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**Dietary sodium sources according to four 3-day weighed food records and their association with multiple 24-hour urinary excretions among middle-aged and elderly Japanese participants in rural areas**

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## Abstract

Reducing sodium (Na) intake is an urgent global challenge, especially in East Asia and high-income Asia-Pacific regions. However, the sources of Na and their effects on urinary Na excretion have not been fully studied. We sought to clarify these sources and their association with urinary Na excretion. We examined four 3-day weighed food records and five 24-h urinary collections from each of 253 participants in Japan, aged 35–80 years, between 2012 and 2013. We compared the levels of Na according to four categories: foods contributing to discretionary or nondiscretionary Na intake, the situation in which dishes were cooked and consumed, food groups and types of cuisine. We also conducted regression analysis in which 24-h urinary Na excretion was a dependent variable and the amounts of food intake in the four categories were independent variables. Levels of Na were the highest in discretionary intake (60·6%) and in home-prepared dishes (84·0%). Of the food groups, *miso* soup showed the highest percentage contribution to Na intake (13·3%) after seasonings such as soy sauce. In the regression analysis, the standardised coefficient for foods of nondiscretionary Na sources was larger than that for discretionary sources, whereas that for home-prepared dishes was consistent with the levels of Na in those foods. Pickled products, followed by fresh fish and shellfish, *miso* soup and rice, were associated with high urinary Na excretion. Thus, discretionary foods (such as *miso* soup) contribute the most to Na consumption, although nondiscretionary intake (such as pickled vegetables) may influence urinary Na excretion.


**Keywords:** discretional; sodium; source; 24-h urine

## Introduction

High sodium (Na) intake is one of the leading dietary risk factors for death and disability-adjusted life years worldwide, especially in East Asia and high-income Asia-Pacific regions[1]. The World Health Organisation advocates <5 g of salt intake per day[2], but few countries have achieved this goal[3]. In addition, salt intake is higher in East Asian countries, including Japan, than in Western countries[3]. According to a simulation conducted in a U.S. study, a 3-g/day reduction of salt intake in the U.S. population would reduce the incidence of cardiovascular disease and related deaths and decrease annual health medical care expenditure by 10–24 billion U.S. dollars[4]. Population-based approaches to salt reduction are needed throughout the world.

To implement a public nutritional approach to reducing salt intake, it is necessary to determine which dishes and foods have high salt levels, identify situations in which people consume salt and examine the determinants of an individual's salt intake. Several studies have been conducted worldwide to investigate the sources of dietary salt[5]. In Western countries, processed foods such as processed cereals and processed meat account for a large proportion of salt intake[5]. In the United Kingdom, salt reduction in processed foods such as bread, processed cereal and processed meat resulted in an approximately 15% decrease in average salt intake over a 7-year period[6]. On the other hand, in Japan, The National Health Promotion Movement in the twenty first century with several goals, including salt reduction, was launched in 2000[7]. The goal of the first term (2000–2010) was to increase the number of food service establishments offering healthy menus[8], and nutrition education tools such as the "Japanese Food Guide Spinning Top" (2005)[9] were developed and used together. In the 10 years since 2001, it has decreased by 1.5 g (from 12.1g to 10.6g per adult per day in average[10,11]. In the second term (2013-), the goal is to increase the number of industry firms supplying low-salt foods[12], and the legal obligation of nutritional labelling for processed foods by salt equivalent (2013) was also enacted. In the second phase up to 2019, the decrement was only 0.5g (10.1 g per adult per day in average[13,14]. Also, in China, a school-based cluster randomized controlled trial was reported a successful effect of salt intake reduction in both children and their families by education on the harmful effects of salt and how to reduce salt intake for the children in the school[15]. In East Asian countries, including Japan, seasonings such as soy sauce and *miso* (fermented soybean paste), followed by soup, seafood and salted foods such as pickled products, account for a large proportion of salt intake[5]. A policy similar to that implemented in the United Kingdom may not be sufficiently effective in East Asian countries, where traditionally prepared dishes are eaten with a discretionary amount of seasonings at home, or in other countries where the sources of salt intake differ from those in the United Kingdom. In most previous studies conducted in Japan[16–22], the source of salt intake was classified only by food groups (according to ingredients), but in one, classification was based on whether the food was seasoned at home or outside the home (commercially)[22]. Moreover, although foods that contribute to overall salt intake may not be consistent with the determinants of individual habitual salt intake, effects of such foods on 24-hour urinary Na excretion have been examined in few studies[22,23].

In this study in Japan, we examined the sources of salt intake listed in four 3-day weighed food records (WFRs) according to the following classifications, as well as the association of those sources with 24-hour urinary Na excretion: by discretionary or nondiscretionary intake, by the situation in which dishes were cooked and consumed, by the food group, and by the type of cuisine.

