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A Statistical Approach for Estimating the Distribution of Usual Dietary Intake to Assess Nutritionally At-Risk Populations Based on the New Japanese Dietary Reference Intakes (DRIs)

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Summary The health of individuals is not markedly affected by the nutrients ingested in a single day; rather it is influenced by dietary habits over a long period of time. However, it is impossible to survey usual intake directly because recording diet over a long period of time is burdensome for the subjects, so usual dietary intake is rarely measured directly. Instead, we estimated the distribution of selected nutrients in subjects' usual dietary intake using a statistical method (Best-Power method) described previously. And we assessed the proportion of nutritionally at-risk subjects in individual groups based on the new Japanese Dietary Reference Intakes (DRIs), the Estimated Average Requirement (EAR), or the tentative dietary goal for preventing life-style related diseases (DG) as cut-points. We collected the survey data from 208 men and 251 women, aged 50 to 69 y in 2004 and 2005. The survey was carried out on three non-consecutive days four times each year: in spring, summer, autumn, and winter. The distribution of nutrients in the usual intake was estimated from a dietary survey of 3 d using one-way analyses of variance. We found that the proportion of the population at risk for nutrient deficiency was overestimated in the 1-d intake distribution. On the other hand, the fraction that was nutritionally at-risk in terms of salt intake, according to DG as the cut-point, was underestimated in the 1-d intake distribution: 74.0% of men and 82.5% of women in the 1-d intake, and 90.5% and 93.2%, respectively, for the estimated usual intake adjusted for seasonal variation.

Key Words dietary assessment, DRIs (Dietary Reference Intakes), EAR (Estimated Average Requirement), usual intake, statistical method

The health of individuals is not markedly affected by the nutrients ingested in a single day; rather it is influenced by dietary habits over a long period of time. It is difficult to estimate usual intakes from surveys carried out for a short period because of the large day-to-day variations of dietary intakes within an individual (*1–8*). However, it is impossible to survey usual intake directly because recording diet over a long period of time is burdensome for the subjects, so usual dietary intake is rarely measured directly.

The dietary reference intakes (DRIs) for Japanese were revised in 2005 (*9*). Dietary assessments typically entail estimating the proportion of the population who are "at risk" for diet-related health problems. The variable of interest is not a person's dietary intake on any one day, but the "usual" dietary intake taken over a period long enough to affect the person's health. However, the National Health and Nutritional Survey, a representative nutritional survey in Japan (NHNS-J) (*10*), is carried out on only one day in November, and consequently cannot assess the "usual intake" of individuals over long periods of time.

In 1986, the National Research Council (NRC) (*11*) proposed a statistical procedure for correcting the bias in the variance of the distribution of average dietary intake. The variance of this adjusted distribution of average dietary intake is an unbiased estimate of the variance of usual dietary intake. The NRC adjustment procedure can be applied to a few days of dietary intake data from a subset of individuals in a sample. It involves one-way analysis of variance (ANOVA) and must be followed if day-to-variability is to be removed from observed intake data. In 1996, Nusser and Iowa State University developed a statistical procedure that better accounts for some of the characteristics of dietary intake data (*12*). Extrapolating from the original NRC report (*11*), Nusser et al. (*12*) also proposed a simplified alternative to the Iowa State University method. This so-called Best-Power method shares the applicability of Nusser's method to complex surveys, but uses only a one-stage power or log-transformation (*12, 13*). These methods are commonly used to estimate the distribu-

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tion of usual intake from a few days of dietary intake data under the assumption that dietary intakes are distributed almost normally. If the data have a highly skewed distribution, then the distribution obtained by taking the logarithm of each observation may be symmetric, and therefore be better approximated by a normal distribution. The expression that relates values in the transformed scale to usual intake data in the original scale is called the back-transformation. The NRC method uses a simple back-transformation that is just the inverse of the original transformation, assuming that the transformed data for 1-d dietary intake is an unbiased estimator of the transformed usual intake. By contrast, the Nusser et al. and Best-Power methods use a back-transformation with a bias-adjustment term, assuming that the data for 1-d dietary intake is an unbiased estimator of usual intake in the untransformed scale (*12*, *13*). The latter assumption follows directly from the definition of usual intake if within-person variation in 1-d dietary intake is solely due to day-to-day variability in diet, but in general they require that all components of within-person variation tend to average out in the original scale. Under these conditions, the latter assumption may be more attractive from a practical standpoint (*13*).

