Table 2 Nutrients with established DRIs and indices (ages 1 year and over)[1]

Nutrients			EAR	RDA	AI	UL	DG
Protein			○	○	—	—	—
Lipids		Total fats	—	—	—	—	○
		Saturated fatty acids	—	—	—	—	○
		n-6 fatty acids	—	—	○	—	○
		n-3 fatty acids	—	—	○	—	○
		Cholesterol	—	—	—	—	○
Carbohydrates		Carbohydrates	—	—	—	—	○
		Dietary fibers	—	—	—	—	○
Vitamin	Oil-soluble vitamins	Vitamin A	○	○	—	○	—
		Vitamin D	—	—	○	○	—
		Vitamin E	—	—	○	○	—
		Vitamin K	—	—	○	—	—
	Water-soluble vitamins	Vitamin B_1	○	○	—	—	—
		Vitamin B_2	○	○	—	—	—
		Niacin	○	○	—	○	—
		Vitamin B_6	○	○	—	○	—
		Vitamin B_{12}	○	○	—	—	—
		Folic acid	○	○	—	○[2]	—
		Pantothenic acid	—	—	○	—	—
		Biotin	—	—	○	—	—
		Vitamin C	○	○	—	—	—
Minerals	Macro	Sodium	○	—	—	—	○
		Potassium	—	—	○	—	○
		Calcium	○	○	—	○	—
		Magnesium	○	○	—	○[2]	—
		Phosphorus	—	—	○	○	—
	Micro	Iron	○	○	—	○	—
		Zinc	○	○	—	○	—
		Copper	○	○	—	○	—
		Manganese	—	—	○	○	—
		Iodine	○	○	—	○	—
		Selenium	○	○	—	○	—
		Chromium	○	○	—	—	—
		Molybdenum	○	○	—	○	—

EAR: Estimated average requirement; RDA: Recommended dietary allowance; AI: Adequate intake; UL: Tolerable upper intake level; DG: Tentative dietary goal for preventing life-style related diseases

[1] Including when the DRIs-J were defined only for certain age groups.

[2] Defined as intake other than from normal food.

3-2-3. Recommended Dietary Allowance

The Recommended Dietary Allowance (RDA) was established based on analyzed requirements for a subject group as the value that meets requirement of nearly all (97 to 98%) of the

Table 3 Coefficients of variation for person-to-person variations used to estimate the Recommended Dietary Allowance from Estimated Average Requirements

Variation coefficient	Coefficient for calculating RDA	Nutrients
10.0%	1.2	Vitamin B_1, vitamin B_2, niacin, vitamin B_6, vitamin B_{12},folic acid, vitamin C, calcium, magnesium, iron (for adults and 15-17 years old) , zinc, selenium, chromium, molybdenum
12.5%	1.25	Proteins
15.0%	1.3	Copper
20.0%	1.4	Vitamin A, iron (for 6 months-14 years old) , iodine

population. RDAs are calculated theoretically as the mean values of EAR+2×SD from the EAR, taking the standard deviation observed between individuals in laboratory studies to approximate that of the population. In practice, however, the SD of EAR is rarely obtained correctly through laboratory studies. Therefore in most cases, estimated values are used. The variation coefficients (SD/mean) used in this edition to calculate RDA are listed in Table 3.

$$\text{RDA} = \text{EAR}\times(1+2\times\text{SD}) = \text{EAR} \times \text{variation coefficient of EAR.}$$

3-2-4. Adequate intake

The Adequate Intake (AI) is defined as intake which is enough to maintain a certain nutrient level in a particular population. In fact, it is the value at which there are nearly no undernourished individuals observed the population. AI is used only when the RDA is unavailable. Basically it is based on epidemiology studies observing the nutritional intake of a healthy population.

AI is based on any of the three concepts listed below, depending on nutrients, gender, or age group.

1) Estimated intake levels showing nearly no deficiency based on studies conducting health checks using biological or other indices together with a survey on nutrition. When nearly no subject in a group showed deficiency, median intake levels were used.
2) No health checks by biological or other indices were available but representative nutrient distributions of Japanese people were obtained.
3) Based on the intake level of healthy human milk-fed infants. Nutritional content and intake volume of human milk is used.

3-2-5. Tolerable upper intake level

The Tolerable Upper Intake Level (UL) is defined as the upper limit of the habitual intake that is considered to have no risk of causing health problems due to excessive intake. Health problems in this section refer to those due to excessive intake and do not include those due to inadequacy.