## Experimental methods

### Study design and participants

The study was initially aimed at examining the validity of the Food Frequency Questionnaire and was conducted on 253 generally healthy middle-aged and elderly residents (107 men and 146 women), 35–80 years of age, from five rural areas (Yokote, Saku, Chikusei, Murakami and Uonuma) in the Japan Public Health Centre-based Prospective Study for the Next Generation (JPHC-NEXT) as in their protocol of the cohort study. As **Figure 1** shows, four 3-day WFRs and five 24-hour urine samples obtained over a 1-year period including four seasons served as the reference measures. Details of the study design and methods of data collection were reported previously[24].

### Ethical approval

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures were approved by the Institutional Review Boards of the National Cancer Centre in Tokyo, Japan [No. 2012-062] and of all other collaborating research institutions, including Nara Women's University [No. 16-04]. Written informed consent was obtained from all subjects.

### Data collection

Participants filled out four 3-day WFRs and provided five 24-hour urine samples between November 2012 and December 2013. The WFRs were filled out over three consecutive days during each season, at approximately 3-month intervals. Five 24-hour urine

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samples were collected, one each on the last day of the four 3-day WFRs and 1 year after the start of the survey. Participants also filled out a self-administered questionnaire to provide information about age and anthropometric data.

**WFRs**

Each 3-day WFR was filled out for three consecutive days: two weekdays and one day during the weekend. The participants recorded all foods, including seasonings and drinks that they consumed during the survey. Each participant measured food portions during meal preparation by using a portable precise digital cooking scale (Tanita Co. Ltd, Tokyo, Japan), which we supplied, and measuring spoons and cups. For foods purchased or consumed outside the home, the participants were instructed to record the approximate quantity of all foods in the meal, the names of the product and venue or both. Trained dietitians checked the WFRs with the participants the day after each 3-day WFR at the study venue in each study area, and the foods and weights were coded. In some cases, the 3-day WFR was submitted by fax or regular mail to the study office, and the dietitian checked with the participant over the telephone.

**Urine collection**

The participants collected 24-hour urine samples by using a portable urine measurement device (sumius U-Container, Sumitomo Bakelite Co., Ltd., Tokyo, Japan), and a 1/50 portion of all collected urine samples was analysed. The data of five participants with three or more collection errors (who did not collect urine twice or more during each collection day) a total of five times were excluded from the analysis of urinary Na excretion. For participants who missed a single urine collection, the mean value of the urine volumes was recorded for that collection. There were no inaccurate urine collections in terms of the volume as >10L/24-hour[25]. In addition, we checked the accuracy of urine collections using creatinine coefficients = creatinine (mg/day) / body weight (kg). Creatinine coefficients of 14.4–33.6 in men and 10.8–25.2 in women were considered acceptable for 24-hour urine collection[26]. We calculated 24-hour urinary excretion of salt equivalents according to the following formula: 24-hour urinary Na excretion = urine Na concentration (mmol/L) $\times$ obtained amount of excretion (mL) $\times$ 50 $\times$ 23.

**Definition of the classification**

Based on self-reports by the participants and detailed interviews by trained dietitians, we classified all foods, ingredients and dishes listed in the 3-day WFRs. The definitions of these classifications are illustrated in **Figure 2**. We classified the sources of dietary Na intake in four ways; each ingredient and each dish were exclusively classified in different categorization.

*Food contributing to discretionary or nondiscretionary Na intake*[22]

All ingredients were classified as contributing to either discretionary or nondiscretionary Na intake. Seasonings such as *miso* and soy sauce were also classified into either category according to the conditions in which they were eaten. The foods contributing to nondiscretionary Na intake included processed foods or those in which seasonings had been added commercially, such as those not prepared at home. The foods contributing to discretionary Na intake included all foods in which the participants added seasonings.

*Situation in which dishes were cooked and consumed*[22]

All dishes were classified as home-prepared dishes, home meal replacements or those eaten outside the home. The home-prepared dishes included those cooked or prepared at home, such as those prepared according to family recipes; the home meal replacements included dishes cooked outside the home and eaten at home or in the workplace, such as commercially prepared dishes; and those eaten outside the home included dishes cooked and eaten at the same place outside the home, such as dishes served at restaurants. All dishes categorized as home meal replacements or those eaten outside the home were classified as nondiscretionary.

*Food group*

This classification was based in principle on the Standard Tables of Food Composition in Japan 2010[27]. We further classified three types of cuisine as food groups because of their relatively large contributions to Na intake in the Japanese population[16,17,19–22]: noodle dishes (e.g. all ingredients in all dishes with noodles, such as pasta, *ramen*, *sob* and *udon*), pickled products (e.g. *tsukudani*: stewed fish in soy sauce, in addition to pickled vegetables and pickled plums) and *miso* soup (all ingredients in all soups in which *miso* has been added as a condiment). All ingredients were classified into 28 food groups: rice, bread, noodle dishes, other cereals, potatoes, sugars and sweeteners, pulse foods, nuts and seeds, vegetables (excluding pickled vegetables), fruits (excluding pickled plums), mushrooms, seaweed, fish and shellfish, pickled products, meat, eggs, milk and dairy products, oils, confectioneries, alcoholic beverages, soft drinks, tea and coffee, broth, salt, soy sauce, *miso* (any kind of *miso* except *miso* soup), *miso* soup and other seasonings. Furthermore, foods in the fish and shellfish category and the meat category were subclassified as ‘fresh’ or ‘processed’ in the multiple regression analysis (described in the ‘Statistical Analysis’ section). The purpose of this subdivision was to consider whether those foods were discretionary or nondiscretionary.