The National Health and Nutrition Examination Survey (NHANES) in the USA was conducted to estimate the distribution of nutrients in the usual intake using the NRC, Nusser, and Best-Power methods (*14*, *15*). These statistical methods are expected to be introduced into Japan as well for assessment of nutritionally at-risk populations.

In this study, we assessed nutritionally at-risk populations based on the new Japanese DRIs using the Best-Power method, which estimated the distributions of usual intake from 3 d of dietary intake data. The Estimated Average Requirement (EAR) cut-point method is a well-known procedure for evaluating nutrient intakes of groups (*16–18*), and we adopted it to assess the proportion of the population at risk for inadequacy. To evaluate the proportion of the population at risk for nutrient excess (and calcium deficiency) we used the dietary goals for preventing life-style related diseases (DG) on the adjusted and unadjusted distributions of dietary intake data.

METHODS

1) Subjects and settings. The subjects were volunteers in districts that cooperated in the dietary survey in 2004 and 2005. The districts are 14 areas of 12 prefectures: Aomori, Akita, Iwate, Yamagata, Nagano, Gunma, Chiba, Okayama, Tokushima, Kochi, Fukuoka, and Miyazaki. The subjects were limited to those who were aged 50 to 69 y according to the age divisions of the DRIs. As a result, 221 men and 275 women were included. Of the original subjects, 13 men and 24 women taking dietary supplements of vitamins or minerals were excluded, so that the analysis was carried out on data from 208 men (average age±SD: 61.0±5.4) and 251 women (60.1±5.4). The survey was carried out four times each year: in May and June (spring), August and September (summer), and November and December (autumn), and February and March (winter). In each season, the survey was carried out on three non-consecutive days, two of which were weekdays and one of which fell on a weekend. The interval from the first to the third day was less than 2 wk in each season.

Nutrient intakes were estimated according to the NHNS-J, whereby a household kept a 1-d diet record of the intake per person of "approximate proportions" (semi-weighed) (*10*, *19*). Dietitians explained the survey method to the subjects, and checked the questionnaires through inquiries when collecting them. Nutrient intakes were calculated using the Fifth Revision of the Standard Food Composition Table (*20*).

This study was approved by the ethics committee of the National Institute of Health and Nutrition in Japan. Sufficient explanations were given orally and by visual materials to all the households from which data were collected. All participants gave written consent for collaboration in this study.

2) Data analyses. All analyses were performed using SAS version 8 (*21*). For each nutrient, the usual intake distribution was estimated using the Best-Power method, with the assumption that a 1-d dietary intake is an unbiased estimate of usual intake in the untransformed scale. The method used was the same as that described previously (*12*). The basic approach consisted of three steps: 1) Transformation of observed dietary intake data to normality; 2) Removal of measurement error in the normal scale; 3) Back-transformation to the original scale.

We estimated the distributions of the intake of energy and the following seven nutrients: protein, fat as energy percentage, sodium as salt, calcium, iron, folic acid, and vitamin C. We chose these nutrients because a deficient or excessive consumption of any one of them can have negative impacts on a person's health. For example, a deficiency of calcium, iron, folic acid, vitamin C, or protein can cause significant health problems, and an excessive consumption of fat and salt is associated with certain diseases. We evaluated the nutritionally at-risk population by comparing the estimated intakes with DRIs (*9*). In regard to the nutrients for which EAR has been determined, namely protein, iron, folic acid, and vitamin C, the proportion of inadequate intake was assessed using the EAR cut-point method. The proportion of the population that was consuming less calcium than the DG, more salt than the DG or that was obtaining more energy from fat than specified in the DG was calculated. It is difficult to evaluate the proportion of a population not meeting the iron requirement using the EAR cut-point method because the presence of menstruating women causes the distribution of requirements to be heavily skewed (*16*, *18*). However, in this study the age of the subjects was 50 y or more. We therefore assumed that the women were post-menopausal, and we adopted the EAR cut-point method for iron.

