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Development of Self-Questionnaire for Internal Dose Assessment by Food Ingestion

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ABSTRACT

Background: The accident at the Fukushima Daiichi nuclear power plant increased the level of anxiety related to the radioactive contamination of various foods sourced in Japan. Particularly, after the accident, the detection of artificial radionuclides in locally produced foods raised food safety concerns. In this study, the radioactivity concentrations and annual ingestions of ^{40}K and ^{137}Cs in food products commonly and frequently consumed by the general public were investigated, and the annual effective dose of each was evaluated.

Materials and Methods: The 2016–2018 data from the Radiation Safety Management Report released by the Korea Nuclear Safety Technology Center was referenced for the evaluation of the amounts of ^{40}K and ^{137}Cs contained in food. Using the food-ingestion survey mentioned above as a reference, we selected 62 foods to include in our radioactivity concentration and dose assessment. We also developed a questionnaire and evaluated the responses from the subjects who answered the questionnaire.

Results and Discussion: The radioactivity concentration of ^{137}Cs was found to be close to or below the level of minimum detectable activity. Additionally, the annual ingestion of 62 foods was 294.77 kg/yr, the effective doses from ^{40}K and ^{137}Cs were 136.4 and 0.163 μSv/yr, respectively.

Conclusion: Thus, the findings confirmed that the effective dose from ^{40}K and ^{137}Cs in food tends to be lower than the effective dose limit of 1 mSv/yr suggested by the International Commission on Radiological Protection (ICRP) Publication 60. The questionnaire developed in this study is expected to be useful for estimating the annual effective dose status of Korean adults who consume foods containing ^{40}K and ^{137}Cs.

Keywords: Internal Exposure, Self-Questionnaire, Food Radioactivity, ^{40}K, ^{137}Cs

Original Research

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Introduction

Before the Fukushima Daiichi nuclear accident, the domestic provisional permissible standard for radioactivity concentration in foods was zero for radioactive iodine (^{131}I), 100 Bq/kg for baby foods, dairy products, and processed dairy products, and 300 Bq/kg for other foods. Additionally, radioactive cesium (i.e., ^{134}Cs and ^{137}Cs) was regulated to a maximum of 370 Bq/kg for all foods. However, after the Fukushima accident, the domestic maximum acceptable concentration of radioactive cesium (^{134}Cs and ^{137}Cs) was changed to 100 Bq/kg for all Japan-sourced foods [1]. The effective dose limit for general artificial radiation, according to the International Commission on Radiological Protection (ICRP) Publication 60, is 1 mSv/yr. This value is the acceptable limit for the total internal and external radiation exposure from foods. Most of this internal and external radiation exposure is known to be attributable to the ^{40}K content within food products [2]. Potassium-40 is a natural radionuclide and an essential element for the human body. In contrast, ^{137}Cs emits gamma rays that are present in the environment in the form of radioactive fallout from nuclear experiments and accidents at nuclear power plants; thus, the evaluation of ^{137}Cs is critical in internal exposure assessments. Human exposure to radionuclides via the ingestion pathway is typically associated with the radionuclide content in the soil, uptake/absorption of nutrients and minerals by plants, chemical properties of the soil, and consumption rates of a particular foodstuff [3, 4]. Considering the various influences, it is important to analyze the presence of radioactive materials in foodstuffs, especially in staple foods, thus gaining insights into their potential effects on humans. Moreover, such analysis provides data on natural radioactivity in crops, providing a reliable basis for dose estimation [5]. Direct measurement of body radioactivity using a whole-body counter is the most reliable method for monitoring the internal exposure of workers and members of the public [6]. However, research on the evaluation of commonly ingested foods is lacking. It is also important to note that differences in the radioactivity concentrations of ^{40}K in the human body may be related to eating habits, and an assessment of food intake is also required for the accurate interpretation and analysis of ^{40}K measurements. A food-based food intake frequency questionnaire has been developed; however, it is mainly for nutrients and foods related to specific diseases or medical conditions such as hypertension and cancer. Therefore, the questionnaire is not suitable for internal exposure evaluation [7, 8]. Considering the two types of radiation safety management reports published by the Korea Institute of Nuclear Safety (KINS) and the Korea National Health and Nutrition Examination Survey (KNHANES), we conducted a food radioactivity and intake frequency survey for the purpose of calculating national statistical data and procuring evidence for policy formulation and evaluation [9–11]. Only the types of foods and radioactive substances consumed by the public are investigated, and the annual effective dose from food intake was no evaluated. Furthermore, although it is a standard practice to measure the radioactivity concentrations of foods, the domestic approach to investigating the relationship between the internal radiation dose and food intake is inadequate compared to that of developed countries.