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*Type of cuisine*

Classification of cuisine reflected the use of a combination of staple foods and cooking methods. All dishes were classified into 1 of 13 types of cuisine: noodle dishes (as described in the 'Food Group' section), pickled products (as described in the 'Food Group' section), soups (including *miso* soup), rice dishes, bread dishes, stir-fried dishes, deep-fried dishes, stewed dishes (simmered in a mixture of condiments), dried fish, grilled or pan-fried or roasted dishes, boiled or steamed dishes, raw and uncooked dishes and 'other dishes'. All dishes made with rice or bread were defined as rice dishes or bread dishes, respectively. The 'raw and uncooked dishes' category included raw vegetables, salads, fruits, *sashimi* (raw fish), tofu (soybean-curd), yogurt and so on. 'Other dishes' included confectioneries, beverages and so on.

**Statistical analysis**

The percentages of Na in foods were determined according to the four sources of Na described. We calculated the ratio of the mean Na intake from the relevant category to the mean total Na intake for each participant. Na intake from the relevant category per 1000 kcal was also calculated in the same way.

Next, we conducted a multiple regression analysis to examine the extent to which Na intake from the sources contributed to each participant's habitual urinary Na excretion, by each of the four classifications separately. Because five participants had missed two or more urine collections in a day, data from 248 participants (103 men and 145 women) were used in the multiple regression analysis. Of these participants, 215 (86·7%; 89 men and 126 women) completed five 24-hour urine collections. In the multiple regression analyses, the amount of the food or the dish intake (in grams) from each category was an independent variable, and 24-hour urinary Na excretion was the dependent variable. In the initial regression model, sex and age (continuous) were also used as independent variables. Results were presented as partial regression coefficient ($B$) with standard error (SE). In addition, to compare which category of food or dish strongly influenced each participant's urinary Na excretion, we calculated the standardised coefficient ($\beta$) in this regression analysis using the mutually adjusted (simultaneous) model in which all categories of food or dish intake (in grams) in each of the four classifications were included as independent variables. We verified the variance inflation factor in order to check the multicollinearity and found that all values of the variance inflation factors were less than 2.3 in food groups. In the multiple regression analysis of intake by food group, seasonings were not included as independent variables because the purpose of the analysis was to examine the relationship between the intake of each food group and urinary Na excretion. We also conducted regression analyses further adjusted for energy intake or body mass index (BMI) and physical activity in METs.

Lastly, we determined the Na intake per serving in each type of cuisine, based on 57 451 dishes consumed by 253 participants. In addition, we used analyses of covariance to compare age- or sex-adjusted least-squares means (with SE) of the percentage of Na consumed according to sex or the age category (<60 years or ≥60 years), respectively.

*P* values of <0·05 were considered statistically significant. To perform all analyses, we used SAS version 9·4 (SAS Institute Inc., Cary, NC, USA).

**Results**

The characteristics of the participants are presented in **Table 1**. Their energy intake, salt intake and BMI were similar to those in the 2012 and 2013 National Health and Nutrition Surveys[13,28]. Of the participants with higher urinary Na excretion, higher percentages were men, were older and had higher BMIs, in comparison with participants with lower urinary Na excretion.

The contributions of foods to Na intake and the results of multiple regression analysis according to the classifications are presented in **Table 2**. Na intake from discretionary foods accounted for 60% of the total Na intake, although in the multiple regression analysis for urinary Na excretion, the standardised coefficient for nondiscretionary Na intake was larger than that for discretionary Na intake. With regard to where dishes were cooked and consumed, the home-prepared dishes accounted for >80% of the total Na intake, which was consistent with the fact that the standardised coefficient for home-prepared dishes was the largest in the multiple regression analysis for urinary Na excretion. Of the food groups, seasonings such as soy sauce and salt accounted for the highest amount of Na intake, followed by *miso* soup, noodle dishes, fish and shellfish and pickled products, the last of which accounted for 6% at most. In the multiple regression analysis of the food group (other than seasonings) with regard to urinary Na excretion, the standardised coefficients were the largest for pickled products, followed by those for rice, fresh fish and shellfish and miso soup. Noodle dishes also showed significant association with urinary Na excretion. In the age- and sex-adjusted models, bread was negatively related to urinary Na excretion (although not significantly), and fruits were significantly and negatively related to urinary Na excretion.