Results are given as mean±SD. First, two-way

Table 1. Characteristics of subjects and nutrient intake data for: 12 d throughout a year and over 3 d each season for men.

Men (n=208)		12 d		Spring (3 d)		Summer (3 d)		Autumn (3 d)		Winter (3 d)		ANOVA p value
		Mean±SD	Median	Mean±SD	Median	Mean±SD	Median	Mean±SD	Median	Mean±SD	Median	
Age	y	60.9±5.6	61.5	60.5±5.6	61.0	60.7±5.7	61.0	61.0±5.6	62.0	61.2±5.6	62.0	
Weight	kg	64.6±8.4	64.0	64.6±8.5	64.0	64.4±8.5	64.0	64.6±8.5	64.0	64.7±8.4	64.0	
BMI		23.3±2.6	23.3	23.3±2.6	23.2	23.2±2.7	23.2	23.3±2.6	23.3	23.4±2.5	23.4	
Dietary intake per day												
Energy	kcal	2,379±404	2,325	2,396±456	2,306	2,407±488	2,332	2,346±471	2,304	2,366±493	2,303	
Protein	g	89.3±16.3	87.4	92.4±19.7	90.5	88.9±20.5	86.2	87.1±18.9	86.6	89.0±20.3	86.1	**
Fat	g	58.5±14.5	55.6	58.9±16.7	56.2	59.5±18.9	56.1	57.4±20.4	53.9	58.4±19.0	54.9	
Fat	%energy	22.2±3.8	22.0	22.0±4.6	21.7	22.0±4.7	21.8	21.7±4.8	21.2	21.9±4.7	21.9	
Salt	g	14.1±3.3	13.9	14.5±4.6	13.6	14.5±4.4	14.0	13.9±4.2	12.9	13.6±3.9	13.3	**
Calcium	mg	648±189	617	661±239	625	634±231	613	643±223	609	654±218	620	
Iron	mg	10.4±2.5	10.0	10.7±3.1	10.4	10.2±4.0	9.8	10.1±2.9	9.9	10.4±2.9	10.1	
Folate	μg	430±135	404	444±155	415	430±252	401	420±172	396	427±166	398	
Vitamin C	mg	128±49	121	120±53	112	124±84	106	145±81	136	125±61	117	***

*p<0.05, **p<0.01, ***p<0.001.

Table 2. Characteristics of subjects and nutrient intake data for: 12 d throughout a year and over 3 d each season for women.

Women (n=251)		12 d		Spring (3 d)		Summer (3 d)		Autumn (3 d)		Winter (3 d)		ANOVA p value
		Mean±SD	Median	Mean±SD	Median	Mean±SD	Median	Mean±SD	Median	Mean±SD	Median	
Age	y	59.9±5.4	60.5	59.6±5.4	60.0	59.8±5.4	60.0	60.0±5.4	61.0	60.3±5.4	61.0	
Weight	kg	54.0±7.1	53.6	54.1±7.2	53.5	53.8±7.2	53.0	54.0±7.1	54.0	54.0±7.1	54.0	
BMI		23.1±2.9	22.9	23.1±2.9	22.8	23.0±3.0	22.8	23.1±3.0	23.0	23.1±2.9	23.1	
Dietary intake per day												
Energy	kcal	1,870±307	1,858	1,880±344	1,877	1,864±391	1,823	1,867±358	1,937	1,871±363	1,833	
Protein	g	74.6±14.1	72.8	76.5±15.8	75.8	73.8±18.1	71.7	73.9±16.7	71.5	74.3±17.0	73.5	
Fat	g	51.0±12.3	48.8	52.2±15.8	50.3	50.7±14.9	49.2	50.3±17.6	48.0	50.8±15.5	47.9	
Fat	%energy	24.5±3.6	24.2	24.5±4.9	24.4	24.2±4.7	24.0	23.7±4.7	23.5	24.1±4.6	24.0	
Salt	g	12.2±3.0	11.8	12.3±3.8	11.7	12.4±4.3	11.8	12.1±3.7	11.6	11.8±3.4	11.4	*
Calcium	mg	631±188	619	646±236	620	616±231	605	634±224	617	630±230	606	
Iron	mg	9.6±2.8	9.2	9.6±2.8	9.3	9.5±5.3	8.6	9.5±3.0	9.1	9.7±3.3	9.2	
Folate	μg	406±141	375	408±136	385	406±335	346	406±160	370	403±144	377	
Vitamin C	mg	138±58	126	132±77	120	123±85	112	158±84	143	137±77	121	***