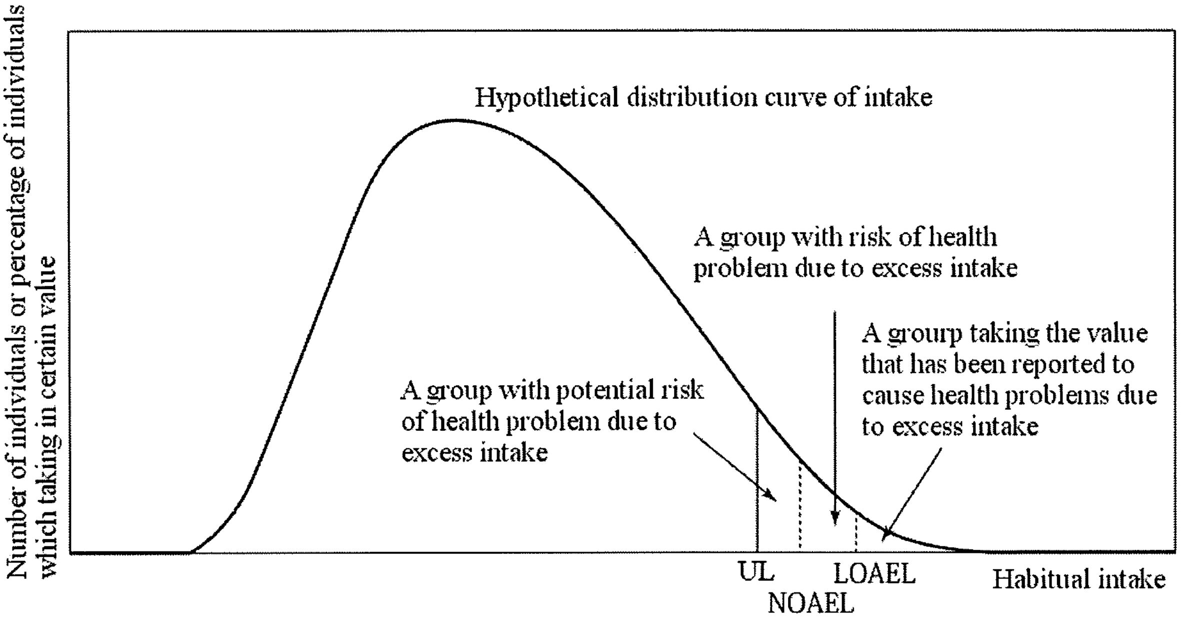

Figure 3 Model of risk of health problems due to excessive intake
The curve shows hypothetical intake distribution in a group. The vertical axis shows frequency or proportion of individuals in the group at a given intake. Those with intake above the UL have potential risk of developing health problems as a result; those with intake over LOAEL are above a level reported to cause health problems.
LOAEL: Lowest observed adverse effect level; NOAEL: No observed adverse effect level

The true tolerable upper intake level is, theoretically, the maximum amount with no adverse effect observed in human studies (no observed adverse effect level, NOAEL, Figure 3). Due to limited availability of human studies on NOAEL and the fact such studies are conducted on isolated groups, the UL used in practice is taken as the NOAEL divided by an Uncertainty Factor (UF), selected in the range 1 - 5 depending on conditions.

When the minimum amount known to cause adverse effects (lowest observed adverse effect level, LOAEL) based on studies of particular groups with excessive intake or use of supplements, the UF is basically 10 and the NOAEL is estimated as the LOAEL divided by 10. However, considering the occurrence of adverse effect of excessive intake of calcium, magnesium, and zinc, their ULs were set lower.

However adverse effects due to excessive intake in humans are rarely reported, it is impossible to conduct human studies to establish NOAELs and LOAEL and their relationships. Therefore, NOAEL or LOEAL need to be estimated based on data collected from animal or in some cases in vitro studies. When only LOEAL is available, NOAEL is estimated by LOEAL divided by a UF of 10, estimated based on animal studies.

There is not enough scientific basis for the UF and it has not reached a settlement among

Table 4 Uncertain factor UF used for calculation of tolerable upper intake level UL

UF	Nutrients
1	Vitamin E, copper, manganese, iodine (infants)
1. 2	Vitamin D (adults) , calcium, phosphorus
1. 5	Vitamin A (pregnant women) ,zinc, iodine (adults)
1. 8	Vitamin D (infants)
2	Molybdenum
3	Folic acid, selenium
5	Vitamin A (adults) , niacin, vitamin B_6
10	Vitamin A (infants)
30	Iron

professionals. Consequently, as described above, an appropriate value for UF was selected in the range 1 - 5 for reports based on humans, and 10 for those based on animals. When NOAEL is used for computation, a lower UF is chosen; when LOAEL is used, a higher UF is selected. The UF is also determined by considering the characteristics of each nutrient, the severity of the illness caused by excessive intake, the quality and number of the studies reporting NOAEL and LOAEL, characteristics of the subject and subject group (sex, age and health status), representatives of the group, and the number of subjects needed to establish UL. UFs used in the computation are listed in Table 4 for nutrients that have UL.

The details for computing UL differ for each nutrient and it is suggested to refer to the detailed information chapters. For some nutrients, reports offering a solid basis for computation were scarce and computation was postponed.

3-2-6. Tentative dietary goal for preventing lifestyle-related diseases

For the purpose of primary prevention of lifestyle-related disease, the Tentative Dietary Goal for Preventing Lifestyle-related Diseases (DG) is designed as a set of target intakes for modern Japanese to achieve a nutrition reducing the risk of disease or biological markers representing illness in a particular group. It is based on epidemiological studies with input from experimental nutritional studies. However, the relationship between nutritional intake and risk of developing lifestyle-related diseases is continuous in nature and quite often there is no threshold. In such cases, it is difficult to propose an optimum quantity or threshold; practicality was then used as the key factor to determine the desirable intake, also taking dietary preferences in other countries, and the intake, dietary composition and preferences of modern Japanese people into consideration.

