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ORIGINAL ARTICLE
Epidemiology

Cardiovascular Risk Assessment Chart by Dietary Factors in Japan
— NIPPON DATA80 —

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Background: Many studies show that dietary factors such as vegetables, fruit, and salt are associated with cardiovascular disease (CVD) risk. However, a risk assessment chart for CVD mortality according to combinations of dietary factors has not been established.

Methods and Results: Participants were 9,115 men and women aged 30–79 years enrolled in the National Nutritional Survey of Japan in 1980 with a 29-year follow-up. Dietary intake was assessed using a 3-day weighed dietary record at baseline. Cox regression models were used to estimate the hazard ratio (HR) of CVD mortality stratified by vegetables, fruit, fish, and salt consumption. HRs of CVD mortality according to combinations of dietary factors were color coded on an assessment chart. Higher intakes of vegetables, fruit, and fish, and lower salt intake were associated with lower CVD mortality risk. HRs calculated from combinations of dietary factors were displayed using 5 colors corresponding to the magnitude of the HR. People with the lowest intake of vegetables, fruit, and fish, and higher salt intake had a HR of 2.87 compared with those with the highest intake of vegetables, fruit, and fish, and lower salt intake.

Conclusions: Vegetables, fruit, fish, and salt intake were independently associated with CVD mortality risk. The assessment chart generated could be used in Japan as an educational tool for CVD prevention.

Key Words: Cardiovascular risk chart; Fish; Fruit; Salt; Vegetables

Many observational studies have reported an association of dietary intake with cardiovascular disease (CVD) risk. In particular, higher consumption of vegetables,[1–4] fruit,[1–4] and fish, [5–7] and a lower consumption of salt,[8–10] have been shown to be associated with lower risk of CVD in people from Asian countries, including Japan, as well as in those from Western countries. An association between dietary patterns and CVD risk has also been reported.[11–15] Principal component analysis, used to identify dietary patterns, has revealed the benefits of consuming several food groups for the reduction of CVD risk.[11–15] However, it is also important for the clinical setting and preventive medicine to show the recommended amount of each food.

Japanese people are well known to have a high salt intake, and salt consumption is known to be an independent risk factor for CVD.[9] Therefore, salt intake is an important consideration if associations between diet and CVD risk are to be established for Japanese people.

In the present study, we constructed a risk assessment

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Table 1. Baseline Characteristics of Participants Aged 30–79 Years (NIPPON DATA80, 1980)

	Total (n=9,115)	Men (n=4,002)	Women (n=5,113)
Age (years)	50.0±12.7	49.9±12.6	50.2±12.7
Body mass index (kg/m²)	22.7±3.2	22.5±2.9	22.9±3.4
Systolic BP (mmHg)	135.5±21.1	138.2±20.6	133.6±21.2
Diastolic BP (mmHg)	81.4±12.2	83.7±12.3	79.6±11.8
Serum total cholesterol (mmol/L)	4.9±0.9	4.8±0.8	4.9±0.9
Casual blood glucose (mmol/L)	5.6±1.7	5.6±1.8	5.5±1.6
Smoking status (n, [%])			
Never	5,285 (58.0)	729 (18.2)	4,556 (89.1)
Former	831 (9.1)	721 (18.0)	110 (2.2)
Current	2,999 (32.9)	2,552 (63.8)	447 (8.7)
Drinking status (n, [%])			
Never	4,803 (52.7)	794 (19.8)	4,009 (78.4)
Former	280 (3.1)	203 (5.1)	77 (1.5)
Current	4,032 (44.2)	3,005 (75.1)	1,027 (20.1)
Total energy (kcal/day)	2,145±489	2,410±476	1,937±388
Protein (%kcal)	15.3±2.1	15.0±2.1	15.5±2.1
Fat (%kcal)	20.8±5.5	19.8±5.1	21.5±5.6
Carbohydrate (%kcal)	61.2±6.6	59.9±6.3	62.3±6.6
Salt (g/day)	14.0±5.2	15.2±5.5	13.1±4.7
Vegetables (g/day)	277.2±110.7	287.7±113.7	268.9±107.6
Fruit (g/day)	167.1±116.6	140.6±96.5	187.8±126.3
Fish (including shellfish) (g/day)	109.2±57.5	125.5±64.0	96.4±48.3
Meat (g/day)	61.5±38.6	71.0±41.6	54.1±34.3

Values are mean±standard deviation for continuous variables. BP, blood pressure.

chart for CVD mortality according to dietary intake of important food groups and salt, using data from NIPPON DATA80, a study involving a 29-year follow-up in a representative Japanese population. This assessment chart could provide useful information for the general Japanese population by visually indicating the risk of CVD mortality according to intake of different dietary factors.