*p<0.05, **p<0.01, ***p<0.001.

ANOVA (individual and season) were used to test for differences across the four seasons. Second, we assessed the differences among the five dietary intake distributions: 1) 1-d data (the first day) for a weekday in autumn, 2) mean intake data for 3 d in autumn, 3) mean intake data for 12 d throughout a year, and 4) the usual intake distribution estimated using the Best-Power method from the 3-d data in autumn, 5) the usual intake distribution adjusted for seasonal variation by adding the difference between the average for 12 d throughout a year and the average for 3 d in autumn to the estimated usual intake from data for 3 d in autumn. Finally, after categorizing the five patterns, we computed the percentages of the population that were at risk.

RESULTS

The characteristics of the subjects are shown in Tables 1 and 2. The means and standard deviations, and medians of nutrient intakes are presented for 3 d in each season. In both men and women, the intake of vitamin C was highest in autumn (p<0.001).

Table 3 shows four different descriptive statistics on dietary intake, i.e. a weekday in autumn, an average of 3 d in autumn, an average of 12 d throughout a year, and usual intakes estimated by the Best-Power method. It was found that the usual intake distributions of many nutrients were markedly narrower than the distributions of 1-d intake data. The season-adjusted estimation of the usual intake distribution was similar to the distribution for 12 d.

Table 4 illustrates the proportion of the population estimated to be nutritionally at risk using the EAR or DG as cut-points. The proportion of the population at risk for nutrient deficiency was overestimated in the 1-d intake distribution. For calcium, based on the 1-d intake distribution, 48.6% of men and 48.2% of women were at risk of deficiency, compared to the estimates of 45.2% for men and 46.5% for women derived from season-adjusted estimation of the usual intake. For folate,

Table 3. Descriptive statistics of the intake of 8 nutrients in men and women for: raw data from 1 d, means of 3 d and 12 d and estimating usual intake by Best-Power method.

(1) Energy, kcal

	Percentile									Mean	SD
	1st	5th	10th	25th	50th	75th	90th	95th	99th		
Men											
1 d	1,441	1,613	1,705	1,979	2,312	2,610	3,095	3,269	3,707	2,339	506
3 d mean	1,439	1,656	1,791	2,004	2,304	2,631	2,989	3,190	3,626	2,346	471
12 d mean	1,610	1,841	1,934	2,078	2,325	2,605	2,989	3,062	3,466	2,379	404
Usual	1,505	1,725	1,850	2,052	2,300	2,602	2,907	3,086	3,451	2,345	421
Usual[1]	1,538	1,758	1,883	2,084	2,333	2,635	2,940	3,119	3,484	2,378	421
Women											
1 d	1,011	1,259	1,359	1,579	1,814	2,154	2,444	2,590	3,140	1,876	429
3 d mean	1,150	1,358	1,449	1,623	1,837	2,088	2,320	2,411	2,914	1,867	358
12 d mean	1,246	1,435	1,516	1,681	1,858	2,060	2,247	2,314	2,891	1,870	307
Usual	1,223	1,426	1,508	1,687	1,849	2,042	2,237	2,334	2,754	1,867	298
Usual[1]	1,226	1,429	1,511	1,690	1,852	2,045	2,240	2,337	2,757	1,870	298

[1] Adjusted for seasonal variation.