Thus, in this study, we investigated the radioactivity concentrations of ^{40}K and ^{137}Cs in foods consumed in South Korea from the perspective of annual intake and evaluated the internal radiation dose. We also developed a self-questionnaire that can be used to facilitate the evaluation of the extent to which daily food intake contributes to the internal radiation dose. We propose the use of our self-questionnaire for the purpose of evaluating the food intake-related internal radiation dose assessment for whole-body counter testers.

Materials and Methods

1. Internal Exposure Evaluation Method

Internal exposure refers to the exposure of body tissues to radioactive substances via inhalation, ingestion, skin absorption, etc. ICRP Publication 60 requires that the consequences of internal exposure, as well as the extent of external exposure, be measured and inclusively evaluated [12]. The internal radiation dose evaluation method has been classified into direct and indirect bioassay methods. The direct bioassay method entails the use of an external measurement system (e.g., a whole-body counter or a lung counter) to directly measure the radioactivity of radionuclides existing in the human body. As previously mentioned, according to ICRP Publication 60, the effective dose limit for artificial radiation is 1 mSv/yr, which is the sum of the internal and external exposure values from foods [12]. The annual effective dose is used to assess body exposure from food intake. The sensitivity of human body to radiation depends on the type of radioactive nuclide in the food and the exposed tissue. The radioactivity concentrations of ^{40}K and ^{137}Cs in food and the annual food ingestion of Korean adults from 2016 to 2018 are excluded from the data on sensitivity of human tissues according to the conversion factor presented by the ICRP Publication 119 (2012); the values are 6.2×10^{-9} Sv/Bq and 1.3×10^{-8} Sv/Bq, respectively [12]. Then, the internal exposure dose is calculated using the following formula:

$$D = f \times C \times U$$

where D is the internal exposure dose (Sv/yr), f is the nuclide dose conversion coefficient (Sv/Bq), C is the nuclide radioactivity (Bq/kg), and U is the annual intake (kg/yr). For the radioactivity of ^{40}K and ^{137}Cs in food, data from 2016 to 2018 procured by KINS ("Marine Environmental Radioactivity Survey" and "Environmental Radioactivity Survey data in Korea") and the Korea Institute of Health and Environment were taken as references [9–11, 13, 14]. The KINS report is a collection of materials that are compiled and published according to food radioactivity values obtained directly from 15 local radioactivity measuring stations across the country. The Disease Control Agency conducts a national health and nutrition survey every year and provides statistical data on food and nutrient intakes of people. For the annual food intake, the materials for consumption food intake from the 7th period (2016 to 2018) data of the National Health and Nutrition Examination Survey were applied.

2. Development of Self-Questionnaire

The items on the self-questionnaire were classified into two categories. The first category consisted of physical condition and basic health check items (e.g., disease history, smoking status, and physical activity level); the second category consisted of food-intake frequency questions for common foods. Current methods employed to evaluate food intake include diet recording methods, 24-hour recall methods, and food frequency questionnaire methods; each of these types of surveys serves a different research purpose [15]. Food-intake frequency survey methods are useful for investigating the relationship between food consumption and diseases that affect the relevant population, as they provide the information about long-term eating habits; however, the level of accuracy of the evaluation is not high [16]. Researchers in many foreign countries, including the United States, have developed and used many food-intake frequency surveys for the primary purpose of studying nutrients that are closely related to health and chronic illness [17]. Because food-intake frequency surveys evaluate a subject's intake of a limited variety of foods, the list must reflect the dietary characteristics of the subject. There is no separate food intake frequency questionnaire for the current internal dose evaluation. We used a list of commonly consumed foods procured via the food intake survey data of 24,629 subjects in the 7th KNHANES (2016–2018), which were the latest data available at the time of the study. Based on the KINS Radiation Safety Management Report, we used a list of highly radioactive and consumable foods. To determine the standard average intake per person, we referred to the data obtained from the food-intake frequency survey of the 7th KNHANES (2016–2018). For each food, the subjects were given nine self-declaration options for the average frequency of food intake over the previous month: rarely, once a month, 2–3 times a month, once a week, 2–4 times a week, 5–6 times a week, once a day, twice a day, or three times a day. The self-questionnaire was used with whole-body counter examinations.