With regard to the type of cuisine, soups (including *miso* soup) and stewed dishes together accounted for approximately 30% of the total Na intake. In the multiple regression analysis, the standardised coefficient was the largest for soup, followed by those for pickled products and stewed dishes. The amount of Na intake per serving of soup was also higher

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than that per serving of other dishes (**Supplementary Table 1**). The percentage of Na intake from rice dishes in general was not small, although the amount of Na per serving was relatively low (**Supplementary Table 1**), and it was significantly and positively associated with urinary Na excretion. In contrast, the percentage of Na intake from noodle dishes was larger than that from rice dishes, and although noodle dishes had the highest amount of Na per serving (**Supplementary Table 1**), they were not significantly associated with the level of urinary Na excretion. Levels of Na intake per 1000 kcal for all categories were similar to the percentages contributed by the categories to the total Na intake. In addition, the results of multiple regression analyses did not change after further adjustment for total energy intake or BMI and physical activity in metabolic equivalent of tasks (METs) (**Supplementary Table 3**). However, the regression coefficients were attenuated and more so for higher calorie food groups or types of cuisine. Moreover, the results did not change after excluding urine samples (6.3% of total samples, including 11 excluded subjects) with an inaccurate creatinine coefficient (data not shown).

The results of the comparisons of percentages of total Na intake according to sex and the age group are presented in **Supplementary Table 2**. The proportion of Na intake from discretionary foods was significantly higher in women and elderly participants, but the proportion of discretionary Na intake was almost 60% in men and relatively younger participants. With regard to the situation in which dishes were cooked and consumed, the proportion of Na intake contributed by home-prepared dishes was significantly higher in elderly participants, but home-prepared dishes also accounted for more than 80% of Na intake in younger participants.

**Discussion**

In this study, approximately 60% of the salt intake was contributed by discretionary foods and more than 80% was contributed by home-prepared dishes, according to the four 3-day WFRs. Seasonings, followed by *miso* soup, noodle dishes, fish and shellfish and pickled products, contributed the largest amount of Na among all food groups. Soups and stewed dishes contributed larger amount of Na than other types of cuisine. Nondiscretionary foods and home-prepared dishes, as well as pickled products, fresh fish and shellfish, *miso* soup and rice, accounted for high urinary Na excretion.

Our study had some strengths in comparison with several previous reports. First, we identified the sources of salt intake in the habitual diet of Japanese participants by conducting a dietary survey for a total of 12 days over four seasons. The number of days necessary to estimate habitual Na intake within a range of ±10% in Japanese adults was reported to be

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8–12 days[29,30]. However, in most of the previous studies, the dietary record covered 1–7 days[5]. In only one study (conducted in Japan) did the investigators examine the sources of salt intake with dietary records for 12 days[19]. According to a 1-day survey by the National Health and Nutrition Survey in Japan, seasonings accounted for at least 50% of Na intake[17]. Moreover, in the International Study of Macro- and Micro-Nutrients (the INTERMAP study), a 24-hour dietary recall was conducted four times among 1145 Japanese participants; it revealed that soy sauce accounted for approximately 20% of the total dietary salt intake, and pickled products and *miso* soup each accounted for approximately 10%, percentages that were similar to our results. The INTERMAP study also revealed that the contribution of discretionary seasoning was larger in Japan than in Europe and the U.S.[16].

Very few studies in Asia[19,31] have focused on contributions of dietary Na by the type of cuisine. A Japanese study[19] demonstrated that *miso* soup was the largest contributor (17·1%), followed by pickled products (12·4%), according to 12 days' worth of food records among 119 participants and a Korean study[31] demonstrated that noodle and dumpling dishes were the largest contributors (15·6%), followed by *kimchi* (14.0%) and soups (10·6%), according to one 24-hour dietary recall among 7167 participants. These findings are the same as our results. Moreover, we examined determinants of individual salt intake by using five 24-hour measurements of urinary Na excretion of foods in different categories. Few studies have focused on the relationship between food intake by some categories, as estimated from dietary records and urinary Na excretion[22,23]. In a Chinese study[23], the researchers used only one 3-day food record and one 24-hour urine collection, and Japanese researchers used 4-day WFR and two 24-hour urine collection.

Because bread contains salt but rice does not[27], the analysis by food groups revealed that the percentage of Na contributed by rice itself was smaller than that contributed by bread. In contrast, the percentage contributed by rice dishes was larger than that by bread dishes. Moreover, the intake of rice and rice dishes had the strongest positive association with urinary Na excretion, whereas bread and bread dishes had a negative association with urinary Na excretion. This might be explained not only by the salt content of the food itself but also by the effect of salt intake from the food that was eaten with rice. Nanri et al.[32] identified three dietary patterns in a subsample of 498 individuals in the JPHC study and reported that the traditional Japanese dietary pattern was positively associated with the intake of rice, *miso* soup, pickles and salty fish, whereas the westernised Japanese dietary pattern was positively associated with the intake of bread and negatively associated with the intake of rice, *miso* soup, pickles and salty fish. In addition, the INTERMAP study[16], which was an international comparison of sources of dietary salt intake, demonstrated that soy sauce, soup (especially *miso* soup), pickled products and fresh and salted fish contributed large proportions of dietary salt intake in the Japanese population, which is consistent with our findings. These results suggested that when Japanese people ate rice as a staple food, they also ate *miso* soup, pickled products and salty fish or seafood seasoned by soy sauce, which contributed heavily to the total salt intake and thus accounted for increased urinary Na excretion. These results strongly suggest that Japanese people need not only personal education about food but also a new approach based on their food culture.

