Radiation

Table 5 shows the results of the multiple answers on the reasons why the measures are not taken against oral internal exposure to radiation. And the results of the test of difference between the population rates estimated using the data obtained from the survey in Ukraine [25], that in Japan [19] and this paper are shown in **Table 5**.

First, the percentage of "Live in area without influence from radioactive material" (59.9%) is the highest and that of "Consider safe, because product is sold at shop" (25.0%) is the next highest. And the percentage of "Fear of radiation has faded" is also high.

On the other hand, the percentage of "Don't worry so much / no ending to worry" (8.9%) is low. Seeing the estimation results of the test of difference between the population rates, this percentage is statistically significantly low with the significant level of 1% even compared to Japan (-21.9%) and Ukraine (-31.8). In Kazakhstan, the citizens have relatively rich knowledge on the influences of oral internal exposure to radiation on the human body and the number of those who take the measures against the contamination is few but the number of those who care about the contamination by radiation consciously are high.

3.6.2. Measures to Be Taken No to Take Radioactive Material in Food

Table 6 shows the results of the multiple answers on the measures to be taken no to take radioactive material in food. And the results of the test of difference between population rates estimated using the data obtained from the survey in Ukraine [25], that in Japan [26] and this paper are shown in **Table 6**. As a result the percentage of "Wash well with water" (44.1%) is the highest and statistically significantly high even compared to Japan (16.2%) with the significant level of 1%.

The next highest is the percentage of "Eat fermented food" (35.5%) in Kazakhstan. The citizens like to eat

Table 5. Reasons why measures are not taken against oral internal exposure to radiation (multiple answers) and test of difference between population rates.

Evaluation item	Frequency	Rate	Difference between population rates	
			KAZ-JPN	KAZ-UKR
Live in area without influence from radioactive material	182	59.9%	—	—
Consider safe, because product is sold at shop	76	25.0%	-0.3%	5.3%
Fear of radiation has faded	73	24.0%	3.2%	9.6%
Don't worry so much / no ending to worry	27	8.9%	-21.9% **	-31.8% **
Have no small child	17	5.6%	-5.0%	-5.2%
Free answer : others	14	4.6%	—	—
Free answer : Dangerous wherever I live / No way to take any measure / Too late to take any measure / Thought it was safe	6	2.0%	—	—
Free answer : No need to worry	3	1.0%	—	—

Note 1: ** indicates that difference between population rates are statistically significant with the significant level of 5%.

Note 2: KAZ-JPN indicates the difference (%) found by subtracting the results in Japan from those in Kazakhstan and KAZ-UKR the difference (%) found by subtracting the results in Ukraine from those in Kazakhstan (same in Table 6).

Table 6. Measures to be taken against oral internal exposure to radiation (multiple answers) and test of difference between population rates.

Evaluation item	Frequency	Rate	Difference between population rates	
			KAZ-JPN	KAZ-UKR
Wash well with water	134	44.1%	16.2% ***	7.0%
Eat fermented food	108	35.5%	31.0% ***	34.5%
Refrain from purchasing food around Semey City	106	34.9%	-7.4%	9.6% *
Don't purchase the food absorbing radioactive material easily	99	32.6%	16.2% **	1.7%
Eat apple and citrus containing much pectin	81	26.6%	24.7% *	10.3% *
Aim at taking balanced diet	64	21.1%	13.7% *	2.7%
Take off leaves and peel	59	19.4%	5.6%	-5.2%
Cook more stew	58	19.1%	12.3% *	6.6%
Cut off leaves, stems and roots	55	18.1%	11.0%	6.9%
Don't eat wild animals	51	16.8%	12.3%	-9.1%
Dump hot water used for boiling in cooking	39	12.8%	5.5%	-3.9%
Don't eat wild grasses and edible wild plants	34	11.2%	-1.3%	-15.7% **
Remove bones	29	9.5%	7.9%	5.6%
Don't eat mushroom	26	8.6%	—	-24.2% **
Rinse in vinegar water	16	5.3%	2.7%	4.3%
Rinse in salt water	15	4.9%	2.4%	3.3%
Take off dietary fiber well	15	4.9%	1.4%	-2.3%
Free answer : others	2	3.9%	2.0%	0.7%
Don't take any measure especially/don't prevent radioactive material	10	3.3%	-0.9%	-21.3% *

Note: ***, **, and * indicate that the difference between population rates has a statistical significance with the significant level of 1%, 5%, and 10% respectively.

the fermented food such as "Kumis" produced by fermenting horse milk and "shubat" produced by fermenting camel milk to facilitate the preservation of food in nomadic life in Kazakhstan. For this reason, there are statistically significantly more opportunities to eat fermented food with the significant level of 1% even compared to Japan (31.0%).