Results and Discussion

As mentioned, the results of the 7th KNHANES on the radioactivity and annual intake of commonly-consumption foods that was developed and administered by KINS were used to evaluate and quantify the contributions of 62 foods to the internal radiation dose in humans. Specifically, we developed a self-questionnaire that included a food-intake frequency survey.

1. Internal Exposure Evaluation

Table 1 shows the average radioactivity concentrations of ^{40}K and ^{137}Cs in the 62 foods analyzed in the 2016–2018 data. Among the 62 food data, the radioactivity concentration range of ^{40}K was from 24.0 to 1,310 Bq/kg-fresh, and that of ^{137}Cs from MDA (minimum detectable concentration) to a maximum of 781 mBq/kg-fresh. Regarding the radioactivity concentrations according to food, the ^{40}K content was the highest in kelp and coffee, relatively high in seaweeds (*Gracilaria* sp., *Hijikia fusiforme*, and sea lettuce), and lowest in rice cake and rice. The ^{137}Cs content was highest in coffee and *A. bisporus*, and relatively high in root plants (lettuce, beans, carrots). Among the 62 foods, rice, milk, and kimchi were associated with the highest annual intake, whereas *Gracilaria* species and mackerel were associated with the lowest annual intake. Table 2 shows the ^{40}K and ^{137}Cs internal radiation dose results according to the food type. The foods with a ^{40}K high internal radiation dose were coffee, kimchi, and green tea, whereas the foods with low internal radiation doses were pen shell clams and horse mackerel. In the case of ^{137}Cs, the internal radiation dose was the highest for coffee and radish, whereas it was lowest for the pen shell and *Gracilaria* sp. For some foods, such as kimchi and sesame leaves, the concentration of ^{137}Cs was extremely low; therefore, the internal radiation dose could not be evaluated. The total intake of all of 62 foods was 294.77 kg/yr; additionally, the total internal radiation dose from ^{40}K was 136.4 μSv/yr. The total internal radiation dose from ^{137}Cs was 0.163 μSv/yr, which is extremely low compared to the annual ^{40}K dose. Thus, we confirmed that the annual internal radiation dose from ^{137}Cs was lower than

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Table 1. Radioactivity concentrations of ^{40}K and ^{137}Cs in foods (unit: Bq/kg-fresh)

Food	^{40}K	^{137}Cs
Persimmon	48.0±0.5	<30.7
Potato	133.2±1.3	<38.6
Egg	38.8±1.2	<22.3
Sweet potato	128.6±1.28	<39.5
Gastropods	56.6±0.63	<43.5
Mackerel	67.5±0.67	48.0±3.5
Chili	86.7±1.54	<108.3
Oyster	26.9±0.4	<38.5
Kimchi	85.0±16	-
Perilla leaf	133±16	-
Gracilaria sp.	419.5±4	<94.8
Hairtail	86.1±0.96	66.2±5
Green tea	465±125	185±84
Oyster mushroom	101.3	-
Kelp	1310.0	<32.0
Chicken	82.3±1.6	<28.3
Carrot	95.5±1.74	<186.1
Pig	73.3±1.3	<33.2
Tofu	43.0±0.52	<25.3
Rice cake	24.0±23	21.0±13
Ramen	60.0±13	-
Anchovy	41.6±0.6	<26.7
Radish	79.9±1.6	<170.4
Radish dried	107.7±1.9	<189.7
Seaweed	187.6±2	<74.5
Banana	141.0	-
Yellowtail	91.9±0.95	141.4±5.8
Pear	42.6±0.49	<17.9
Chinese cabbage	76.5±0.8	<29.7
Baekhab	39.6±0.5	<52.7
Bread	33.0±9	26.0
Apple	37.9±1.4	<15.9
Spanish mackerel	102.2±0.95	116.2±4.9
Lettuce	125.1±2.2	<200.6
Beef	66.7±1.2	<33.3
Conch	52.6±0.7	<49.0
Watermelon	39.6±0.4	<14.2
Gray mullet	70.0±0.78	64.1±4.8
Rice	24.4±0.3	<17.5
Mugwort	239.2±2.3	<85.2
Green pumpkin	70.8±1.42	<165.1
Agaricus bisporus	132.3	761.5
Onion	44.7±0.86	<16.8
Orange	25.6	-
Cucumber	56.8±0.98	<93.9
Squid	71.4	<24.0
Yogurt	42.0±19	15.0±7
Milk	45±3	<18.7
Horse mackerel	66.7±0.73	66.7±4.6
Gizzard	66.2±0.75	35.5±4.7
Coffee	1,077.0±216	781.0±274
Bean	528.9±2.1	<192.5
Pen shell	42.4±0.5	<27.3
Tomato	70.3±0.76	<23.3
Hijikia fusiforme	311.3±3.6	<83.6
Green onion	63.9±1.1	<105.3
Sea lettuce	285.3	-
Enoki mushroom	132.1±24	53.0±33
Grape	60.9±0.7	<22.4
Ark clams	40.7±0.47	<33.7
Skate	50.8±0.51	63.9±3.9
Mussel	29.5±0.35	<23.5
Total	8,478.1	4,968.8