(2) Protein, g

	Percentile									Mean	SD
	1st	5th	10th	25th	50th	75th	90th	95th	99th		
Men											
1 d	39.6	52.6	57.7	70.2	84.9	101.1	118.5	127.1	147.9	86.4	23.2
3 d mean	50.6	58.1	64.4	74.3	86.6	98.4	110.7	122.7	141.3	87.1	18.9
12 d mean	60.9	66.7	68.8	77.7	87.4	99.6	111.1	121.8	131.1	89.3	16.3
Usual	52.2	63.5	68.1	76.0	86.4	96.7	107.6	114.1	128.5	87.1	16.0
Usual[1]	54.5	65.7	70.4	78.2	88.7	98.9	109.8	116.3	130.7	89.3	16.0
Women											
1 d	36.1	42.5	48.6	58.8	71.8	84.3	97.0	108.5	133.7	73.0	20.3
3 d mean	42.1	51.0	55.1	62.0	71.5	82.5	96.3	106.5	124.6	73.9	16.7
12 d mean	45.0	53.2	59.0	65.0	72.8	82.4	91.9	99.5	112.1	74.6	14.1
Usual	46.4	53.7	57.5	64.6	73.1	81.8	91.3	97.6	112.5	73.9	13.5
Usual[1]	47.2	54.4	58.3	65.3	73.8	82.5	92.0	98.3	113.2	74.6	13.5

[1] Adjusted for seasonal variation.

(3) Fat, %energy

	Percentile									Mean	SD
	1st	5th	10th	25th	50th	75th	90th	95th	99th		
Men											
1 d	8.7	11.7	13.7	17.6	21.5	25.7	29.6	33.8	37.7	21.7	6.2
3 d mean	11.9	13.4	15.5	18.9	21.4	24.6	28.1	30.0	34.0	21.9	5.0
12 d mean	14.4	15.9	17.2	19.6	22.0	24.8	27.0	28.2	30.4	22.2	3.8
Usual	14.2	15.7	17.0	19.3	21.6	24.1	26.1	27.7	30.1	21.7	3.6
Usual[1]	14.5	16.0	17.3	19.6	21.9	24.3	26.4	27.9	30.4	22.0	3.6
Women											
1 d	9.7	13.9	15.7	19.3	23.5	27.9	31.3	33.6	38.8	23.6	6.4
3 d mean	15.1	16.6	18.2	20.7	23.8	27.1	29.5	32.2	36.2	24.0	5.0
12 d mean	17.0	19.3	20.0	21.9	24.2	27.0	29.2	30.1	32.7	24.5	3.6
Usual	16.7	18.5	19.7	21.4	23.8	26.0	27.6	28.7	31.0	23.7	3.2
Usual[1]	17.2	18.9	20.2	21.9	24.2	26.4	28.1	29.2	31.5	24.2	3.2

[1] Adjusted for seasonal variation.

(4) Salt, g

	Percentile									Mean	SD
	1st	5th	10th	25th	50th	75th	90th	95th	99th		
Men											
1 d	5.9	7.1	8.0	9.9	12.9	16.3	20.2	22.7	27.8	13.6	4.8
3 d mean	6.5	8.3	9.6	11.0	12.9	16.0	19.9	21.4	26.4	13.9	4.2
12 d mean	6.8	9.2	10.2	11.9	13.9	16.0	18.8	19.7	23.8	14.1	3.3
Usual	7.5	9.0	9.8	11.3	13.6	15.8	18.6	19.9	23.2	13.9	3.5
Usual[1]	7.7	9.3	10.1	11.6	13.9	16.0	18.8	20.2	23.5	14.1	3.5
Women											
1 d	4.9	6.1	6.9	9.0	11.3	14.1	17.3	18.8	24.8	11.9	4.1
3 d mean	5.7	7.1	7.8	9.6	11.6	13.9	17.1	18.7	24.1	12.1	3.7
12 d mean	6.3	8.1	8.7	10.1	11.8	14.1	15.9	17.1	22.0	12.2	3.0
Usual	6.2	7.6	8.4	10.0	11.7	13.9	15.9	17.9	21.3	12.1	3.1
Usual[1]	6.2	7.7	8.5	10.1	11.8	14.0	15.9	17.9	21.4	12.2	3.1

[1] Adjusted for seasonal variation.