In this edition, particular emphasis was placed on the primary prevention of cardiovascular

Table 5 Type of DG relative to the contents and its relations to the nutrients

Types of DG relative to the contents	Nutrients
Nutrients defined to bring their intake close to DG	Dietary fiber, n-3 fatty acids, calcium (with the intake increase desirable)
	Cholesterol, sodium (with intake decrease desirable)
DG is defined within a range and nutrients intake is designed to be within this defined range	Total fats, saturated fatty acids, carbohydrates
EAR, RDA, or AI are given but only UL is listed for DG	n-6 fatty acids

DG, tentative dietary goal for preventing life-style related diseases; EAR, estimated average requirement; RDA, recommended dietary allowance; AI, adequate intake; UL, tolerable upper intake level

diseases (e.g. hypertension, dyslipidemia, stroke and cardiac infarction) , cancer (especially stomach cancer) and DR for lipids (fatty acid) , cholesterol, carbohydrate, dietary fiber, sodium (salt) and potassium.

Osteoporosis and fracture are problems where preventive measures are strongly desirable, focusing on maintaining bone mass. This edition takes calcium and vitamin D as nutrients thought related to maintaining bone mass. Bone mass is used as an index to evaluate inadequacy of calcium, from which the EAR and RDA are determined; DG is not obtained. Plasma 25-hydroxyvitamin D level was used to determine adequate intake of vitamin D. Vitamin D was not included as a nutrient related to prevention of osteoporosis and fracture due to insufficient consensus regarding the relationship between vitamin D, osteoporosis, and fracture.

Also, the EAR and RDA of vitamin C are set with a view to preventing cardiovascular diseases. For computation, EAR and RDA were used rather than TG.

Lipids (including saturated fatty acids and n-6 fatty acids) and carbohydrates are energy-generating nutrients and the balance between them is important. Targets for these nutrients were therefore set in terms of percentage of total energy (%E).

The DG is established to bring habitual intake close to dietary goals or within the designated range. Relationships between types of DG and the content and nutrients are shown in Table 5.

4. Basic parameters used in designing DRIs-J

4-1. Age Groups

The age groups employed in this edition are shown in Table 6. As with the previous edition, infants were divided into 2 groups: 0 to 5 months and 6 to 11 months. These age groups were further divided into three groups for energy and protein: 0 to 5 months, 6 to 8 months and 9 to 11 months.

Children were defined as those aged 1 to 17 years, adults as aged 18 and over. Where elderly people required separate treatment, those aged 70 years and over were designated as such.

For details, refer to "Infants and Children", "Pregnant and Lactating", and "Aged" in II Particular Topics, Chapter 2.

Table 6 Reference physique (reference heights and reference weights)[1]

Age	Males		Females[2]	
	Reference height (cm)	Reference weights (kg)	Reference height (cm)	Reference weights (kg)
0-5 months	62.2	6.6	61.0	6.1
6-11	71.5	8.8	69.9	8.2
1-2 years	85.0	11.9	84.7	11.0
3-5	103.5	16.7	102.5	16.0
6-7	119.6	23.0	118.0	21.6
8-9	130.7	28.0	130.0	27.2
10-11	141.2	35.5	144.0	35.7
12-14	160.0	50.0	154.8	45.6
15-17	170.0	58.3	157.2	50.0
18-29	171.0	63.5	157.7	50.0
30-49	170.0	68.0	156.8	52.7
50-69	164.7	64.0	152.0	53.2
≥70	160.0	57.2	146.7	49.7

[1] Median of each age group from the 2005 and 2006 National Nutrition Survey in Japan was used for one year old and over, Median height and weight of growth percentile curve of each month groups from 2000 National Growth Survey in Infancy and Childhood for under one year old.
[2] Excluding pregnant women.

4-2. Reference physiques

The DRIs-J designate only single representative values for each gender and age group, without considering physical distinctions (height and weight) within each group. In other words, the DRIs-J are designed typical physiques in each age group. Reference physiques for those aged one year and over were based on median heights and weights of those of corresponding gender and age measured at the 2005 and 2006 National Nutrition Survey in Japan.[3, 4)] For infants ages 0 through 11 months, the medians of the group of corresponding age (in months) obtained from 2000 National Growth Survey in Infancy and Childhood[5)] were used. These are called the reference physiques (reference heights and weights) (Table 6).

4-3. Nutrition intake values used to establish AI and DG

In certain instances, the base nutritional intake of the population is needed to establish AI and

DG. In this edition, the median and percentile intakes for each gender and age group (ages one year and over) according to the 2005 and 2006 National Nutrition Survey [3,4] were used as references.

Age groups for children aged 6 through 11 differ between DRIs-J and National Nutrition Survey (6 to 7, 8 to 9 and 10 to 11 for the former, 6 to 8 and 9 to 11 for the latter). Hence, the National Nutrition Survey values for the 6 to 8 age group were used for the DRIs-J 6 to 7 age group, the mean of age groups 6 to 8 and 9 to 11 for DRIs-J 8 to 9 age group, and 9 to 11 for the DRIs-J 10 to 11 age group.

It is known that almost all nutritional surveys (including dietary recording methods) are plagued by under-reporting.[6] There are studies showing under-reporting in 16% of male and 20% of female in Japanese groups on average.[7] However, the degree of under-reporting in the 2005 and 2006 National Nutrition Surveys [3,4] mainly used in this edition are unknown; theory and practical methods to solve these problems have not been proposed, even in western countries. Therefore, in this edition, data obtained from the 2005 and 2006 National Nutrition Surveys [3,4] were used as-is.

Table 7 lists nutrients using intake data from surveys for AI and DG.