Methods

Study Participants

NIPPON DATA (National Integrated Project for Prospective Observation of Non-communicable Disease and Its Trends in the Aged) is a series of cohort studies that are principally based on the National Cardiovascular Survey of Japan (NCSJ) and the National Nutrition Survey of Japan (NNSJ). The present study analyzed data from the NIPPON DATA80 study, for which the baseline survey was conducted in 1980.[16–19] Briefly, 300 survey districts throughout Japan were randomly selected, and a total of 10,546 people (4,639 men and 5,907 women, aged ≥30 years) agreed to participate, with a participation rate of 76.6%. We excluded 1,431 men and women from this analysis because of missing information at baseline (n=152), a history of CVD (n=274), age ≥80 years (n=144), total energy intake <500 kcal/day or >5,000 kcal/day (n=15), or the absence of a present address, which was needed to link the participants to their vital statistics records (n=846). Therefore, we analyzed data for the remaining 9,115 participants (4,002 men and 5,113 women) in the present study.

Baseline Survey

The NCSJ and NNSJ were conducted at public health centers in 1980. The NCSJ consisted of physical examinations, blood tests, and a self-administered questionnaire regarding lifestyle, in which participants were asked about their drinking habit (never, former, or current drinker), smoking habit (never, former, or current smoker), and medical history of diabetes, myocardial infarction, angina, or stroke. Body mass index was calculated as weight (kg) divided by the square of height (m^2). Blood pressure was measured by a trained observer using a standard mercury sphygmomanometer. Non-fasting blood samples were obtained and centrifuged soon after collection. The concentrations of total cholesterol and glucose were measured enzymatically. Lipid measurements were standardized using the Center for Disease Control/National Heart, Lung, and Blood Institute (CDC-NHLBI) Lipids Standardization Program.[20]

Nutritional Survey

The NNSJ in 1980 using weighed dietary records over 3 representative consecutive days, excluding weekends and holidays, in each household. A representative person from the household recorded all the food and beverages that any household member consumed during the 3 days. These dietary records were thoroughly reviewed and confirmed by trained dietitians. The Modified Standards Tables for Food Composition in Japan, 3rd edition, was used to calculate nutritional intake. The intakes of individual household members were estimated by distributing the whole household intake proportionally according to the sex and age of the members, in reference to average intakes by sex

Table 2. Multivariable-Adjusted HR for Mortality From CVD, According to the Baseline Factors of 4,002 Men and 5,113 Women Aged 30–79 Years From a 29-Year Follow-up of NIPPON DATA80

Variables	Person-years	No. of CVD deaths	HR*	95% CI
Vegetable intake (g/day)				
≥350	46,952	245	1 (Ref.)	
175–350	143,866	641	1.04	0.89–1.21
<175	32,952	184	1.28	1.04–1.58
Fruit intake (g/day)				
≥200	68,704	362	1 (Ref.)	
100–200	86,407	378	1.04	0.90–1.21
<100	68,660	330	1.19	1.02–1.40
Fish (including shellfish) intake (g/day)				
≥80	147,395	694	1 (Ref.)	
40–80	62,351	295	1.05	0.91–1.22
<40	14,025	81	1.39	1.10–1.77
Salt intake (g/day)				
<8 men, <7 women	10,350	57	1 (Ref.)	
≥8 men, ≥7 women	213,420	1,013	1.35	1.02–1.79

*Adjusted for sex, age (<40, 40–49, 50–59, 60–69, or ≥70 years), smoking status (never, former, or current), drinking status (never, former, or current), and total energy intake (per 1,000kcal/day increase). All variables were simultaneously included in the same model. CI, confidence interval; CVD, cardiovascular disease; HR, hazard ratios.

and age group from NNSJ 1995.[17] From 1995, information on food sharing among household members was collected and individual intakes were assessed. Further details on estimation of individual intakes are described elsewhere.[17,21] The food groups evaluated in this study were vegetables, fruit, fish, cereals, soy and soy products, dairy products, and meat.