The large contribution of seasonings, soups and fish and shellfish to Na intake in this study was consistent with the findings in many Japanese studies in which dietary salt sources were examined by food groups[16–21]. In addition, the high contribution of discretionary foods and home-prepared dishes to Na intake was consistent with the findings of previous studies carried out not only in Japan[22] but also in other East Asian countries, such as China and Korea[5]. In countries where home-prepared and discretionary seasoned meals contribute heavily to salt intake, people should be encouraged to reduce their discretionary use of seasonings, inasmuch as the stronger the preference for salty foods, the higher the urinary Na excretion[33]. In particular, not only personal educational approaches but also dietary–cultural approaches may be needed to raise awareness about soups (especially *miso* soup), which contain high levels of Na and are significantly associated with urinary Na excretion: for example, reducing portion sizes or reducing the frequency of consumption (i.e., intervention to provide meals to a specified population continuously, such as an educational intervention for school lunch, by downsizing the tableware and reducing the frequency of soup dishes consistently and feasibly according to the National Health Promotion in Japan). Moreover, in the long term, policy interventions in food industries, as in the U.K., should be emphasised on condiments than on food service and home meal replacement.

On the other hand, we found that the major nondiscretionary food eaten at home and the major determinant of Na excretion was pickled products, although their contribution to Na intake and the amount of Na per serving were not the highest. These results suggest that approaches such as reducing the salt content of processed foods, such as pickled products, may be restrictive for reduced dietary salt in the whole population as the home-prepared and discretionary sources were the major salt intake sources. Regarding noodle dishes, regression analyses revealed no significant relation between noodle dishes and Na excretion despite of their notable contribution to salt intake per serving and percentage contribution to Na intake. This finding may be due to an attenuation of the correlation between Na intake from noodle dishes and Na excretion in the initial sex- and age-adjusted model as a potential confounder because the noodle dishes are more eaten among men and relatively young people (Supplementary Table 2). However, further analysis without adjusting for sex or age showed a significant and larger regression coefficient (SE, p-value) for Na excretion with noodle dishes by 1.8 (0.72, $p = 0.01$) than that in the initial model.

Our study had several limitations. First, because food composition tables in Japan are based on ingredients, comparison with diets in other countries is limited. For example, in the Standard Tables of Food Composition used in the U.S.[34], pizza is listed as one kind of food, but in Japan, the Standard Tables of Food Composition[27] lists its ingredients. Similarly, fast food eaten at restaurants is also categorized broadly as bread, meat, vegetables and seasonings. We categorized these dishes based on self-reports and detailed interviews; however, the amount of ‘home meal replacement’ or ‘eating out’ consumption may have been underestimated. Second, the study was conducted only in rural areas; therefore, the dietary behaviours of the study participants might differ from those of urban populations, although the rural areas studied in this report did not differ much from the overall Japanese population in terms of mean sodium intake[28]. The contribution of nondiscretionary Na intakes, such as that from home meal replacements and meals eaten outside the home, might have been underestimated; however, the degree of underestimation may be negligible because even the national survey in Japan, which included urban populations, revealed that only 41% of men and 29% of women regularly (at least twice a week) either ate outside the home or consumed home meal replacements[26]. Also, young adults were not included in this study, although they have lesser sodium excretion than older adults[22]. Finally, dietary habits may have changed after this survey was conducted. However, the main target of the populational approach to salt reduction has probably not changed, inasmuch as seven previous studies conducted in Japan[16–22] between 1977 and 2013 have shown consistent percentages and rankings of salt intake contribution by food group, despite the 36-year gap. Furthermore, we could not rule out all of the possible residual confounding, such as self-reported bias for anthropometry. Also, selection bias from social desirability for WFR could not be ignored.

## Conclusion

In the population of this study, the contribution of discretionary foods, such as soups (including *miso* soup), to the total Na intake was large, whereas nondiscretionary foods with high Na, such as pickled products, strongly affected individual urinary Na excretion. To reduce salt intake for a whole population, the main targets may be home-prepared dishes and the use of discretional seasoning; however, reducing the salt content of processed foods, such as pickled products, may be restrictive for individuals with high salt intake.

## Availability of the data and materials

We cannot publicly provide individual data because of participant privacy, according to ethical guidelines in Japan. In addition, the informed consent we obtained does not include a provision for publicly sharing the data. The datasets used and analysed during this study are available from the corresponding author on reasonable request.

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**Conflict of interest**

The authors declare no competing interests.

