Statement

Evaluation of vitamin supplies in Germany

Data on vitamin intake

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Contents

Abstract

Background: In popular media and professional journals, there are regular but conflicting reports on vitamin supply in Western countries. The role of vitamin-fortified foods and nutritional supplements is also the subject of controversial debate time and again. The German Nutrition Society has therefore compiled a statement of the vitamin supply in Germany based on available data.

Methods: The results from existing representative nutrition surveys of various population groups in Germany have been used to assess the vitamin supply. The calculated nutrient intake, based on determined food consumption, was compared to the reference value of nutrient intake among various population groups. Vitamin D intake was not considered because vitamin D can be formed endogenously and intake data are not suitable to describe its supply. Specific situations are described in which even healthy people with an adequate supply of vitamins may be at risk, and targeted diet supplementation with specific nutrients may be appropriate.

Results: Representative studies show that reference values for the majority of vitamins are reached by median intake among people living in private households in Germany. That means the supply is sufficient for most groups. Exceptions include folate and the following vitamins among particular age groups: vitamin A (girls 7 to < 12 years old), vitamin E (children 1 to < 5 years old, pre-adolescents 7 to < 12 years old, nursing home residents ≥ 65 years old), and vitamin C (infants 6 to < 12 months old, nursing home residents ≥ 65 years old). Moreover, the intake of some B vitamins is critical among nursing home residents. The calculated deviation below a reference value ("calculated deficiency") is not equivalent with vitamin deficiency, it only indicates an increased likelihood of an undersupply. A deviation below the reference values for vitamin intake is usually the result of poor food choices.

Conclusions: Germany is not a country with significant vitamin deficiency in the general population. Vitamin deficiency and related diseases occur extremely rarely in Germany. It is only recommended in specific situations that healthy people supplement their diet with various critical vitamins and other nutrients, particularly as part of medical care: ► Newborns: 3 x 2 mg of vitamin K. ► Infants: 10 µg of vitamin D and 0.25 mg of fluoride daily. ► Women who want to, or could, become pregnant: 400 µg of folic acid daily, preferably at least four weeks prior to conception and during the first trimester of pregnancy. ► Pregnant and nursing women: after consulting with a doctor, 100 (to 150) µg of iodide daily and iron only in cases of proven iron deficiency. ► People who cannot or barely spend time outdoors and therefore have little or no endogenous synthesis: vitamin D. The German Nutrition Society recommends that the entire population should use iodized and fluoridated table salt and foods prepared with iodized salt. Particular attention should be paid to nutrient intake among the elderly. This is especially true for elderly in nursing homes whose basal metabolic rate, physical activity, and, consequently, energy requirements are reduced. The foods consumed should therefore have a higher nutrient density.

1 Introduction

Non-scientific reports describing Germany as a vitamin-deficient country do not reflect the actual vitamin supply situation. Rather, they severely confuse the consumer. Based on these reports, many fear a deficiency and intend to overcome poor diet and lifestyle habits by taking extra vitamins and other nutrients in the form of supplements and/or fortified foods. Studies have not yet demonstrated that the consequences of poor dietary habits may be balanced by taking vitamin supplements or other dietary supplements. Moreover, the lack of benefits from vitamin supplementation above the reference intakes is associated with an increased health risk due to high intake amounts, particularly when high-dose supplements are taken permanently and fortified foods are consumed simultaneously.

Negative, “bad”, news regarding vitamin supply is often disseminated through press reports; in part, these are strongly interest-driven. Similar news can also be found in relevant journals [0]. Such statements are not in line with the assessment of national nutrition societies. In many cases, a look at the authors’ backgrounds or their financing reveals a potential conflict of interest.

In addition, negative reports are frequently triggered by

- a non-reflective, synonymous use of the terms ***vitamin deficiency*** *(= the vitamin requirement is not met resulting in metabolic disorders and diseases)* and ***calculated vitamin deficiency*** *(= reference values for nutrient intake are not met).*
- synonymous use of the terms ***requirement*** *(= amount of a nutrient that is needed to ensure the functions of an organism)* and ***reference value*** *(= theoretically derived quantity of a nutrient needed to ensure adequate intake among almost all healthy people in the population).*
- lack of knowledge about the validity, differences and the evaluation of different dietary assessment methods.
- lack of representativeness among samples studied and neglecting other statistical and methodological criteria.