Follow-up Survey

Participants were followed for 29 years, from 1980 to 2009. To determine the cause of death during the follow-up period, the National Vital Statistics database of Japan was used, with permission from the Management and Coordination Agency, Government of Japan. The underlying cause of death was coded according to the 9th International Classification of Disease (ICD9) until the end of 1994, and the 10th Revision (ICD10) from the beginning of 1995. The details of the classification are described elsewhere.[19]

The primary endpoint was cardiovascular death during the 29-year follow-up period. The corresponding ICD9 and ICD10 codes for cardiovascular disease death were 393–459 (ICD9) and I00–I99 (ICD10).

Statistical Analysis

Categories for food groups and salt consumption levels were chosen on the basis of cutoff values from several dietary guidelines held by the Japanese government i.e., National Health Promotion Movement in the twenty first century (Health Japan 21 [2nd edition]),[22] Japanese Food Guide Spinning Top,[23] and Dietary Reference Intakes for Japanese in 2015.[24] Vegetables intake was classified into 3 categories: (1) <175 g/day, (2) 175–350 g/day, (3) ≥350 g/day. Fruit intake was classified into 3 categories: (1) <100 g/day, (2) 100–200 g/day, and (3) ≥200 g/day. Fish (including shellfish) intake was also classified into 3 categories: (1) <40 g/day, (2) 40–80 g/day, and (3) ≥80 g/day. Salt intake was classified into 2 categories: (1) <8 g/day for men or <7 g/day for women, and (2) ≥8 g/day for men or ≥7 g/day for women. The consumption of cereals, soy and soy products, dairy products, and meat (g/day) were divided into tertiles.

Cox proportional regression models were used to estimate the hazard ratio (HR) and 95% confidence interval (CI) of CVD mortality according to food and salt intake categories in the same model. To control for potential confounders, multivariable models were adjusted for sex, age, smoking status (never, former, or current), drinking status (never, former, or current), and total energy intake (per 1,000 kcal/day increase). We did not observe the interaction by sex on the association between food/salt intake and CVD mortality risk; sex was used for adjustment only.

We constructed risk assessment charts for the HRs for CVD mortality by combining the risks of vegetables, fruit, fish, and salt intake category, which were significantly associated with CVD mortality risk. The HRs for combinations of dietary intakes were calculated by multiplying together the HRs for given intakes of each dietary factor (vegetables, fruit, fish, and salt). A total of 54 patterns were displayed using color codes on the assessment chart.

All analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA). $P<0.05$ was considered to be statistically significant.

Results

Baseline Characteristics of the Study Participants

The baseline characteristics of the participants are shown in **Table 1**. The mean (standard deviation [SD]) ages for the men and women were 49.9 (12.6) and 50.2 (12.7) years, respectively. While systolic and diastolic blood pressures were higher in men than in women, the serum total cholesterol level was higher in women than in men. The proportion of current smokers was far greater among the men than the women. Total energy intake (kcal/day) was higher in men than in women. Correlation analysis of the relationships among the 4 dietary factors demonstrated stronger positive correlations (Spearman correlation coefficient ≥0.3)

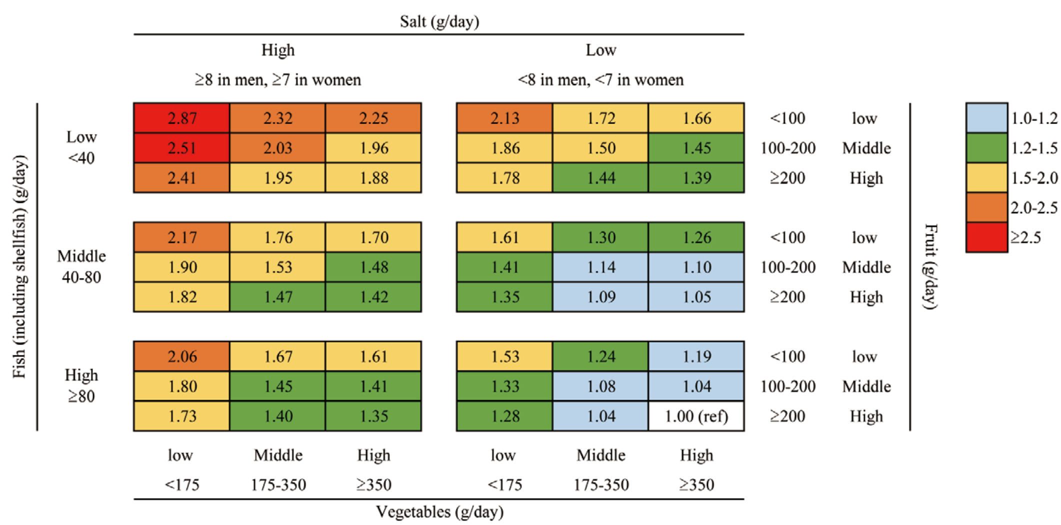

Figure. Risk assessment chart for death from cardiovascular diseases according to intake of different dietary factors, calculated using data from 4,002 men and 5,113 women aged 30–79 years from the NIPPON DATA80 study. The hazard ratio (HR) of cardiovascular disease mortality according to the dietary intake of a combination of factors (vegetables, fruit, fish, and salt) was calculated by multiplying together the HRs for each of the dietary factors.

between the intakes of salt and fish, and salt and vegetables, than between the other combinations (**Supplementary Table**).