**Authors' contributions**

All authors contributed to the study conceptualisation and design. The material preparation, data collection and data analysis were performed by FO, RT, JI, MY, SM, YI, KK, KN, JT, TY, HI, MI, ST and NS. The first draft of the manuscript was written by FO, and all the authors reviewed previous versions of the manuscript. All authors read and approved the final manuscript.

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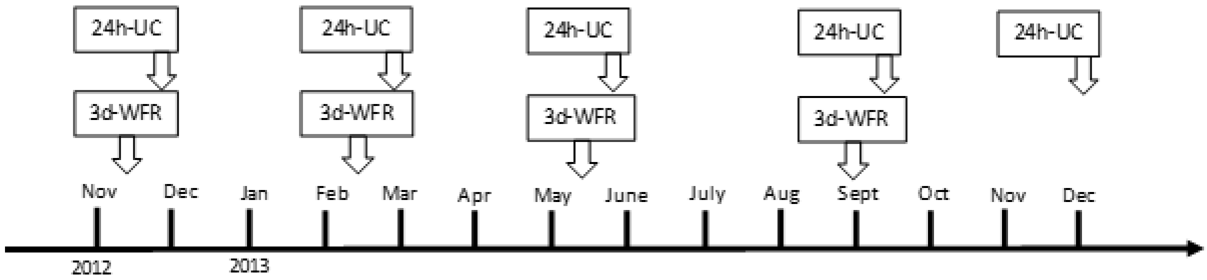


**Fig. 1** Data collection sequence of WFR and 24h-UC.

24h-UC, 24-hour urinary collections; 3d-WFR, consecutive 3-day weighed food record.

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**(1) Food contributing to discretionary or nondiscretionary Na intake***

| **Discretionary** | **Nondiscretionary** |
|---|---|
| Foods seasoned by the study participants (e.g. fresh materials, condiments) | Foods processed or seasonings added commercially (e.g. processed foods, eating outside the home) |

* Analysis was based on individual intake.

**(2) Situation in which dishes were cooked and consumed***

| **Home-prepared dishes** | **Home meal replacement** | **Eating out** |
|---|---|---|
| Dishes cooked or prepared at home (e.g. according to family recipes) | Dishes cooked outside the home and eaten at home or in the workplace (e.g. side dishes and prepared dishes) | Dishes cooked and eaten at the same place outside the home (e.g. dishes served at restaurants) |

* Analysis was based on individual intake.

**(3) Food group*, †**

| Rice | Bread | Noodle dishes‡ | Potatoes | Pulse foods | Vegetables§ | Fruits‖ | Seaweed¶ | Fish and shellfish** | Pickled products‡ | Meat | Eggs | Milk†† | Oils | Confectioneries | Alcohol beverages | *Miso* | *Miso* soup‡ | Salt | Soy sauce | Other seasonings | Broth | Other foods‡‡ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

* Analysis was based on individual intake.

† Definition was based in principle on the Standard Tables of Food Composition in Japan 2010[15].

‡ Some types of cuisine classified as food groups.

§ Vegetables excluded pickled vegetables.

|| Fruits excluded pickled plums.

¶ Seaweeds excluded *tsukudani* (stewed seaweeds in the mixture of condiments).

** Fish and shellfish excluded *tsukudani* (stewed fish and shellfish in the mixture of condiments).

†† Milk and dairy products

‡‡ Others included other cereals, sugars and sweeteners, nuts and seeds, mushrooms, soft drinks, and tea and coffee.

**(4) Type of cuisine*, §§**

| Rice dishes | Bread dishes | Noodle dishes | Soups | Stewed|||| dishes | Grilled or pan-fried or roasted dishes | Stir-fried dishes | Deep-fried dishes | Boiled or steamed dishes | Dried fish | Pickled products | Raw or uncooked dishes | Other dishes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

* Analysis was based on individual intake.

§§ We defined the categories based on the following priorities to classify exclusively: noodle dishes, pickled products, soups, rice dishes, bread dishes, stir-fried dishes, deep-fried dishes, stewed dishes, dried fish, grilled or pan-fried or roasted dishes, boiled or steamed dishes, raw or uncooked dishes and other dishes.

|||| Simmered in the mixture of condiments.

**Fig. 2** Classification of recorded foods and dishes: (1) all foods contributing to discretionary or nondiscretionary Na intake; (2) home-prepared dishes, home meal replacement or eating out; (3) 28 food groups; and (4) 13 types of cuisine.