Table 7 Nutrients with intake data used to compute their AI and DG

	Nutrients
AI	n-6 fatty acids, n-3 fatty acids, vitamin D, vitamin E, pantothenic acid, biotin[1],phosphorus, manganese[1]
DG	Total fats, saturated fatty acids, n-3 fatty acids, sodium, potassium

AI, adequate intake; DG, tentative dietary goal for preventing life-style related diseases

[1] Study data other than those from the National Nutrition Survey in Japan were used for references.

4-4. Integration of research results

The DRIs-J are based as much as possible on methods of systematic review and results of high quality studies. In such cases, a value must be established based on results from multiple studies. As such, the values were established using the guidelines shown in Table 8.

Table 8 Method to integrate the research results

Quality of studies	Presence (or absence) of studies on Japanese people	Basic integration concept
Relatively uniform	Studies with Japanese research subjects	Prioritize results of studies conducted on Japanese subjects
	No studies with Japanese research subjects	Use of material available overall
Highly variable between studies	High-quality studies with Japanese research subjects	Prioritize results of studies conducted on Japanese subjects
	Studies with Japanese research subjects, relatively low quality in comparison with other studies	Select high-quality studies and use their mean
	No studies with Japanese research subjects	

4-5. Management of interventional studies using supplements

Some nutrients are thought to aid prevention of lifestyle-related diseases when taken in extremely high doses that cannot be obtained from usual food. In some cases, interventional studies using supplements are conducted to prove such effects. These study reports have been searched, collected and read, and included as references. However, there have been claims of unfavorable health effects[8)] raised after a certain favorable results have been reported. A conservative approach is therefore needed when considering the suitability of additional intake from non-usual foods (such as supplements) . In this edition, studies with intakes which clearly cannot be achieved by combining usual food without supplements were excluded from DGs.

4-6. Extrapolation

4-6-1. Basic concepts

Data used to establish five indices (EAR, RDA, AI, UL and DG) of DRIs-J have been obtained for a limited range of gender and age groups. Therefore, to establish DRIs-J for each gender and age group, extrapolation of available data is required. Reference values for EAR and AI are often based on the daily intake (weight/day), while reference values for UL are given per kg of body weight. Extrapolation methods were therefore prepared individually.

For RDA, the EAR for each gender and age group is established by extrapolating from reference values for EAR; each resulting EAR was then multiplied by the RDA coefficient shown in Table 3. The AI for each gender and age groups is determined by extrapolating from AI reference values; the corresponding DG were then obtained by using each extrapolated AI and the median if the intake of the respective gender and age groups.

4-6-2. Estimated average requirement and adequate intake

It is difficult to decide on the method of extrapolation considering the characteristics of each nutrient. It has been noted that there is significant correlation between efficiency in energy metabolism and body surface area. Formulas to estimate the body surface area from body height and/or weight were developed and are now widely used.[9] There are number of formulae; for DRIs-J, the formula proposed in 1974 using the weight ratio to the power of 0.75 has been adopted.[10] Further studies have been conducted in recent years and it has been reported that the method is useful in estimating the organ weights of a number of organisms including that of circulation and respiratory organs in mammals.[11]

Thus, the following formulas have been set for adults and children. When the reference values for EAR and AI are given per day (weight/day) and a representative value (median or mean) of body weight in a given group have been obtained, extrapolation is made thus:

$$X = X_0 \times (W/W_0)^{0.75} \times (1+G)$$

where

X = EAR or AI (intake per day) of the specific age group

X_0 = reference value of EAR or AI (intake per day)

W = reference body weight of the specific age group

W_0 = median or mean of body weight of studied subject group that provided reference value of EAR or AI

G = growth factor (refer to Table 9 for data)

In some studies, the reference value of EAR or AI may be given per kg of body weight. In this case, extrapolation was made as follows:

$$X = X_0 \times W \times (1+G)$$

Where

X = EAR or AI (intake per day) of the age group

X_0 = reference value of EAR or AI (intake per day)

W = reference body weight of the age group

W_0 = median or mean of body weight of studied subject group that provided reference value of EAR or AI

G = growth factor(refer to Table 9 for data)

Table 9 Growth factors used in establishment of the EAR or AI (age one year old and over)

Age groups	Growth factors
1-2 years	0.3
3-14	0.15
15-17 boys	0.15
15-17 girls	0
18 years and above	0

EAR, estimated average requirement; AI, adequate intake

For children, the following should be taken into consideration: (1) quantity needed for growth; and (2) the quantity accumulated in the body during the growth stage. For DRIs-J growth factors, the values adopted by FAO/WHO/UNU[12] and the United States and Canada in their DRIs[9] were modified to suit Japanese people in each age group (Table 9).

For 6 to 11 month-old infants, two methods were considered: (1) extrapolation based on the value for 0 to 5 month-old infants; and (2) use the median value of the 0 to 5 month-old and those 6 to 11 month-old groups. Hence, basically either of two formulas is applied.

When extrapolating from the DRIs-J of 0 to 5 month-old infants, the formula is as follows[9]:

$$(\text{reference weight of 6 to 11 month-old infants} / \text{reference weight of 0 to 5 month-old infants})^{0.75}$$

However, 0 to 5 month-old infants are in the growth stage and their DRIs-J probably include allowance for the growth factor, which the formula given above does not take into consideration. When the reference weight is substituted, the expressions for boys and girls are $(8.8/6.4)^{0.75}$ and $(8.8/6.4)^{0.75}$, and the products are 1.27 and 1.28, respectively. This formula produces extrapolated values that are slightly different between boys and girls. Therefore the mean of these values was computed and used as the common AI for both genders.