Then, the percent of "Don't purchase food from place of origin" (32.6%) such as Semey which is considered to be contaminated with radioactive material is also high in Kazakhstan. This percentage is statistically significantly high with the significant level of 1% even compared to Ukraine (9.6%) where it is said that there are less harmful rumors in contrast to Japan.

Furthermore, the percentage of "Don't purchase the food absorbing radioactive material easily" (32.6%) such as berry, whey, and spinach is also high in Kazakhstan and statistically significantly high even compared to Japan (16.2%).

Additionally, the origin of the word of "Almaty" with the most population in Kazakhstan is "apple country" and the percentage of those who "Eat apple and citrus containing much pectin" (26.6%) is statistically significantly higher even compared to Japan (24.7%) and Ukraine (10.3%).

Furthermore, in Kazakhstan the percentages of "Aim

Table 7. Willingness to pay for flour and mutton with lower than regulated level of radioactive material in Kazakhstan ($n = 304$).

Item	Evaluation / Question	0 KZT	1∼5 KZT	6∼10 KZT	11∼15 KZT	16∼20 KZT	21∼25 KZT	26∼30 KZT	31∼35 KZT	36∼40 KZT	41∼45 KZT	46∼50 KZT	51 KZT or more	Average Standard deviation
Flour	How much will you pay extra at maximum for 1 kg of the flour which is produced in Kazakhstan (store price is 240 KZT) and certificated by the Government?	16.4%	6.9%	3.0%	2.3%	4.3%	3.3%	3.3%	2.6%	2.6%	1.0%	10.2%	44.1%	33.32
		50	21	9	7	13	10	10	8	8	3	31	134	21.88
Item	Evaluation / Question	0 KZT	1∼100 KZT	101∼200 KZT	201∼300 KZT	301∼400 KZT	401∼500 KZT	501∼600 KZT	601∼700 KZT	701∼800 KZT	801∼900 KZT	900∼1000 KZT	1,000 KZT or more	Average Standard deviation
Mutton	How much will you pay extra at maximum for 1 kg of the mutton which is produced in Kazakhstan (store price is 4,000 KZT) and certificated by the Government?	19.1%	8.9%	3.6%	4.6%	1.6%	5.9%	5.9%	2.3%	1.6%	3.6%	12.2%	30.6%	581.25
		58	27	11	14	5	18	18	7	5	11	37	93	436.87

Note 1: "KZT" indicates the international currency symbol of Kazakhstani tenge.
Note 2: This is close-ended question. Taking "1~5 KZT" as an example, this means 1 KZT or more and less than 5 KZT.

at taking balanced diet" (21.1%) and "Cook more stew" (12.3%) are statistically significantly higher even compared to Japan, while the percentages of "Don't eat wild grasses and edible wild plants" (11.2%), "Don't eat mushroom" (8.6%) and "Don't take any measure especially/don't prevent radioactive material" (3.3%) is statistically significantly lower even compared to Ukraine.

3.7. Willingness to Pay for Flour and Mutton with Lower than Regulated Level of Radioactive Material

In Kazakhstan, there is no system that a state certificates the food which is not contaminated by radioactive material as in the cases in EU and Sweden.[14] Kazakh citizens are asked whether they would purchase the food with lower than regulated level of radioactive material with more expensive price, if the regulated level of radioactive materials were stipulated.

Table 7 shows the aggregate results of the willingness to pay for flour and mutton with lower than regulated level of radioactive material.

3.7.1. Willingness to Pay for Flour with Lower than Regulated Level of Radioactive Material

First, the citizens are asked to what extent they would pay extra for the flour with lower than regulated level of radioactive material. The shop price of flour is supposed 240 KZT (= 68.22 JPY) pro kg.[15] As a result of totalization those who have no willingness to pay account for 16.4%, but those who will pay 51 KZT (= 14.50 JPY) or more extra 44.1%, the highest percentage.