Table 3. (Continued)

(5) Calcium, mg

	Percentile									Mean	SD
	1st	5th	10th	25th	50th	75th	90th	95th	99th		
Men											
1 d	227.6	290.7	339.5	418.2	611.8	789.6	943.3	1,100.2	1,335.5	628.7	264.0
3 d mean	255.1	344.8	385.6	470.9	609.1	786.7	926.1	1,069.1	1,218.3	642.6	222.6
12 d mean	317.6	398.1	434.6	513.0	616.8	767.6	910.5	974.6	1,137.1	647.9	189.2
Usual	317.5	372.6	421.2	492.1	617.2	764.0	901.3	992.6	1,155.0	642.5	189.2
Usual[1]	322.9	378.0	426.5	497.4	622.5	769.3	906.7	997.9	1,160.3	647.8	189.2
Women											
1 d	143.7	279.9	360.3	442.2	607.9	784.0	977.9	1,121.8	1,517.9	633.7	261.7
3 d mean	199.5	319.0	387.3	464.3	616.7	717.9	933.9	1,020.4	1,242.9	633.5	223.6
12 d mean	297.3	357.5	406.5	483.9	618.7	747.2	873.2	951.7	1,137.0	631.3	187.6
Usual	275.3	351.7	404.3	491.5	618.0	749.9	897.3	980.0	1,209.4	633.5	194.2
Usual[1]	273.1	349.6	402.1	489.4	615.8	747.7	895.1	977.9	1,207.2	631.4	194.2

[1] Adjusted for seasonal variation.

(6) Iron, mg

	Percentile									Mean	SD
	1st	5th	10th	25th	50th	75th	90th	95th	99th		
Men											
1 d	4.6	5.9	6.2	7.6	9.4	11.8	14.3	16.5	21.0	10.1	3.5
3 d mean	5.7	6.4	6.8	8.1	9.9	11.6	13.7	15.1	18.5	10.1	2.9
12 d mean	6.0	7.4	7.7	8.5	10.0	11.7	13.5	14.7	17.1	10.4	2.5
Usual	5.8	7.0	7.4	8.5	9.9	11.4	12.8	14.0	16.7	10.1	2.4
Usual[1]	6.0	7.2	7.6	8.7	10.1	11.7	13.0	14.2	17.0	10.4	2.4
Women											
1 d	4.1	5.1	6.0	7.2	8.9	11.0	13.8	15.4	20.5	9.5	3.4
3 d mean	4.6	5.7	6.6	7.7	9.1	11.0	13.1	13.7	16.2	9.5	3.0
12 d mean	5.2	6.2	7.1	7.9	9.2	10.8	12.4	13.9	17.7	9.6	2.8
Usual	5.2	6.5	7.0	8.0	9.2	10.7	12.3	13.5	15.8	9.5	2.5
Usual[1]	5.2	6.5	7.0	8.0	9.2	10.7	12.3	13.5	15.8	9.5	2.5

[1] Adjusted for seasonal variation.