4-6-3. Tolerable upper intake level

Like EAR and AI, there are no extrapolating methods of UL that are sufficiently reliable. For those age groups with insufficient evidence, basically either of two methods can be used to establish the value.

When the reference value of UL is given as a quantity per kg of body weight, extrapolation is made as follows:

$$X = X_0 \times W$$

Where

X = UL (intake per day) of the specific age group

X_0 = reference value of UL (intake per day)

W = reference body weight of the specific age group

Table 10 Basic formulas for rounding numbers

Approximate median value	Rounding
0.5	Nearest 0.1.
1	Nearest 0.1.
5	Nearest 0.5.
10	Nearest whole number.
50	Nearest 5.
100	Nearest 10
500	Nearest 50
1,000	Nearest 100.
5,000	Nearest 500.

When reference value of UL is given as a quantity per day, extrapolation is as follows:

$X = X_0 \times (W/W_0)$

Where

X = UL (intake per day) of the specific age group

X_0 = reference value of UL (intake per day)

W = reference body weight of the specific age group

W_0 = median or mean of body weight of studied subject group that provided reference value of UL

4-7. Rounding methods

In view of the convenience of use and reliability of the values, EAR, RDA, AI, UL and DG were routinely rounded off according to the rules shown in Table 10. For children, adults, and aged, a single rule was applied for each nutrient. For infants, additional values for pregnant and lactating women were rounded to the same number of digits as those used for other gender and age groups. After rounding operations, the numbers were smoothed if necessary to remove excessive differences between age groups. Refer to specific sections on nutrients using rounding methods other those discussed in this section.

3. Basic Concept of Application

1. Basic points

1-1. Objective

This chapter aims to describe a basic theory for the correct application of the Dietary Reference Intakes for Japanese 2010 (DRIs-J). Though theory and application of DRIs have been discussed in America and European countries, a united theory and method have not been established.[13-15] Japanese physique, nutritional intakes and diseases needing prevention are not the same as in western countries: therefore, even if such a united theory and method are obtained in western countries, it may not be applicable to Japanese people.

Therefore, in this edition, we have decided to establish a basic theory and study process using DRIs-J is applied to Japanese people(individuals or groups) as a primarily guideline while referencing reports from America and Europe.

1-2. Subjects and groups

Subjects of the DRIs-J are healthy individuals or groups mainly composed of healthy individuals. They also include individuals living freely without dietary instruction, diet therapy or diet restrictions, even given individual has risk factors such as high blood pressure, dyslipidemia or hyperglycemia at low levels.

Where dietary instruction, diet therapy or diet restriction is recommended to individuals or groups with disease or undergoing preventative treatment, guidelines for the disease in question should be applied preferentially and DRIs-J should be used as supporting reference.

1-3. Basic categories of application purpose

The DRIs-J are used for many purposes, in particular dietary improvement and food services. Dietary improvement consists of assessment of dietary intake, formulation based on assessment, and practice. Theories of application are different between individuals and groups, and are therefore considered separately. Even given a number of subjects, where evaluation of dietary intake and dietary instruction is done on an individual basis, care is needed to treat each subject as an individual.

The term "food service" refers to dietary planning for particular groups and on-going meal services under appropriate quality control based on the plan. The values presented in DRI are targets and do not necessarily need to be achieved immediately for ether purpose.

Also, DRIs may be used as a base to establish guidelines relating to eating habits and intake.

1-4. Sources of intake

Sources of intake of energy and nutrients are foods eaten orally as meals. Besides normal foods, those eaten for the purpose of health improvement and not treatment of disease, such as tonic drinks, nutritional supplements, nutrient enriched foods (fortified foods), foods for specified health uses (FOSHU), foods with nutrient function claims (FNFC), health food products and supplements are also included. However, Tolerable Upper Intake Level(UL) of folic acid is limited to intake from non-normal foods.

1-5. Duration of intake

The DRIs-J are standards for habitual intake and are presented in units of intake per day. They do not indicate intake to be fulfilled in the short term (e.g. a single day). This is due to wide range of day-to-day variability[16-19] and health problems related to DRIs-J caused by inadequate or excessive intake.

The time taken to develop health problems due to inadequate or excessive intake depends on nutrients and the type of health problems. For example, it is reported that after feeding meals with virtually all vitamin B_1 eliminated for 2 weeks, serum vitamin B_1 decreased greatly and various symptoms thought to be caused by deficiency emerged within 4 weeks.[20] This illustrates the necessity of dietary management over periods shorter than one month. Meanwhile, there are reports that excessive intake of sodium (salt) are correlated with hypertension due to aging,[21] showing the importance of dietary management over several decades. Thus, the time required to develop or improve health problems differs depending on the type of nutrient and health problem.

Meanwhile, due to intake characteristics of nutrients, in particular day-to-day variability, it is difficult to specify habitual intake term. Very roughly, based on reports of observation of day-to-day variability of energy and nutritional intake,[17-19] the period required for assessing or managing habitual intake or for management is approximately one month allowing certain measurement errors and individual variability, and excluding certain nutrients which have great day-to-day variability.

1-6. Individual variability

There are differences in the intake requirement among individuals. For example, the true energy requirement has a standard deviation of 200 kcal/day in male and 160 kcal/day[22] in female adults even with minimal variation in measurement. There are also nutrients reported for which requirements and health effects differ due to various factors such as difference in absorption efficiency of the digestive system when intake is the same.[23-25]

However, the degree of individual variability depends on the type of nutrition and many other related factors. There is no convenient but accurate method for most nutrients to measure individual variability. Therefore, at present, it is practical to treat and understand individual variability existence in terms of probabilities.