Relationship Between Dietary Factors and CVD Mortality

After 29 years (mean [SD] follow-up period, 24.6 [7.4] years) and 223,770 person-years of follow-up, there were 1,070 CVD deaths. **Table 2** shows the relationship between dietary factors and CVD mortality risk. The risk of CVD mortality was significantly elevated in the lowest intake category compared with the highest intake category for vegetables (HR: 1.28, 95% CI: 1.04–1.58), fruit (HR: 1.19, 95% CI: 1.02–1.40), and fish (HR: 1.39, 95% CI: 1.10–1.77). Compared with lower salt intake, higher salt intake was also associated with a higher risk of CVD mortality (HR: 1.35, 95% CI: 1.02–1.79). These associations were similar when food and salt consumption were evaluated using energy-adjusted intakes (g/1,000 kcal) (data not shown). The consumption levels of cereal, soy/soy products, dairy products, and meat were not significantly associated with the risk of CVD death (data not shown).

In contrast, higher intakes of vegetables, fruit, and fish, and lower salt intake, were significantly associated with a lower risk of death from stroke. The associations between dietary factors, except fish, and the risk of death from coronary heart disease (CHD) were similar, but not significant (data not shown).

Risk Assessment Chart for CVD Mortality According to Dietary Factors

By multiplying together the HRs for CVD death for each dietary factor, we constructed an assessment chart for the risk of CVD death according to dietary pattern (**Figure**), using a heat map of 5 different levels relative to the reference. The risk of CVD mortality for individuals with the worst dietary pattern (lowest vegetables, fruit, and fish intake, combined with high salt intake) was around 3-fold greater than that of individuals with the reference pattern (highest vegetables, fruit, and fish intake, combined with low salt intake).

Discussion

This study has shown that the dietary intake of vegetables, fruit, fish, and salt was independently associated with the risk of CVD mortality in a general Japanese population. Based on these results, we constructed an assessment chart for Japanese people for the risk of CVD mortality according to dietary patterns. To the best of our knowledge, this chart is the first to show the risk of CVD mortality according to a combination of dietary factors, and it could be a useful educational tool for the prevention of CVD in Japan.

Japanese people are known for their long life expectancy.[25] Although it remains high, salt intake in Japan has markedly decreased over the past several decades, and this reduction in salt intake has contributed to a reduction in the risk of stroke, through a decrease in blood pressure.[26,27] These changes have been linked to the long life expectancy in Japan. The Japanese dietary pattern, characterized by high fish intake and low fat intake, as well as high salt intake,[28,29] has been related to a lower risk of CHD.[28] Thus, the Japanese dietary pattern is considered to be healthy, but there is little substantial evidence for this.

The NIPPON DATA cohort has shown an association of dietary factors, such as vegetables,[1] fruit,[1] n-3 polyunsaturated fatty acid/fish,[5,30] sodium/potassium ratio,[8] dairy products,[31] and soy/soy products[32] with CVD mortality risk. Of these dietary factors, vegetables, fruit, n-3 polyunsaturated fatty acid/fish, and sodium (salt) have also been associated with CVD risk in other Japanese cohorts, as well as in cohorts in other countries.

In the present study, vegetables, fruit, fish, and salt consumption were individually associated with the risk of

CVD mortality in a Japanese general population. These findings agreed with the results from the NIPPON DATA cohort, as well as those from other cohorts in Japan and other countries.[1–9] Previous studies have shown associations between a single dietary factor and CVD risk, although there was adjustment for other factors. Our study is the first to show an association between intake amounts of a combination of dietary factors and the risk of CVD mortality.

Relationships between dietary pattern and CVD mortality have been reported previously for Japanese people. In those studies, the Japanese dietary pattern,[12] a vegetable-rich dietary pattern,[13] or a prudent dietary pattern[11] were proposed to be associated with a lower risk of CVD mortality, based on principal component analysis. These dietary patterns are characterized by higher intakes of vegetables, fruit, and fish, factors that were chosen for the present study. However, studies on dietary pattern cannot report the absolute intake of each food group. Conversely, our assessment chart provides useful information for the general population by visually indicating the risk of CVD mortality according to the intake of key food groups and salt.