Table 2. Annual effective dose from ^{40}K and ^{137}Cs due to food intake

Food	Intake (kg/yr)	Annual effective dose (μSv/yr)	
		^{40}K	^{137}Cs
Persimmon	4.909	1.460	0.00196
Potato	6.731	5.559	0.00337
Egg	10.373	2.492	0.00301
Sweet potato	4.676	3.728	0.00240
Gastropods	0.015	0.005	0.00001
Mackerel	1.110	0.464	0.00069
Chili	1.555	0.836	0.00219
Oyster	0.372	0.062	0.00019
Kimchi	23.528	12.399	-
Perilla leaf	0.920	0.758	-
Gracilaria sp.	0.004	0.009	-
Hairtail	0.515	0.275	0.00044
Green tea	3.570	10.291	0.00859
Oyster mushroom	0.445	0.280	-
Kelp	0.307	2.490	0.00013
Chicken	11.165	5.696	0.00410
Carrot	2.705	1.601	0.00654
Pig	17.670	8.035	0.00762
Tofu	6.866	1.830	0.00226
Rice cake	5.933	0.883	0.00162
Ramen	4.931	1.834	-
Anchovy	1.248	0.322	0.00043
Radish	9.348	4.629	0.02071
Radish dried	1.205	0.804	0.00297
Seaweed	0.296	0.344	0.00029
Banana	4.172	3.647	-
Yellowtail	0.073	0.042	0.00013
Pear	3.376	0.891	0.00079
Chinese cabbage	2.628	1.246	0.00101
Baekhab	0.022	0.005	0.00002
Bread	7.366	1.507	0.00249
Apple	17.648	4.142	0.00365
Spanish mackerel	0.153	0.097	0.00023
Lettuce	2.422	1.894	0.00637
Beef	8.161	3.377	0.00353
Conch	0.051	0.017	0.00003
Watermelon	4.712	1.156	0.00087
Gray mullet	0.044	0.019	0.00004
Rice	52.206	7.903	0.01187
Mugwort	0.055	0.081	0.00006
Green pumpkin	3.165	1.390	0.00679
Agaricus bisporus	0.175	0.144	0.00173
Onion	10.516	2.916	0.00230
Orange	2.300	0.365	-
Cucumber	5.460	1.921	0.00666
Squid	1.694	0.750	0.00053
Yogurt	5.413	1.410	0.00106
Milk	25.470	7.221	0.00620
Horse mackerel	0.007	0.003	0.00001
Gizzard	0.066	0.027	0.00003
Coffee	2.730	18.231	0.02772
Bean	0.982	3.219	0.00246
Pen shell	0.011	0.003	-
Tomato	5.256	2.291	0.00159
Hijikia fusiforme	0.029	0.056	0.00003
Green onion	3.946	1.563	0.00540
Sea lettuce	0.153	0.271	-
Enoki mushroom	0.310	0.254	0.00021
Grape	3.037	1.147	0.00088
Ark clams	0.102	0.026	0.00004
Skate	0.029	0.009	0.00002
Mussel	0.416	0.076	0.00013
Total	294.77	136.4	0.163

the effective dose limit of 1 mSv/yr recommended by ICRP Publication 60. The total annual effective dose from ^{40}K in foods mainly consumed in Korea, as determined in this study, was lower than that reported for Iran (5,240 μSv/yr) [18] and similar to that for Japan (130–217 μSv/yr) [19]. The total annual effective dose from ^{137}Cs in foods mainly consumed in Korea, as reported in this study, was lower than that reported in Iran (2,490 μSv/yr) [18] as well as Japan (49–378 μSv/yr) [19].