(7) Folate, μg

	Percentile									Mean	SD
	1st	5th	10th	25th	50th	75th	90th	95th	99th		
Men											
1 d	160.3	194.3	227.5	295.4	380.6	498.9	616.4	701.4	1,050.9	413.0	191.8
3 d mean	173.3	223.9	244.9	308.7	395.6	507.0	609.0	659.7	803.4	420.1	171.5
12 d mean	211.7	265.6	291.9	342.8	403.5	506.0	579.4	640.2	770.5	430.1	135.4
Usual	191.4	237.5	267.5	321.6	401.5	493.6	565.9	629.8	894.2	418.3	150.5
Usual[1]	201.3	247.4	277.4	331.5	411.4	503.5	575.9	639.8	904.2	428.2	150.5
Women											
1 d	119.6	189.8	227.7	284.6	352.1	479.7	595.6	733.3	1,069.0	394.6	170.3
3 d mean	145.7	218.4	251.5	298.2	369.6	483.1	594.9	679.4	1,080.0	405.5	159.7
12 d mean	198.9	246.7	275.0	310.9	375.2	488.7	561.9	625.7	760.8	405.8	141.1
Usual	176.9	234.4	261.3	319.1	382.7	466.5	552.9	621.5	849.0	404.3	140.8
Usual[1]	177.2	234.7	261.6	319.4	383.1	466.8	553.2	621.8	849.3	404.6	140.8

[1] Adjusted for seasonal variation.

(8) Vitamin C, mg

	Percentile									Mean	SD
	1st	5th	10th	25th	50th	75th	90th	95th	99th		
Men											
1 d	18.8	37.7	51.4	82.0	124.0	179.4	238.3	302.9	473.1	141.8	92.5
3 d mean	37.4	43.8	61.6	89.6	136.4	182.2	237.2	300.1	359.4	145.0	81.4
12 d mean	48.9	60.6	69.0	91.7	121.1	158.1	189.5	216.2	270.9	128.3	48.5
Usual	34.6	57.7	71.0	96.6	137.0	177.9	222.7	260.0	349.2	144.6	72.9
Usual[1]	17.9	41.0	54.3	79.9	120.3	161.2	206.0	243.3	332.5	127.9	72.9
Women											
1 d	24.3	40.0	54.0	83.2	139.1	206.6	266.3	324.3	518.2	157.0	102.3
3 d mean	40.3	54.2	70.6	98.1	142.7	196.5	267.2	328.2	467.3	157.8	83.8
12 d mean	51.7	68.1	78.6	95.1	125.2	170.6	207.5	227.3	330.5	137.3	58.2
Usual	41.8	64.0	80.3	107.2	146.8	194.1	248.4	287.7	397.8	157.7	72.9
Usual[1]	21.5	43.7	59.9	86.9	126.5	173.8	228.0	267.4	377.4	137.4	72.9

[1] Adjusted for seasonal variation.

Table 4. Estimated proportion of the population below or above at risk intake levels for: raw data from 1 d, means of 3 d and 12 d and estimating usual intake by Best-Power method.

Gender	Nutrient		At risk level	% of population at risk[1]				
				Raw 1 d	3 d mean	12 d mean	Usual	Usual[2]
Men	Protein	g	<50	3.9	1.0	0	0.5	0.2
	Fat	%energy	25≦	27.9	22.1	24.0	17.5	18.6
	Salt	g	10≦	74.0	86.5	90.9	88.9	90.5
	Calcium	mg	<600	48.6	47.1	46.2	46.3	45.2
	Iron	mg	<6	7.2	3.4	1.0	1.6	1.0
	Folate	μg	<200	5.8	2.9	0.5	1.3	1.0
	Vitamin C	mg	<85	27.9	21.6	19.7	18.6	28.0
Women	Protein	g	<40	2.4	0	0	0	0
	Fat	%energy	25≦	39.8	37.8	43.0	35.2	40.8
	Salt	g	8≦	82.5	88.4	96.0	93.0	93.2
	Calcium	mg	<600	48.2	48.6	45.0	46.2	46.5
	Iron	mg	<5.5[3]	6.0	3.2	2.0	1.6	1.6
	Folate	μg	<200	6.4	3.2	1.2	1.7	1.7
	Vitamin C	mg	<85	25.1	17.1	15.1	13.0	23.8

[1] Percentage below EAR or above DG.
[2] Adjusted for seasonal variation.
[3] EAR of post-menopausal women; the EAR cut-point method would be inappropriate for menstruating women, because the theoretical distribution of requirement for iron intake is heavily skewed.

those at risk of deficiency in the 1-d intake distribution were 5.8% of men and 6.4% of women; considering the season-adjusted estimated usual intakes, they were 1.0% and 1.7%, respectively. Regarding salt intake, the proportion of the population above the DG was underestimated in the 1-d intake distribution; based on the 1-d intake data, 74.0% of men and 82.5% of women were at risk for overconsumption of salt compared to the season-adjusted estimates for usual intake, which were 90.5% and 93.2%, respectively.