However, for energy intake, it is desirable to use body weight and body mass index (BMI) to evaluate the balance of intake and energy expenditure instead of energy intake obtained from dietary surveys since these indices are relatively easy and accurate to measure and can be used to evaluate energy balance.

Also, there are cases where individual requirements can be estimated to some extent, such as iron which could be estimated from haemoglobin concentration of blood and menstrual blood loss.[26, 27] Under such circumstances, how such information can be used should be evaluated carefully.

1-7. Classification and priority by nutrient characteristics (Table 11)

DRIs-J show standards for energy and nutritional intakes but the reliability and priority in application are not uniform.

Keeping an adequate balance of energy intake and expenditure is fundamental to nutritional management. Nutrients are categorized into two types depending on purpose: maintaining and improving health (including healthy growth), and primary prevention of lifestyle-related diseases. Primary prevention of lifestyle-related diseases should be the objective when maintenance of health is assured. Therefore, it is preferred that EAR, RDA, AI and UL are considered prior to DG. Also, priority is low for nutrients with no confirmed deficiency in humans and nutrients for which intake cannot be estimated.

Based on this concept, the order of priority is as follows: (1) energy, (2) protein, (3) lipids (% energy), (4) other nutrients listed in the Standard Tables of Food Composition in Japan, 5th revised and enlarged Edition[28] (with EAR and RDA or AI),(5) other nutrients listed in the Standard Tables of Food Composition in Japan 5th revised and enlarged Edition[28] (with DG) , and (6) nutrients not listed in the Standard Tables of Food Composition in Japan 5th revised and enlarged Edition.[28]

In actual application, more specific nutrients need to be identified. As an example: (1) energy, (2) protein, (3) lipids, (4) vitamins A, B1, B2, C, calcium, and iron, (5) saturated fatty acids, dietary fiber, sodium (salt) and potassium, and (6) other important nutrients for study group.

However, this order of priority is not fixed and needs to be arranged depending on characteristics of subject individuals and groups, and the purpose for DRIs-J. An important point is to choose and use nutrients on both a theoretical and practical basis, and to be able to explain reasons for choice including limitations.

1-8. Points to consider for primary prevention of lifestyle-related diseases

Targeted lifestyle-related diseases in DRIs-J are limited to cardiovascular diseases (e.g. hypertension, certain dyslipidemia, stroke and cardiac infarction), and stomach cancer. This is because the diseases in question were limited to those having quantitative relationships between nutritional intake and diseases identified through studies and prevention strategies of importance to Japanese people.

Table 11 Priority of energy and nutrients in applying DRIs-J

Energy/Nutrients	Nutrients (examples)	Notes
1.Energy	—	Including alcohol
2. Protein	Protein	—
3. Lipids	Lipids	% energy (%E)
4. Nutrients listed in the food composition table[1] (Nutrients with EAR and RDA or AI)	Vitamin A, vitamin B1, vitamin B2, vitamin C, calcium, iron	Nutrients known with deficiency (critical) and that prevention of the deficiency are important. Require consideration on relatively short term intake.
5. Nutrients listed in the food composition table[1] (Nutrients with DG)	Saturated fatty acids, dietary fiber, sodium, potassium	Important nutrients for primary prevention of lifestyle-related disease. Require consideration on relatively long term intake.
6. Nutrients not listed in the food composition table[1]	—	Usually low priority. Attention requires with particular group or group with particular food habits

[1] Standard Tables of Food Composition in Japan 5th Revised and Enlarged Edition

Obesity (risk factor of many lifestyle-related disease and increase the risk of total mortality) and energy intake are also taken under consideration.

For primary prevention of lifestyle-related diseases, the following two points need to be considered in the application of DRIs-J to dietary improvement and food services.

1) Sustainability over several years or more, not just several months.
2) Consideration of all related risk factors and preventive factors holistically, rather than trying to prevent a specific lifestyle-related disease with a specific nutrient.

2. Points for application based on indices

2-1. Estimated energy requirement

In food services, the Estimated Energy Requirement (EER) of subjects needs to be considered to determine energy per serving.

EER is established based on energy expenditure measured by the doubly-labeled water method (DLW). Physical activity levels (PALs) are estimated and established based on measurement of energy expenditure and basal metabolic rate.

$$\text{PAL} = \text{EER} / \text{basal metabolic rate}$$

However, from an application point of view, EER is estimated by estimating PALs in addition to gender and age groups.

The above relation shows that EER is obtainable if the basal metabolic rate and PAL are known; however, the basal metabolic rate is not always easy to measure, and the estimation error of PAL also far from negligible. Therefore it is not always practical to estimate the energy requirements using the basal metabolic rate and PALs.

It is practical to use PAL II (normal) instead when the information necessary to estimate PAL is unavailable. However in such cases, the risk of inappropriate application increases and measures of caution such as frequent reviews of the application method are desirable.

There are several simple formulas to estimate the basal metabolic rate based on gender, age (age groups), height and weight, and others, such as the Harris-Benedict equation,[29] an equation used by the FAO/WHO/UNU,[12] and the Ganpule equation for Japanese people.[30] However, it has been noted several times that equations for western people tend to overestimate the energy requirement.[31,32] When using these equations for estimating energy requirements, their reliability and points of application need to be fully considered in addition to the estimation error of PAL.