2. Self-Questionnaire

Based on the evaluation results of the ^{40}K and ^{137}Cs radioactivity concentrations in foods (Table 1) and the internal radiation dose due to food intake (Table 2), commonly consumed foods in South Korea were classified into food groups. We developed a self-questionnaire to evaluate the internal radiation dose directly resulting from the ingestion of food. Appendix 1 presents the self-questionnaire. The areas of focus of the self-questionnaire include the physical condition of the subject, disease history, smoking status, and level of physical activity, all of which are covered in a basic health examination. For the food-intake frequency survey, the foods are presented in food groups (i.e., grains, beans, tubers, and nuts; vegetables; fruits and mushrooms; meat; seafood and seaweed; and coffee, tea, dairy products, and other foods). Some subjects were offered the option to list and provide information regarding foods that they frequently consume but are not listed in the survey. This information can be used to evaluate the annual internal radiation dose attributable to the non-listed food(s) through the analysis of the radioactivity concentration(s) in future investigations. To help the subjects visualize a single serving, a picture of a paper cup was added to the food-intake survey sheet. The survey sheet states that the capacity of the paper cup corresponds to 100 g of each food product. Because there may be inter-individual differences in the amount of food consumed in one meal, we chose to classify and present three or four amount options in the food-intake frequency survey. Specifically, after the 100-g serving size was defined, depending on the food, the survey options were grouped as either 1/2, 1, 1½, and 2 or 1/8, 1/4, and 1/2.

Conclusion

In this study, we investigated the radioactivity concentrations of ^{40}K and ^{137}Cs, as well as their annual internal dose via intake of frequently and commonly consumed foods. The annual intake and annual effective dose from ^{40}K were much higher than those from ^{137}Cs. Because the chemical and metabolic characteristics of K and Cs are similar, the distributions of ^{40}K and ^{137}Cs in the most frequently consumed foodstuffs in Korea show similar trends. The annual intake and radioactivity concentrations were evaluated by referring to the materials of the 7th KNHANES (2016–2018) on food intake and the 2016–2018 Radiation Safety Management Report released by KINS. Using the food-intake survey mentioned above as a reference, we selected 62 foods to include in our radioactivity concentration and internal radiation dose evaluations. We also developed an internal exposure self-questionnaire, which includes a food-intake frequency questionnaire, for the purpose of internal radiation dose evaluation. The questionnaire consists of 26 items, including basic health check-up items. In the food-intake frequency questionnaire, the subjects were offered the following options regarding the frequency of food eaten over the period of the previous month: rarely, once a month, 2–3 times a month, once a week, 2–4 times a week, 5–6 times a week, once a day, twice a day, and three times a day. However, more extensive studies are necessary to elucidate the effects of ^{40}K and ^{137}Cs in the human body after their ingestion via foods, as the radioactivity concentration in food may affect the concentration in the body. Statistical analysis should be conducted to derive the relationship between food ingestion and radioactivity concentration in the body. In addition, it is expected that the dose assessment questionnaire developed in this study can be used for epidemiological studies that are purposed to better understand the daily food ingestion of Korean adults and to evaluate the annual effective dose of consumed foods.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Ethical Statement

The study was conducted in accordance with the tenets of the Declaration of Helsinki, and the protocol was approved

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by the Institutional Review Board of the Dongnam Institute of Radiological and Medical Sciences (DIRAMS) for all experimental procedures (Approval No. D-2203-001-002).

Author Contribution

Conceptualization: Kang YR, Kim JK, Lee CG, Lee JE. Data Curation: Kim HJ, Kye YU, Lee DY, Kang YR. Writing of the original draft: Kang YR, Kim JK, Lee CG, Lee JE. All the authors have proofread the final version.

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Appendix 1. Internal exposure self-questionnaire

Internal exposure self-questionnaire

Number		Height (cm)		Weight (kg)	
Gender	Male / Female	Age		Radiation worker	Yes / No

※ Consent

The information obtained from the questionnaire will be used in relation to an internal exposure examination. In accordance with Article 17.1.1 of the personal information protection act (Provision of Personal Information) and Article 21 (Record, Reading, etc.) of the Medical Act, we must obtain your consent before using your information

① I Agree. ____(Signature) ② I' not Agree.