3.7.2. Willingness to Pay for Mutton with Lower than Regulated Level of Radioactive Material

Similarly, the citizens are asked to what extent they would pay extra for the mutton with lower than regulated level of radioactive material. The shop price of mutton is supposed 4,000 KZT (= 1,137.0 JPY) pro kg. As a result of totalization those who have no willingness to pay account for 19.1%, but those who will pay 1,000 KZT or more extra 30.6%, the highest percentage.

From the above it can be seen that 30 to 40% of the Kazakh citizens would purchase the flour and mutton with lower than regulated level of radioactive material even with the price more expensive than 20%.

4. Estimation Results

In this chapter the results estimated using the ordinal logit model and the Tobit model based on the method of estimation in Section 2.3.2 are shown.

4.1. Estimation Results on Actual Situation of Knowledge in Terms of Nuclear Tests

Table 8 shows the estimation results in terms of the damage caused by radioactive material from the nuclear tests, the reliability of the information disclosure by the government of the former Soviet Union and the safety confirmation of radioactive material in food. As a result of the estimation, although pseudo R^2 of 0.010–0.017 is low, the likelihood ratio test of the null hypothesis that the regression coefficient is zero is rejected by the model in **Table 8**.

Taking "Reliability of information disclosure by government of the former Soviet Union" (see **Table 2**) as an example, the survey is conducted by classifying the evaluation into 5 classes from "Don't trust at all" to "Trust well," but the classes from "Don't trust at all" to "Neither trust nor don't trust" are integrated, because the differences among the classes are not statistically significant. Similarly, as for "Safety confirmation of radioactive material in food" (see **Table 2**), the classes from "Don't trust

14. After the Chernobyl nuclear power plant accident the production, transportation and consumption of the food contaminated by the radioactive fallout are regulated within EU [26]. As for the food circulated within EU, European Food Safety Authority (EFSA) lets the specialists conduct the risk evaluation on all the matters influencing the safety of food within EU and provides the scientific information on safety [26]. In Sweden, Livsmedelsverket (the National Food Administration) controls the safety and fair trade of food including the control of the pollutants and radioactive material in food and daily eating habit [26].
15. 1 KZT is converted to 4.21853 JPY as of December 14, 2019 (see [39]).

Table 8. Damage caused by radioactive material from nuclear tests, reliability of information disclosure by government of the former Soviet Union and safety confirmation of radioactive material in food according to personal attributes (estimation results of ordinal logit model).

Variables	Damage caused by radioactive material from nuclear tests			Reliability of information disclosure by government of the former Soviet Union			Safety confirmation of radioactive material in food		
	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value
Male=1	-0.441	0.229	0.054 *				0.549	0.230	0.017 **
Age				0.020	0.010	0.056 *			
Number of household members	0.967	0.426	0.023 **	-0.117	0.082	0.154			
Child=1	0.145	0.088	0.098 *						
cut1	3.359	0.515	0.000 ***						
cut2	1.897	0.400	0.000 ***						
cut3	1.616	0.390	0.000 ***	-0.120	0.519	0.817	0.088	0.141	0.533
cut4	-0.837	0.363	0.021 **	-2.138	0.538	0.000 ***	-2.262	0.206	0.000 ***
Likelihood ratio	649.3 **			602.7 **			584.1 **		
AIC	663.3			610.7			590.1		
χ^2 value	11.3			6.1			5.7		
McFadden	0.017			0.010			0.010		

Note 1: ***, **, and * indicate statistical significance with the significant level of 1%, 5%, and 10%, respectively (same in Tables 9~12).

Note 2: "cut" indicates threshold value. cut 1 and cut 2 of "Reliability of information disclosure by government of the former Soviet Union" and "Safety confirmation of radioactive material in food" are integrated.

Note 3: 7 personal attributes are introduced in the estimation formula, but the estimation is made by deleting the explanatory variables with the significant level of 20% or more and leaving the ones with the significant level of 1~10% by using Backward Selection method until the optimal estimation result can be obtained (same in Tables 9, 11, and 12).

at all" to "Neither trust nor don't trust" are integrated. The marginal effect is omitted due to space constraint.