Previous studies have shown that consumption of soy/soy products,[33,34] meat,[35,36] rice[37] or dairy products[31] is associated with the risk of CVD mortality. In the present study, consumption of these food groups was not significantly associated with CVD mortality. The 4 dietary factors chosen for inclusion in our chart were more effective at demonstrating a relationship between diet and CVD mortality risk.

We confirmed that the effects of dietary factors on stroke or CHD mortality risk were similar to those on CVD mortality; the numbers of deaths from stroke and CHD were 477 and 219, respectively, while total CVD deaths numbered 1,070. The aim of this study was to create a chart predicting the risk of total CVD mortality according to dietary factors. Therefore, we indicated the risk of total CVD mortality as the main result.

Several previous studies have shown that the consumption of vegetables is not associated with CVD risk.[38,39] Those studies generally used food frequency questionnaires (FFQs) to assess dietary intake. In FFQs, participants are asked to indicate the mean frequency of consumption of the foods listed, but portion size is not fully considered. Therefore, it is usually difficult to evaluate the amount of salt intake using FFQs. Because vegetables intake tends to positively correlate with salt intake, the lack of adjustment for salt intake would likely lead to an underestimation of the inverse relationship between vegetables intake and CVD risk. In the present study, we used data from 3-day weighed dietary records, from which we could obtain the absolute intake quantities (g/day) of each food and salt. We consider this to be the likely reason for the discrepancy between some previous studies and the present study.

The Japanese Food Guide Spinning Top is another tool that is used to illustrate dietary balance and quality for Japanese people.[23] A recent report showed that the dietary score derived from this guide is associated with the risks of all-cause and CVD mortality,[40] and the guide can evaluate the effect of dietary pattern using various food groups. However, fish is assessed in the "main dish" category, which also includes meat and eggs. In addition, vegetables are assessed in the "side dish" category, which also includes potatoes. Thus, this guide does not evaluate the influence of specific dietary factors on CVD risk, and we believe that the chart created in the present study is more suitable as a tool for CVD prevention in the general population.

Many previous studies have reported the effects of dietary education, focused on dietary pattern (DASH diet[41] or Mediterranean diet[42]) or specific food group intake (vegetables,[41] fruit[41] or fish[43]), on CVD risk or CVD risk factors. However, few have reported the effects of dietary education using educational tools in interventional studies. Therefore, further studies are needed to evaluate the effectiveness of dietary educational tools, including our chart.

We constructed our risk assessment chart using the relative risks of CVD mortality. However, several previous risk charts for CVD incidence/death[44–46] were based on absolute risk, calculated using several risk factors. Although it is possible to evaluate absolute CVD risk using our chart, younger people have an extremely low absolute risk of CVD mortality, making a chart based on relative risk more appropriate. Consistent with this decision, the Japan Atherosclerosis Society has recommended the use of a relative risk chart for younger people with a low absolute CVD risk.[47]

Study Limitations

First, we did not have individual nutritional data, because only household data were available. We estimated the nutrient intake of each household member by dividing household intake data from the NNSJ80 conducted in 1980 into proportions using average intakes data classified according to sex and age group that was calculated for the NNSJ95, as described in our previous report.[17] However, this method cannot guarantee accurate estimation of individual intakes. Second, the dietary assessment was carried out only once at baseline, and thus changes in dietary habit during the follow-up period were not accounted for. Third, the 3-day dietary record method was performed in November, and therefore incapable of evaluating seasonal variation. Finally, we cannot exclude residual confounding by unmeasured or unknown factors. For example, physical activity, alcohol intake amount, and socioeconomic status were not considered in this analysis.

Conclusions

We evaluated the CVD mortality risk associated with differing intakes of specific food groups, and used these data to generate a visual indication of the CVD mortality risk associated with the consumption of combinations of food groups and salt. This assessment chart could be used as a nutritional educational tool for the prevention of CVD in Japanese people. For example, a health professional, such as a dietitian, could provide personalized dietary advice using the chart, after assessing dietary intake by dietary record or FFQ. The use of this assessment chart with a food model could also be useful for nutritional education. We encourage the use of this chart by the community health sector for educating the Japanese general population.

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Conflict of Interest Statement

All authors declare no conflicts of interest.

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Supplementary File

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