**Table 1** Characteristics of the study participants.

| | Total | 24-hour urinary Na excretion* | | |
|---|---|---|---|---|
| | | <3586mg/day | 3586-4583mg/day | >4583mg/day |
| | *n* 253 | *n* 82 | *n* 83 | *n* 83 |
| Men † | 107 (42·3%) | 19 (23·2%) | 33 (39·8%) | 51 (61·4%) |
| Age (years) ‡ | 57 (49, 63) | 55 (45, 63) | 56 (49, 61) | 58 (53, 64) |
| Body mass index (kg/m²)‡ | 22·9 (21·1, 24·7) | 22·1 (20·3, 23·4) | 23·2 (21·1, 25·0) | 23·9 (22·4, 25·2) |
| Energy intake (kcal/day)‡ | 1935 (1660, 2239) | 1711 (1607, 1961) | 1973 (1653, 2212) | 2156 (1831, 2546) |
| Na intake (mg/day)‡ | 4028 (3431, 4791) | 3362 (2923, 3777) | 4014 (3503, 4483) | 4883 (4339, 5373) |
| 24h urinary Na excretion (mg/day) *,‡ | 4124 (3435, 4935) | 3142 (2773, 3435) | 4118 (3838, 4376) | 5306 (4929, 5790) |

Na: sodium

* 248 participants (103 men and 145 women) successfully collected urine.

† Number.

‡ Median (25th percentile, 75th percentile)

**Table 2** Mean percentage contribution by foods or dishes to Na consumption.*

| | Na intake (mg; *n* 253) | | | | The amount of food intake (g): Multiple linear regression analyses (*n* 248) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Contribution (%) | | Amount (mg/1000kcal) | | Sex- and age-adjusted models† | | | Mutually adjusted model‡ | | | |
| | Mean | SD | Mean | SD | *B*§ | SE | *P* value | *B*§ | SE | *P* value | β‖ |
| **Food contributing to discretionary or nondiscretionary Na intake** | | | | | | | | | | | |
| Discretionary | 60·6 | 14·1 | 1290 | 454 | 0·35 | 0·11 | *<0·01* | 0·43 | 0·11 | *<0·001* | 0·25 |
| Nondiscretionary | 39·4 | 14·1 | 803 | 288 | 1·01 | 0·24 | *<0·001* | 1·15 | 0·23 | *<0·001* | 0·32 |
| **Situation in which dishes were cooked and consumed** | | | | | | | | | | | |
| Home-prepared dishes | 84·0 | 14·0 | 1775 | 514 | 0·35 | 0·10 | *<0·001* | 0·50 | 0·10 | *<0·001* | 0·30 |
| Home meal replacement | 7·1 | 7·1 | 143 | 138 | 2·34 | 0·79 | *<0·01* | 2·39 | 0·78 | *<0·01* | 0·18 |
| Eating out | 8·9 | 10·3 | 174 | 203 | 0·97 | 0·31 | *<0·01* | 1·08 | 0·31 | *<0·001* | 0·22 |
| **Food group** | | | | | | | | | | | |
| Rice | 0·1 | 0·2 | 2 | 4 | 1·65 | 0·58 | *<0·01* | 1·52 | 0·64 | *0·02* | 0·18 |
| Bread | 2·9 | 3·1 | 57 | 57 | -5·77 | 3·30 | *0·08* | 4·00 | 3·59 | *0·27* | 0·07 |
| Noodle dishes | 11·5 | 8·3 | 243 | 185 | 1·12 | 0·74 | *0·13* | 2·08 | 0·73 | *<0·01* | 0·18 |
| Potatoes | 0·03 | 0·03 | 0·6 | 0·5 | 1·76 | 3·09 | *0·57* | 1·25 | 3·37 | *0·71* | 0·02 |
| Pulses | 0·3 | 0·4 | 6 | 8 | 2·73 | 1·63 | *0·10* | 3·00 | 1·67 | *0·07* | 0·11 |
| Vegetables | 0·6 | 0·4 | 13 | 6 | 0·39 | 0·66 | *0·56* | -1·09 | 0·77 | *0·16* | -0·11 |
| Fruits | 0·02 | 0·02 | 0·4 | 0·4 | -1·77 | 1·01 | *0·08* | -3·05 | 1·11 | *<0·01* | -0·21 |
| Seaweeds | 1·0 | 1·2 | 22 | 31 | 10·25 | 7·52 | *0·17* | 11·78 | 7·37 | *0·11* | 0·10 |
| Fish and shellfish | 6·7 | 3·5 | 139 | 73 | — | — | — | — | — | — | — |
| Fresh fish and shellfish | — | | — | | 8·06 | 2·53 | *<0·01* | 5·81 | 2·60 | *0·03* | 0·15 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Processed fish and shellfish | — | — | 7·07 | 4·02 | *0·08* | -1·81 | 4·36 | *0·68* | -0·03 |
| Pickled products | 6·2 5·0 | 137 127 | 11·45 | 2·45 | *<0·001* | 10·99 | 2·57 | *<0·001* | 0·28 |
| Meat | 3·4 2·2 | 49 36 | — | — | — | — | — | — | — |
| Fresh meat | — | — | 4·45 | 2·71 | *0·10* | 0·71 | 2·79 | *0·80* | 0·02 |