First, as for "Damage caused by radioactive material from nuclear tests," because the coefficient of male (−0.441) shows a negative value, female knows more the damage by radioactive material. And those who have many household members (0.967) and have child (0.145) know the damage more.

Next, those who have "Reliability of information disclosure by government of the former Soviet Union" are a little older in age (0.020). Taking the average age of the samples of 37.4 years old (see **Table 1**) into consideration, those who belonged to the former Soviet Union trust the information disclosure by the government of the former Soviet Union.

On the other hand, as for "Safety confirmation of radioactive material in food," male (0.549) confirms it more.

Summing up, as for "Damage caused by radioactive material from nuclear tests," female has more knowledge than male, and as for "Safety confirmation of radioactive material in food," male confirms the safety more than female, accordingly there is a difference between sexes.

4.2. Estimation Results on Actual Situation of Knowledge on Radioactive Material in Food

Table 9 shows the estimation results on the actual situation of the knowledge on radioactive material in food.

First, as for "Knowledge on external and internal exposure to radiation," those who are older in age (0.024) have more knowledge.

And as for "Influences of oral internal exposure to radiation on human body," those who are older in age (0.021) and have child (0.546) have more knowledge.

Then, as for "Knowledge on physical and biological half-time," those who are older in age (0.017) and have less household members (−0.184) have more knowledge.

Additionally, as for "Knowledge on influences on human body after biological half-time," those who earn low income (−0.044) have more knowledge. Contrarily, as for "Knowledge on stable iodine," those who earn high income (0.037) have more knowledge.

Summarizing the knowledge on radioactive material in food, those who lived in the time when the nuclear tests were conducted in the former Soviet Union and are a little older in age have more knowledge and there are differences depending on income.

4.3. Correlation between Measures Against Contamination of Radioactive Materials in Food and Reasons Why Measures Are Not Taken/Measures Which Are Taken

Table 10 shows the correlation between the measures against the contamination of radioactive materials in food and the reasons why the measures are not taken/the measures which are taken and the marginal effects

First, seeing the regression coefficient, the coefficients of the reason why the measures are not taken such as "Fear to radiation has faded" (−0.344), "Live in area without influence from radioactive material" (−0.317), and "Don't worry so much/no ending to worry" (−0.487) show the negative values. The reason of "Fear to radiation

Table 9. Knowledge on radioactive material in food according to personal attributes.

Variables	Knowledge on external and internal exposure to radiation			Influences of oral internal exposure to radiation on human body			Knowledge on physical and biological half-time			Knowledge on influences on human body after biological half-time			Knowledge on stable iodine		
	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value
Male=1													0.352	0.223	0.114
Age	0.024	0.012	0.048 **	0.021	0.011	0.056 *	0.017	0.010	0.091 *	0.015	0.011	0.176			
Number of household members				-0.129	0.093	0.167	-0.184	0.080	0.022 **	-0.135	0.083	0.105			
Child=1				0.546	0.256	0.033 **									
Monthly income										-0.044	0.023	0.058 *	0.037	0.022	0.098 *
cut1	0.926	0.467	0.047 **	0.806	0.529	0.128	1.128	0.507	0.026 **	1.838	0.592	0.002 ***	0.897	0.290	0.002 ***
cut2	-0.098	0.459	0.831	-0.540	0.527	0.305	-0.468	0.503	0.352	0.578	0.582	0.321	-1.166	0.293	0.000 ***
Likelihood ratio	504.4 **			607.7 *			650.9 **			605.5 *			629.6 *		
AIC	510.4			617.7			658.9			615.5			637.6		
χ^2value	4.1			7.8			8.6			7.3			5.3		
McFadden	0.008			0.013			0.013			0.012			0.008		

Note 1: "cut" indicates threshold value. cut 1 and cut 2 mean "know a little" and "know well" respectively.

Note 2: Although "Influence of radiation on child" and "Late effect of radiation" (see Table 3) are also estimated other than the estimation formula in Table 9, they are omitted as a result of the likelihood ratio test.

Table 10. Correlation between measures against contamination of radioactive material in food and reasons why measures are not taken/measures which are taken and the marginal effects (estimation results of ordinal logit model).