2-2. Estimated average requirement

Since the Estimated Average Requirement (EAR) has a 50% probability of inadequate intake in an individual, being the intake level which is inadequate for half of the group, it is very problematic; urgent support is needed when the intake of some or many members in a group is below the value. However, it is important to understand the purpose of application, definition of indices, and characteristics of nutrients because application methods differ depending on the purpose.

2-3. Recommended Daily Allowance

The Recommended Daily Allowance (RDA) is the intake level giving nearly zero probability of inadequacy in an individual and nearly no individuals with inadequate intake in a group. Therefore, if an individual or group is taking in around or above this value, it is assumable that there is nearly no risk of inadequacy. However, it is important to understand the purpose of application, definition of the indices, and characteristics of nutrients because application methods differ depending on the purpose.

2-4. Adequate Intake

The Adequate Intake (AI) is determined when EAR is unavailable. It has very low risk of inadequacy when taken above the value and has characteristics closer to the RDA than EAR. By definition, its value is theoretically higher than that of RDA. However, it is not possible to identify existence of inadequacy or its risk when intake is below the value.

Therefore, when intake is close to the AI, there is nearly no probability of inadequacy in an individual and nearly no individual with inadequate intake in a group. On the other hand, when intake is below AI, there is a clear possibility of inadequacy (but also of adequacy).

2-5. Tolerable Upper Intake Level

The Tolerable Upper Intake Level (UL) indicates a threshold intake above which an above-zero risk of health problems exists. However, there is nearly no possibility of excessive intake from eating usual food. Also, establishment of the AI it is theoretically and empirically difficult and in most cases is based on a few instances of accidents. This shows the insufficiency of scientific evidence for the AI. Therefore, the AI should be understood as value to avoid getting close to rather than a value not to exceed.

The UL is an index for health problems caused by excessive intake and not for primary prevention of lifestyle-related diseases. This needs to be well minded in application of AI.

2-6. Tentative Dietary Goal for Preventing Lifestyle-related Diseases

The Tentative Dietary Goal for Preventing Lifestyle-related Diseases (DG) is established as an index for primary prevention of lifestyle-related diseases. There are many causes of lifestyle-related diseases; diet is one of them. Therefore it is not correct to strictly maintain DG simply for primary prevention of lifestyle-related diseases.

As an example, excessive intake of sodium (salt) is one of the causes of hypertension and from that point of view, a DG is established for sodium. Also, there are other lifestyle features related to hypertension such as excessive intake of alcohol and inadequate intake of potassium from nutritional sources[33)] in addition to obesity, lack of exercise, and other factors. Application of sodium DG needs to be determined with consideration to the above points and characteristics of subjects or groups.

Compared with health problems due to inadequate or excessive intake, lifestyle-related diseases are developed as the outcome of lifestyle(including dietary) habits over very long periods. In view of these characteristics of lifestyle-related diseases, long term (lifetime) management is important rather than just strict short term management.

3. Points of assessment in the dietary survey

3-1. Dietary survey

3-1-1. Relationship with application

Evaluation of energy and nutritional intakes are performed by comparison of intakes from dietary assessment with each index value of DRIs-J. However, due to various problems discussed below, especially measurement errors in dietary assessment, using this method for application of DRIs-J needs adequate consideration of standardization and accuracy in management.

Therefore, knowing the types and characteristics of measurement errors in dietary assessment is as important as understanding DRIs-J values. Under- and over-reporting, as well as day-to-day variation, are the two major measurement errors that need special attention in dietary assessment.

3-1-2. Under- and over-reporting

Several methods are known for dietary assessment and most are based on self-reporting by subjects. In such cases, reporting errors are unavoidable. Under- and over-reporting are known as the most significant reporting errors. Between these, under-reporting occurs frequently; under-reporting of energy in particular requires careful attention.

However, the level of error differs depending on methods and subjects; it is reported that under-reporting exists in about 11% in male and 15% in female Japanese subjects on average.[7] In this study, the energy intake obtained by the food weighing method over 16 days is compared with the basal metabolic value estimated from a gender and age group. However, attention is required when interpreting results due the measurement accuracy of the basal metabolic value, and trends of under-reporting shown in young male and female adults, middle-aged women, and middle-aged men with tendencies toward obesity.

From the point of view of application, in some cases under-reporting is thought to have an non-negligible effect on the interpretation of dietary assessments. For example, if the energy needed to lose 1kg of body weight is around 7000 kcal,[34,35] the excessive energy intake of a man who gains 5 kg in a year is 96 kcal/day (= 7, 000×5/365). And if there is 13% under-reporting, the measurement error due to under-reporting would be 260 kcal/day for a man whose total intake is 2000 kcal/day. That is far greater than the 96 kcal/day described above. This example shows that under-reporting makes it impossible to compare the values of dietary assessment results and EER.

Furthermore, under- and over-reporting are strongly affected by the degree of obesity.[36] For example, one study reported the relationship between reporting errors and degree of obesity (using BMI) in Japanese, comparing intakes estimated from nitrogen (a biomarker of protein intake), potassium, and sodium from 24-hour urine excretion and self-reported intakes. The study reported trends of over-reporting in the lower BMI group and under-reporting in the higher BMI group for all three nutrients (Table 12).[37]

3-1-3. Day-to-day variation

It is widely known that day-to-day variations exist in energy and nutritional intakes.[17] On the other hand, information on intakes without the effect of day-to-day variations is required because DRIs-J are based on normal intake spans.