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※ Please read and compete the questions.

< Illness History >

1. Have you been diagnosed and/or are on medication for any of the following diseases?

	Diagnosed		Medication	
Cerebral apoplexy (stroke)	Yes	No	Yes	No
Myocardial infarction/angina	Yes	No	Yes	No
High blood pressure	Yes	No	Yes	No
Diabetes	Yes	No	Yes	No
Dyslipidemia	Yes	No	Yes	No
Tuberculosis	Yes	No	Yes	No
Etc. (cancer)	Yes	No	Yes	No

2. Has anyone in your immediate family died of the following conditions?

Cerebral apoplexy (stroke)	Yes	No
Myocardial infarction/angina	Yes	No
High blood pressure	Yes	No
Diabetes	Yes	No
Etc. (contain cancer)	Yes	No

< Smoking and e-cigarettes >

3. Have you ever smoked more than 5 packs of cigarettes (100 cigarettes) in your lifetime?

(1) No (▶ Go to question 4)
(2) Yes, but I have quit smoking (▶ Go to question 3-1)
(3) Yes, and I currently smoking (▶ Go to question 3-2)

3-1. Previously smoked but have since quit

How many years did you smoke before quitting?	_____ years
How many cigarettes did you smoke a day on average?	_____ cigarettes

3-2. Still smoking

For how many years have you been smoking	_____ years
How many cigarettes do you smoke a day on average?	_____ cigarettes

4. Have you ever used an e-cigarette?
(1) Yes (▶ Go to question 4-1)
(2) No

4-1. How often have you used an e-cigarette in the last month?
(1) No
(2) 1–2 days a month
(3) 3–9 days a month
(4) 10–29 days a month
(5) Every day

< Physical activity (exercise) >

5-1. In a typical week, how often do you do high-intensity physical activity that results in you beign out of breath?
( ) days per week

*E.g., Running, aerobics, intensive bike riding, etc.

5-2. How many hours per day do you usually engage in high-intensity physical activity that results in you being out of breath?
( ) hour(s) ( ) minute(s) per day

6-1. In a typical week, how many days do you do moderate-intensity physical activity that results in you out of breathe?

*Please exclude any physical activity related to answer 5.
*E.g., Walking, tennis, casual bike riding, cleaning, etc.

6-2. How many hours per day do you usually engage in moderate-intensity physical activity that results in you being out of breath?
( ) hour(s) ( ) minute(s) per day

7. In the past week, on how many days did you do strength training, such as push-up, sit-ups dumbbells, weights or iron bars?
( ) days per week

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Appendix 1. Continued

<Food intake frequency survey>

1. Have there been any changes in the type and amount of meals you consumed in the past year? (Changes in meal rate or time are not applicable)

(1) Yes A few my eating habits changed ( ) months ago. (2) No

2. On average, how many meals a day did you eat in the past year?

(1) 1 meal (2) 2 meals (3) 3 meals (4) 4 meals (5) >4 meals ( )

Reference Volume

Paper cup (200 mL)	Food	Volume (100 g)	Food	Volume (100 g)
	Tofu	1/2 block	Banana	Medium size 1/2 piece
	Potato	Medium size 1/2 piece	Orange	1/2 piece
	Nut	A handful	Oyster	7–8 pieces
	Onion	Large size 1/2 piece	Hairtail	A fillet of 7–8 cm
	Cucumber	1/2 piece	Squid	10 × 10 cm, 2 pieces
	Green onion	1 piece	Kelp	8 × 25 cm, 1 piece
	Bean sprouts, Balloon flower	A handful	Calm	Medium size 4 pieces
	Enoki mushroom	Commerically available bag	Chicken	1 piece of chicken
	Shiitake mushroom	Large size 3 pieces	Beef	Palm size
	Button mushroom	Medium size 8–9 pieces	Pork	5 × 15 cm, 3–4 pieces
	Apple, Persimmon	3 pieces	Egg	Medium size 2 pieces

8. Tick the number of grains and starches consumed in the past month, as well as your average intake.

	Infrequent	1 Month		1 Week			1 Day			Reference volume	Average intake per serving			
		1	2–3	1	2–4	5–6	1	2	3					
Rice	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1 bowl (300 mL)	1/2	1	1 1/2	2
Potato, Sweet-potato	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1 piece	1/2	1	2	
Bean, Tofu	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1/2 cup (100 mL)	1/4	1/2	1	
Nut	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1/4 cup (50 mL)	1/8	1/4	1/2	
Wheat	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1/4 cup (50 mL)	1/8	1/4	1/2	

8-1. Please write down the type of nuts you frequency consumed. (E.g., walnuts, almonds, etc.)