Variable	Measures against radioactive material in food			Don't take at all			Don't take so considerably			Neither take nor don't take			Take to some degree			Take considerably		
	Coefficient	Standard deviation	p value	dy/dx	Standard deviation	p value	dy/dx	Standard deviation	p value	dy/dx	Standard deviation	p value	dy/dx	Standard deviation	p value	dy/dx	Standard deviation	p value
Fear to radiation has faded, because several decades have passed since end of nuclear test	-0.344	0.158	0.029 **	0.133	0.062	0.031 **	-0.010	0.010	0.313	-0.020	0.011	0.060 *	-0.041	0.019	0.036 **	-0.063	0.026	0.017 **
Live in area without influence from radioactive material	-0.317	0.142	0.026 **	0.119	0.052	0.023 ***	0.001	0.005	0.919	-0.016	0.007	0.036 **	-0.037	0.017	0.034 **	-0.067	0.031	0.034 **
Don't worry so much / no ending to worry	-0.487	0.241	0.043 **	0.191	0.095	0.044 **	-0.026	0.025	0.285	-0.031	0.018	0.084 *	-0.057	0.028	0.040 **	-0.077	0.030	0.009 ***
Rinse in salt water	0.846	0.298	0.005 ***	-0.261	0.067	0.000 ***	-0.066	0.044	0.130	0.012	0.011	0.279	0.070	0.016	0.000 ***	0.246	0.109	0.024 **
Take off leaves and peel	-0.408	0.180	0.023 **	0.159	0.071	0.025 **	-0.015	0.014	0.274	-0.025	0.013	0.052 *	-0.048	0.022	0.027 **	-0.071	0.028	0.010 **
Refrain from purchasing food around Semey City	0.196	0.135	0.146	-0.073	0.050	0.141	0.000	0.004	0.940	0.010	0.007	0.146	0.023	0.016	0.154	0.041	0.029	0.162
Don't purchase the food absorbing radioactive material easily	0.218	0.136	0.111	-0.082	0.050	0.105	-0.001	0.004	0.852	0.011	0.007	0.109	0.025	0.016	0.116	0.046	0.030	0.129
Wash well with water	0.227	0.143	0.112	-0.086	0.053	0.109	0.001	0.004	0.870	0.012	0.008	0.123	0.027	0.017	0.118	0.047	0.030	0.121
cut1	-0.427	0.151																
cut2	0.248	0.151																
cut3	0.546	0.152																
cut4	1.050	0.159																
Likelihood ratio	-436.4 ***																	
AIC	896.7																	
χ^2value	25.6																	
pseudo R^2	0.029																	

Note 1: "cut" means threshold value and indicates cut 1 (Don't take so considerably)~cut 4 (Take considerably).

Note 2: "Reasons why measures are not taken against oral internal exposure to radiation" (see Table 5) and "Measures to be taken against oral internal exposure to radiation" (see table 6) except for free answer and others are introduced in the estimation formula, but the estimation is made by deleting the explanatory variables with the significant level of 20% or more and leaving the ones with the significant level of 1~10% by using Backward Selection method until the optimal estimation result can be obtained (same in Tables 9~12).

has faded" shows the negative value similarly in the estimation results in Ukraine [25] and two reasons of "Don't worry so much/no ending to worry" have the negative values in the estimation results in Ukraine [25] and that in Japan.

On the other hand, the measures taken not to take radioactive material in food such as "Rinse in salt water" (0.846) show the positive values. This is estimated because in Kazakhstan there are many foods of meat preserved with salt, for example, "Zhaya," the salted and smoked food of meat of rump and hind leg of horse, "Kylmai," the sausage made by mixing minced meat with blood, garlic, salt and pepper, and "Mypalau," the food made by salting brain, bone marrow, and meat of sheep and adding garlic.

Meanwhile, the measures such as "Take off leaves and peel" (−0.408) show the negative values. The food consumption in Kazakhstan consists of 1,663,000 t of flour and flour products, 1,105,000 t of meat, 911,000 t of confectionery, 867,000 t of dairy products except for milk, etc., and the food consumption of vegetables and fruits including fruit juice amounts to only 201,000 t [40]. In the Kazakh, traditional food mutton, beef, and dairy products are often used and it expected that the less residents take the measure to take off leaves and peel of vegetables and fruits.