However, degrees of day-to-day variation differ among individuals and groups, and nutrients as well.[16-19] Furthermore, due to difficulties associated with the study method, it is reported that the actual day-to-day variation in Japanese people remains poor. For example, Table 13 shows the assessment days required to obtain intake data within a range of ±5 % or ±10 % of habitual intake in individual level for Japanese women. [18, 19] Understand it also differs based on nutrients and ages.

When assessing intake for a group, variability of intake in the group has an non-negligible effect on results. Because of the existence of day-to-day variations, distribution curves obtained from the study widen as research days are shortened compared to the distribution curve of habitual intake. Therefore, the percentage of individuals with inadequate or excessive intake using DRIs-J values differs between the distribution curves from short term studies and habitual intake. For example, study that researched 50 to 69 years old male and female s for 12 days using the food weighing method reported results given in Table 14.[38)]

The existence of season variation is also presumed in addition to day-to-day variation; vitamin C is reported as a nutrient with a clear seasonal intake difference in Japanese people (Table 15).[16,38,39)] There are reports on other nutrients' seasonal differences[16,37,38)]. Consideration is desirable when wide fluctuations due to season are expected.

Table 12 Relationship between reported intake and intake estimated from 24-hours urinary nitrogen (biomarker of protein intake), potassium, and sodium on BMI basis (353 female Japanese dietetic students aged 18–22 years)

	BMI(kg/m2) , median (range)					
	18. 4 (14. 8 - 19. 2)	19. 9 (19. 3 - 20. 4)	21. 1 (20. 4 - 21. 6)	22. 2 (21. 6 - 23. 1)	24. 7 (23. 1 - 34. 2)	P for trend
Nitrogen	1.11	0.98	1	0.93	0.85	<0.0001
Potassium	1.15	1.1	1.06	0.96	0.89	<0.0001
Sodium	1.34	1.21	1.09	1.14	0.94	<0.0001

Values are median of estimated intake (g/day) [reported intake (g/day) /excretion amount (g/day)], dietary survey curried by self-administered diet history questionnaire

Table 13 Research days required to obtain intake data which is within ±5% or ±10% of habitual intake in individual level in Japanese adult women

Error ranges		±5 %		±10%	
Age groups		Middle[1]	Elder[2]	Middle[1]	Elder[2]
Energy	kcal/day	15	12	4	3
Protein	g/day	21	21	5	5
Lipid	g/day	43	43	11	11
Saturated fatty acids	g/day	59	-	15	-
Polyunsaturated fatty acid	g/day	61	-	15	-
Cholesterol	mg/day	109	-	27	-
Carbohydrates	g/day	19	13	5	3
Dietary fibers	g/day	49	-	12	-
Carotene	µg/day	258	140	64	35
Vitamin C	mg/day	132	80	33	20
Potassium	mg/day	30	21	8	8
Calcium	mg/day	65	47	16	12
Iron	mg/day	31	27	8	7

[1] calculated from reference #19: mean age 49.8, n = 42, Tokai area, 16 days of food weighting method

[2] calculated from reference #18: mean age 61.2, n = 60, rural area of Miyagi prefecture, 12 days of food weighting method

Table 14 Percentage of nutritionally at-risk populations on research day basis [38] (%)
(50-69 years old male and female, three days of food weighting methods for each four season, total of 12 days)[1]

Nutrients		Male (n = 208)				Female (n = 251)			
		At risk level	research days			At risk level	research days		
			1	3[2]	12		1	3[2]	12
Protein	g/day	<50	3.9	1.0	0	<40	2.4	0	0
Lipid	g/day	25≦	27.9	22.1	24.0	25≦	39.8	37.8	43.0
Sodium	g/day	10≦	74.0	86.5	90.9	8≦	82.5	88.4	96.0
Folic acid	μg/day	<200	5.8	2.9	0.5	<200	6.4	3.2	1.2
Vitamin C	mg/day	<85	27.9	21.6	19.7	<85	25.1	17.1	15.1
Calcium	mg/day	<600	48.6	47.1	46.2	<600	48.2	48.6	45.0
Iron	mg/day	<6	7.2	3.4	1.0	<5.5	6.0	3.2	2.0

[1]Risk population was calculated after adjusting intake distribution close to normal distribution by functional transformation
[2]Result of autumn 3 day research

Table 15 Season variation of vitamin C: mean intakes (mg/day) of 3 studies carried for one year in Japan by food weighting method.

Ref. No.	Gender	Age	n	research days	spring	summer	autumn	winter	p-value
16)	Female	48	80	7	136	128	160	154	<0.001
38)	Male	61	208	3	120	124	145	125	<0.001
	Female	60	251	3	132	123	158	137	<0.001
39)	Male	56	75	7	113	127	154	130	<0.001
	Female	54	85	7	120	131	163	145	<0.001

3-2. Physical status survey

Body weight and body mass index (BMI) are the most important indices for overall physical condition and are recommended to be actively used. When evaluating the results of planned and practised dietary improvements, changes in body weight are greater and thus a keener index than changes in BMI. It is recommended to measure and record the body weight every 4 weeks and follow for more than 16 weeks when aiming at a weight decrease or increase.[40] Beside the physical condition, abdominal girth, body fat percentage and other indices exist, and should be used depending on the purpose.