9. Tick the number of vegetables consumed in the past month, as well as the average intake.

	Infrequent	1 Month		1 Week			1 Day			Reference volume	Average intake per serving		
		1	2–3	1	2–4	5–6	1	2	3				
Kimchi	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1/4 cup (50 mL)	1/8	1/4	1/2
Radish, Onion	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1/4 cup (50 mL)	1/8	1/4	1/2
Green onion, Cucumber	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1/4 cup (50 mL)	1/8	1/4	1/2
Lettuce, Garlic, Chili	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	Lettuce 10 pieces Chili 3 pieces	5	10	15
Tomato, A green-pumpkin, Carrot	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1/4 cup (50 mL)	1/8	1/4	1/2

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Appendix 1. Continued

9-1. Please write down the type of vegetable you frequently consumed.

10. Tick the number of fruits and mushrooms consumed in the past month, as well as the average intake.

	Infrequent	1 Month		1 Week			1 Day			Reference volume	Average intake per serving		
		1	2–3	1	2–4	5–6	1	2	3				
Banana, Apple	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1 piece	1/2	1	2
Persimmon, Pear	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1 piece	1/2	1	2
Orange	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	2 pieces	1	2	3
Grape	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1 cup (200 mL)	1/2	1	2
An agaric mushroom	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1/4 cup (50 mL)	1/8	1/4	1/2
Shiitake mushroom, Button mushroom	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1/4 cup (50 mL)	1/8	1/4	1/2

10-1. Please write down the type of fruits and mushrooms you frequently consumed.

11. Tick the number of times you consumed meat in the past month, as well as the average intake.

	Infrequent	1 Month		1 Week			1 Day			Reference volume	Average intake per serving		
		1	2–3	1	2–4	5–6	1	2	3				
Pork	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	For 1 person (150 g = 1 cup)	1/2	1	2
Beef	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	For 1 person (150 g = 1 cup)	1/2	1	2
Chicken	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	2 cup (400 mL)	1	2	3
Egg	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1 piece	1/2	1	2

11-1. Please write down the type of meat you frequently consumed.

12. Tick the number of times you consumed seafood and seaweed in the past month, as well as the average intake.

	Infrequent	1 Month		1 Week			1 Days			Reference volume	Average intake per serving		
		1	2–3	1	2–4	5–6	1	2	3				
Squid, Mackerel	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1/4 cup (50 mL)	1/8	1/4	1/2
Green laver, Kelp	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1/4 cup (50 mL)	1/8	1/4	1/2
Manila clam, Mussel, Oyster, Clam	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1/4 cup (50 mL)	1/8	1/4	1/2

12-1. Please write down the type of seafood and seaweed you frequently consumed.

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Appendix 1. Continued

13. Check the number of drinks, dairy products, and other intakes you consumed in the past month, as well as the average intake per serving.

	Infrequent	1 Month		1 Week			1 Day			Reference volume	Average intake per serving		
		1	2–3	1	2–4	5–6	1	2	3				
Coffee	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	2 ts (10 mL)	1	2	3
If you drink more than 3 coffees a day, how many cups did you drink on average? (_____) cups a day													
Cream	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	2 ts (10 mL)	1	2	3
Sugar	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	2 ts (10 mL)	1	2	3
Green tea	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1 cup (200 mL)	1/2	1	1 1/2
Milk	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1 cup (200 mL)	1/2	1	1 1/2
Yogurt	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1 piece (100 g)	1/2	1	2
Rice cake	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	Baekseolgi 1/2 piece, Injeolmi, Jeolpyeon 3 pieces	1/4	1/2	1
Ramen	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1 piece	1/2	1	1 1/2
Bread	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	1 piece	1/2	1	2

13-1. Please write down the type of drinks, dairy products, and other intakes you frequently consumed.