Next, the estimation results of marginal effect are mentioned. 5 marginal effects are estimated from "Don't take at all" to "Take considerably."

"Rinse in salt water" (0.246) which is undertaken easily

Table 11. Reasons why measures are not taken against oral internal exposure to radiation and measures which are taken against oral internal exposure to radiation according to personal attributes (estimation results of binary logit model).

Variable	Reasons why measures are not taken against oral internal exposure to radiation									Measures which are taken against oral internal exposure to radiation					
	Fear to radiation has faded, because several decades have passed since end of nuclear test			Live in area without influence from radioactive material			Have no small child			Refrain from purchasing food around Semey City			Don't worry so much / no ending to worry		
	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value
Male=1	0.345	0.163	0.035 **												
Child=1	0.530	0.277	0.056 *	-1.044	0.296	0.000 ***	0.529	0.373	0.156	-0.634	0.318	0.046 **			
East Kazakhstan=1	0.012	0.006	0.043 **				-0.029	0.011	0.006 ***						
Age				-0.020	0.007	0.006 ***	0.020	0.011	0.062 *						
Education													-0.336	0.136	0.014 **
Monthly income										-0.065	0.030	0.028 **			
Constant term	-1.088	0.153	0.000 ***	1.062	0.281	0.000 ***	-2.114	0.477	0.000 ***	-0.112	0.130	0.388	-0.440	0.491	0.370
Likelihood ratio	-162.3 **			-194.4 ***			-56.2 ***			-191.8 ***			-56.8 **		
χ^2 value	10.6			20.7			18.68			9.49			5.98		
pseudo R^2	0.032			0.051			0.143			0.024			0.050		
Variable	Measures which are taken against oral internal exposure to radiation														
	Take off leaves and peel			Eat apple and citrus containing much pectin			Cook more stew			Aim at taking balanced diet			Don't eat wild grasses and edible wild plants		
	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value
Male=1	-0.318	0.178	0.073 *	-0.453	0.168	0.007 ***	-0.426	0.182	0.019 **	-0.594	0.186	0.001 ***			
Child=1							-0.559	0.376	0.137						
East Kazakhstan=1										-0.009	0.006	0.134			
Education				0.133	0.101	0.188							0.269	0.137	0.049 **
Monthly income										0.063	0.027	0.021 **			
Constant term	-0.755	0.101	0.000 ***	-0.983	0.402	0.015 **	-0.700	0.103	0.000 ***	-0.725	0.186	0 ***	-2.270	0.553	0.000 ***
Likelihood ratio	-148.0 *			-171.5 ***			-144.2 **			-146.5 ***			-104.4 **		
χ^2 value	3.28			9.45			7.99			19.92			4.24		
pseudo R^2	0.011			0.027			0.027			0.064			0.020		

at home has a positive large marginal effect under those who "Take considerably."

Contrarily, the measures such as "No ending to worry" (0.191), "Take off leaves and peel" (0.159), "Fear to radiation has faded" (0.133), and "Live in area without influence from radioactive material" (0.119) have a positive large marginal effect under those who "Don't take at all." Although the safety against radioactive material in food is confirmed under the circumstances where the contamination is still spreading even 28 years after the closure of the nuclear test site in Kazakhstan, only the measures to be take easily such as "Rinse in salt water" are taken.

4.4. Reasons Why Measures Are Not Taken Against Oral Internal Exposure to Radiation and Measures Which Are Taken Against Oral Internal Exposure to Radiation

Table 11 shows the estimation results of the reasons why the measures are not taken against oral internal exposure to radiation and the measures which are taken against oral internal exposure to radiation.

First, the estimation results of the reasons why the measures are not taken against oral internal exposure to radiation are considered.

The residents who don't take any measure, because "Fear to radiation has faded" are those who are male (0.345), have child (0.012), and live in East Kazakhstan State (0.530). Although those who confirm the safety of radioactive material are male (see **Table 8**), those whose fear to radiation has faded are also male.

The residents who don't take any measure, because they "Live in area without influence from radioactive material" are those who live in other areas than East Kazakhstan State (−1.044) and are younger in age (−0.020).

The residents who don't take any measure, because they "Have no small child" are those who have no child (−0.029) actually and are older in age (0.020).

Next, the measures which are taken against oral internal exposure to radiation are considered.