DISCUSSION

The number of days necessary for data collection to estimate usual intake differs with the nutrient being considered. In general, the minimum number of days required for estimating individual usual intake ranges from 3 to 10 d for energy and macronutrients, whereas 20 to 50 d are needed for food components with large day-to-day variation, such as cholesterol and vitamins A and C (*22*). Therefore, it is impossible to survey usual intake directly because recording diet over a long period of time is burdensome for the subjects. Instead, several methods have been proposed to estimate usual intake from a few days of dietary intake data (*11–13*). Both of these procedures have been used in previous studies for evaluating nutritionally at-risk populations (*23–28*).

However, estimates of the usual intake distribution of the population using a national representative sample have rarely been reported. Mackerras and Rutishauser estimated the usual intake distribution from the Australian National Nutrition Survey in 1995 using the NRC method (*29*). They selected about 10% of the first interview group as a sub-sample for the second interview. The second interview was conducted on a different day of the week within 10 d of the first interview. Their results took in all nutrients except vitamin A, and the 10th-90th percentile range was expressed as a percentage of its median. The transformation of the raw data resulted in a narrowing of the width of the distribution. They defined the nutritionally at-risk population using cut-points set at 70% of the recommended dietary intake (RDI) for all nutrients and at the EAR of the UK and the USA because the EAR had not been determined in Australia. Their result was similar to our result; the proportion of nutritionally at-risk individuals from the adjusted intake data was lower than the proportion calculated from the unadjusted intake data using the EAR cut-point method. The EAR cut-point method is very simple though it has some errors. In addition, we showed that the proportion of the population above the DG was underestimated by the 1-d intake distribution. Therefore salt intake in the NHNS-J is possibly underestimated.

The Goldberg cut-off method is commonly used to correct the overall bias of underreporting at the group level using the ratio between energy intake (EI) and the basal metabolic rate (BMR) (*30*). However, this method of correcting the energy intake distribution did not serve the purpose of this study and therefore was not used. Nor was the relationship between usual energy intake and body mass index (BMI), a useful indicator of the energy intake–expenditure relationship, investigated.

A statistical model to estimate the usual intakes of a large population is still under investigation owing to these and other problems. In this study, the usual intake was estimated by the Best-Power method from 3 d of data collected in autumn. Consequently, it is possible

that there is a difference between the "true" and usual intake, especially since the daily intake of vitamin C has been shown to vary with season (*31*, *32*). Therefore we adjusted differences for seasonal differences by adding the differences between the 12-d average (throughout a year) and the 3-d autumn average to the estimated usual intake from data for 3 d in autumn.

The size of the subgroup sample and the number of days necessary for collection of the second intake data are under discussion (5, *24*–*26*). Hoffmann et al. (*25*) demonstrated that estimated percentiles of usual intake are similar for surveys of 2 and 7 d, as in the second study. Owing to the burden experienced by the subjects, the duration of the survey cannot be increased indefinitely. It will be necessary to examine the size and the duration of the sub-sample survey that is carried out as part of a large-scale survey. We suggest that the NHNS-J would conduct a second survey of some subjects as it is necessary to estimate usual intake using a statistical method in the future, because the proportion of nutritionally at-risk subjects in individual groups are either underestimated or overestimated in the present NHNS-J, which is carried out over 1 d.

There was a limitation in this study. The subjects were not selected randomly because the difficulty of a 12-d dietary survey makes it highly likely that many randomly selected subjects would drop out of the study. However, the regional bias was lessened because the survey was carried out over a wide area of Japan.

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