| Processed meat | — | — | 11·61 | 7·20 | *0·11* | 5·10 | 7·23 | *0·48* | 0·04 |
| Eggs | 1·3 0·6 | 25 11 | 10·17 | 4·44 | *0·02* | 6·01 | 4·79 | *0·21* | 0·08 |
| Milk and dairy products | 2·5 2·1 | 47 35 | -0·74 | 0·76 | *0·33* | -0·40 | 0·76 | *0·60* | -0·03 |
| Oils | 0·9 0·8 | 18 15 | — | — | — | — | — | — | — |
| Confectioneries | 1·9 1·6 | 37 30 | 0·35 | 2·17 | *0·87* | 1·53 | 2·21 | *0·50* | 0·04 |
| Alcohol beverages | 0·1 0·2 | 2 3 | 0·68 | 0·30 | *0·02* | 0·39 | 0·30 | *0·20* | 0·09 |
| Broth | 2·5 2·1 | 53 49 | — | — | — | — | — | — | — |
| *Miso* (excluding *miso* soup) | 2·0 1·9 | 43 43 | — | — | — | — | — | — | — |
| *Miso* soup | 13·3 7·6 | 295 197 | 2·03 | 0·52 | *<0·001* | 1·27 | 0·56 | *0·02* | 0·15 |
| Salt | 10·7 4·4 | 221 102 | — | — | — | — | — | — | — |
| Soy sauce | 14·3 7·2 | 301 183 | — | — | — | — | — | — | — |
| Other seasonings[¶] | 13·3 6·4 | 275 141 | — | — | — | — | — | — | — |
| Others ** | 3·6 4·4 | 81 110 | 0·47 | 0·22 | *0·04* | 0·31 | 0·22 | *0·15* | 0·08 |
| **Type of cuisine** | | | | | | | | | |
| Rice dishes | 7·4 5·8 | 148 119 | 1·12 | 0·51 | *0·03* | 0·75 | 0·53 | *0·16* | 0·10 |
| Bread dishes | 4·8 4·7 | 92 86 | -2·57 | 1·95 | *0·19* | 0·97 | 2·05 | *0·63* | 0·03 |
| Noodle dishes | 11·5 8·3 | 243 185 | 1·12 | 0·74 | *0·13* | 1·29 | 0·70 | *0·07* | 0·11 |
| Soups[††] | 17·0 8·1 | 374 222 | 2·13 | 0·47 | *<0·001* | 1·86 | 0·50 | *<0·001* | 0·24 |
| Stewed dishes[‡‡] | 11·7 6·3 | 252 154 | 1·94 | 0·79 | *0·01* | 1·65 | 0·77 | *0·03* | 0·13 |
| Grilled dishes[§§] | 9.2 4·5 | 186 96 | 2·85 | 1·30 | *0·03* | 1·50 | 1·31 | *0·25* | 0·07 |
| Stir-fried dishes | 4·7 3·1 | 98 71 | 1·58 | 1·71 | *0·36* | 0·26 | 1·75 | *0·88* | 0·01 |
| Deep-fried dishes | 3·6 2·6 | 72 54 | 5·81 | 1·92 | *<0·01* | 2·80 | 1·86 | *0·13* | 0·09 |
| Boiled or steamed dishes | 5·5 3·3 | 118 80 | -0·45 | 1·22 | *0·71* | -2·68 | 1·33 | *0·05* | -0·14 |
| Dried fish | 1·6 1·6 | 32 33 | 2·56 | 6·54 | *0·70* | -2·2 | 6·33 | *0·72* | -0·0 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 8 | | | 2 |
| Pickled products | 6·2 | 5·0 | 137 | 127 | 11·45 | 2·45 | *<0·001* | 8·02 | 2·47 | *<0·01* | 0·20 |
| Raw and Uncooked dishes | 9·7 | 4·1 | 199 | 92 | 0·03 | 0·51 | *0·95* | -0·51 | 0·54 | *0·35* | -0·06 |
| Other dishes [\|\|\|\|] | 7·2 | 4·6 | 141 | 83 | 0·42 | 0·13 | *<0·01* | 0·40 | 0·13 | *<0·01* | 0·18 |

Na, sodium; SD, standard deviation; SE, standard error.

* In multiple linear regression analyses, 24-hour urinary Na excretion was a dependent variable and the amount of food intake (in grams) in each category was an independent variable.

† The amounts of food intake (grams) of each category, sex and age were included as independent variables, and multiple 24-hour urinary Na excretion was used as a dependent variable.

‡ The amount of food intake (grams) of every category, sex and age were included as independent variables, and multiple 24-hour urinary Na excretion was used as a dependent variable.

§ *B*: the partial regression coefficient.

|| β: standardised coefficient.

¶ Other seasonings included dressings, spices, vinegars, Worcestershire sauces and ready-made mixed seasonings.

** Others included other cereals, sugars and sweeteners, nuts and seeds, mushrooms, soft drinks and tea and coffee.

†† Soups included *miso* soup.

‡‡ Simmered in the mixture of condiments.

§§ Grilled, pan-fried or roasted dishes.

|| || Other dishes included confectioneries, beverages and so on.