The residents who "Refrain from purchasing food around Semey City" are those who live in other areas than East Kazakhstan State (−0.634) and earn low income (−0.056). As for "Knowledge on influences on human body after biological half-time," the residents with low income have such knowledge (see **Table 9**), but they take the measures by refraining from purchasing the food around the nuclear test site in the case of low income.

The residents who "Don't worry so much/no ending to worry" have low level of education (−0.336). Contrarily, the residents who "Don't eat wild grasses and edible wild plants" have high level of education (0.269).

Those who "Take off leaves and peel," "Eat apple and citrus containing much pectin," "Cook more stew," and "Aim at taking balanced diet" are female (each −0.318, −0.453, −0.426, and −0.594). Those who know "Damage caused by radioactive material from nuclear tests" are female (see **Table 8**) and those who take the measures against oral internal exposure to radiation are also female.

And those who "Aim at taking balanced diet" have high level of income (0.063). Those who have "Knowledge on stable iodine" earn more (see **Table 9**) and it would be possible that the higher the level of income becomes, the better knowledge on oral internal exposure to radiation the residents have.

Table 12. Estimation results on willingness to pay for flour and mutton with lower than regulated level of radioactive material (estimation results of Tobit model).

Variable	Flour			Mutton		
	Coefficient	Standard deviation	p value	Coefficient	Standard deviation	p value
Male=1	-9.906	2.6	0.000 ***	-123.7	52.1	0.018 **
Age	-0.165	0.1	0.165	-4.9	2.4	0.039 **
Education				-48.2	29.8	0.107
Constant term	43.2	4.5	0.000 ***	995.5	140.3	0.000 ***
Likelihood ratio	-1359.1 ***			-2271.5 ***		
AIC	2726.1			4552.9		
$\chi 2$ value	19.6			15.2		
pseudo R2	0.007			0.003		

4.5. Willingness to Pay for Food with Lower than Regulated Level of Radioactive Material

Table 12 shows the estimation results whether there is a difference in the willingness to pay for the food with lower than regulated level of radioactive material according to the personal attributes. Tobit analysis is used to analyze the relation where the objective variable takes always the value of 0 until the explanatory variable reaches a certain value, but the objective variable increases in proportion of the explanatory variable, if the explanatory variable exceeds the threshold. Accordingly, this model is applied in estimating the data in the case where many respondents select "0 KZT" in this paper (see **Table 7**).

As a result, female (flour -9.906, mutton -123.7) purchases more the flour and mutton with lower than regulated level of radioactive material. And those are younger in age (-4.9) have the higher willingness to pay for the mutton with lower than regulated level of radioactive material. Also in the survey results in Ukraine [25] and Sweden [26], female purchases more the food with lower than regulated level of radioactive material and the similar tendencies can be recognized in Kazakhstan.

5. Conclusions

5.1. Results

This paper takes the Republic of Kazakhstan as a case and analyses the influences of the radioactive contamination from the Semipalatinsk Test Site on the choice action of meal statistically. As a result of the analysis the following results are obtained.

28 years have passed since the closure of the Semipalatinsk Test Site, but nearly 90% of the citizens know the health damage caused by radioactive material from the nuclear tests and female knows the fact more than male. Even today, more than half of the citizens confirm the safety of radioactive material in purchasing food and male confirms it more than female. However, the fear to radiation has faded more quickly for male. And the citizens who live in East Kazakhstan State where the Semipalatinsk Test Site is located take the measure to refrain from purchasing the food around Semey City, but the percentage of those who take the measures against oral internal exposure to radiation declines in the cases that the citizens have no child and the fear to radiation has faded.

More than 80% of the citizens in Kazakhstan know there are external and internal exposure in exposure to radioactive material. And as for the influences of oral internal exposure to radiation on human body, Kazakh citizens know the fact on this subject more than Ukrainian citizens and Japanese citizens. In Kazakhstan, the state has not conducted the education on radiation, but the citizens have obtained any knowledge on radiation and the level of their knowledge on radioactive material in food is fairly high. As for the knowledge on radioactive material in food, the class of age of those who know the nuclear tests were conducted in the time of the former Soviet Union has the knowledge more and the level of the knowledge depends on the level of income. Namely, the citizens with high level of income care about the balanced diet and are more conscious on health and take the measures against the radioactive contamination by avoiding the risk to take radioactive material, while the citizens with low level income try to contain the contamination by refraining from purchasing the food around Semey City.

Although the citizens have high level of knowledge on radiation in Kazakhstan, those who take any measure against oral internal exposure to radiation account for about a quarter of the citizens and more than 60% of them don't take any measure. The measures against radioactive material in food taken by the citizens are limited to the ones which can be easily carried out in the everyday life such as washing food with water. However, in Kazakhstan the percentage of the citizens who don't worry about radioactive material is lower compared to Ukraine and Japan. Overwhelmingly more citizens worry about the radioactive contamination in Kazakhstan. And those who don't worry about radioactive material in Kazakhstan have low level of education.

Because many citizens worry about radioactive material in Kazakhstan, it would be possible that 30 to 40% of the Kazakh citizens would purchase the food with lower than regulated level of radioactive material even with the price more expensive than 20%. Those who know the damage by radioactive material more are female and those who take the measures against oral internal exposure to radiation are also female. Accordingly, those who purchase

the food with lower than regulated level of radioactive material are female.

5.2. Consideration

In Kazakhstan, the hypothesis we designed that the Kazakh citizens "have poor knowledge on radioactive material in food" is rejected because mainly the generations who know the nuclear tests have high level of such knowledge. And the hypothesis that the Kazakh citizens "don't take any measure against oral internal exposure to radiation in purchasing food" is rejected because female who purchases the food daily takes the measures against the internal exposure to radiation and has the high willingness to pay for the food with lower than regulated level of radioactive material. In Kazakhstan, the education on radiation has not been carried out as in the case of the disaster-stricken counties of the Chernobyl nuclear power plant accident. However, the information on the radioactive contamination caused by the nuclear tests and the radioactive fallout has been disclosed little by little in a limited way by the state since the independence. After the nuclear tests the researchers from Kazakhstan, Japan and other countries have synthesized the radiobiological, physical and medical knowledge and examined the total picture of the nuclear damage. Based on the knowledge and information obtained from there, the medical examination and support have been implemented and the Kazakh citizens have made use of such knowledge and information, which is estimated to have exerted the favorable influences to the choice action of meal.

5.3. Problems in Future

This study analyses the influences of the radioactive contamination from the Semipalatinsk Test Site on the choice action of meal statistically. And finally, the problems in the future are mentioned.

The fact should be kept in mind that even the generations who know the nuclear tests since the 1980's know the areas where they live are contaminated by the radioactive fallout from the nuclear test site (see **Table 2**) and there are internal and external exposures to radiation (see **Table 3**), but they cannot answer about the physical and biological half-time correctly (see **Table 3**). In fact, even the student teachers who will inform the children who don't know the fact of the damage and risk cannot answer about the half-time correctly [41]. In the future, it is desirable to conduct the detailed survey on whether the correct knowledge could be kept and passed down through the generations under the circumstances where the knowledge on the half-time and radiation of each nuclide and the foods which are easily contaminated has faded with the passage of time. And if the survey area had been limited to East Kazakhstan State contaminated heavily, the ratio of those who take the measures against the contamination of radioactive material would have been higher than that of the samples of this study. It is difficult to conduct the internet survey focusing on East Kazakhstan State and this survey has a certain limitation under the existing circumstances.

As mentioned above, it cannot be denied that the setting of the survey area has a problem in our survey. Nonetheless, it deserves special mention that nearly 90% of the citizens including those who live in the areas far from the nuclear test site and with less victims remain the nuclear tests in their memory even today 28 years after the closure of the nuclear test site and a quarter of them take the measures against the contamination. The authors would like to design the survey focusing on East Kazakhstan State and Semey City to confirm the consciousness of the residents there again.

Finally, not only the radioactive contamination caused by the nuclear tests but also the environmental pollution by the uranium exploration has become the problem in Kazakhstan. The possibility that the problem of the environmental pollution caused by the uranium exploration would be a factor to raise relatively the literacy on the internal exposure to radiation among the general citizens cannot be excluded. The subject on whether the promotion of the next generation of the energy would be influenced by the difference between the generation who knows the nuclear tests and the generation who don't know them is examined in another paper.

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