2 Reference values for nutrient intake

Reference values for nutrient intake [1] are differentiated into **recommended intake**, **estimated values** and **guiding values for intake**, whose different derivations and validities must be considered when consulting the reference values. The starting point for the derivation of reference values is the determination of the **average requirement** *(= daily nutrient intake assumed to meet the needs of 50 % of a defined group of people)* (Figure 1).
Reference values for nutrient intake are amounts which are assumed to

- protect nearly all healthy individuals in a population from deficiency-related conditions,
- ensure complete physiological and psychological performance and
- create a certain body reserve.

It is not possible to accurately assess a person's supply of vitamins and minerals (see Chapter 3) based on reference values alone. For this purpose, it would be necessary to know a person's individual requirement. Reference values should be understood as ideal, or benchmark, values as applied to an individual person or population group in order to ensure an adequate nutrient supply.
Because the human organism has storage and certain adaptation characteristics for different intake levels for many vitamins, it is not necessary to reach the reference values on a daily basis. If possible, the reference values for nutrient intake should be obtained in terms of average weekly amount.

3 Methodology

3.1 Assessment of nutrient supply based on intake data

A reliable and accurate assessment of vitamin supply can only be accomplished using validated biochemical and clinical parameters. However, to assess vitamin supply, nutrition surveys may also be used among individuals or population groups (see below) wherein the nutrient intake is calculated based on the recorded food consumption and is compared with the reference values.
The intake levels recommended in the reference values for nutrient intake [1] ensure an adequate nutrient supply among almost all healthy people (about 98 %). Healthy individuals whose intake meets these recommendations are therefore adequately supplied with approximately 98 % probability. A calculated deviation below the recommended intake or estimated value ("calculated deficiency") does not necessarily allow the conclusion that an actual deficiency exists. It only increases the likelihood of undersupply. Exceeding the reference values beyond a certain amount of regular nutrient intake (tolerable upper intake level) may increase the risk of adverse and potentially harmful side effects (Figure 2).
When considering groups of people, the comparison of average intakes (50^{th} percentile, median) with recommended intake values (98^{th} percentile) has only limited significance because only the same percentiles may be compared. A comparison, therefore, underestimates the true nutritional situation and overestimates the proportion of people with insufficient supplies.
Using this approach, the distribution of intake and requirement among groups of people remain disregarded. They can only be taken into account adequately if the intake values of the individuals are related to the requirement distribution curve of the group. The incidence of inadequate nutrient intake in the relevant population group might be determined by using the variation of the nutrient intake distribution and the average requirement. The former can be calculated, but the exact values of the average requirements are only available for a few nutrients [1]. Although the approach mentioned here does not allow for accurate assessment of vitamin supply of individuals, the comparison provides good guidance when assessing vitamin supply of individuals or population groups.

Vitamin D intake is not included in this report. Vitamin D intake from food sources represents only a small amount of total vitamin D supply and is therefore not suitable to determine the supply level. The total supply from oral intake and endogenous synthesis by UVB irradiation of the skin is reflected by the serum concentration of 25-hydroxyvitamin D [25 (OH) D].
For a valid calculation of nutrient intake based on intake and consumption data, the timeliness and correctness of the nutrient data from food tables and databases is a decisive factor. Different growing and feeding conditions and differing amounts among brands of a food and uncertain losses of nutrients in food storage and processing [3] contribute to uncertainties. Furthermore, when evaluating the supply levels of population groups, the dietary assessment methods used should be considered alongside the representativeness of the population sample. For dietary surveys, different survey methods are available with varying validity, reflecting either the actual or the usual nutrient supply [4].

3.2 Vitamin deficiency

Vitamin deficiency in humans can be caused by permanently low vitamin intake (i.e. anorexia nervosa, consumption of only foods with low nutrient density, unbalanced diets), an impairment of intestinal absorption (i.e. chronic diarrhoea), increased vitamin requirements (i.e. diseases with fever and increased metabolism, drug interactions) and increased losses of vitamins (i.e. hemodialysis) [3]. Clinically relevant vitamin deficiency diseases are only rarely identified among otherwise healthy adults in Germany.
A vitamin deficiency usually develops in several stages (Figure 3): a marginal supply marks the beginning and is associated with a loss of body stores. This is followed by a subclinical deficiency which, for example, is characterised by a decrease in urinary excretion and decreasing plasma levels of vitamins. Nonspecific, reversible deficiency symptoms can occur at this early stage of a vitamin deficiency. The use of the term "manifest vitamin deficiency" presupposes that there were clinically relevant, measurable disturbances or characteristic deficiency symptoms which may be irreversible in the case of prolonged deficiency.
Non-attainment of daily vitamin intake reference values is often incorrectly described as a "vitamin deficiency". However, between the calculated non-attainment of reference values *(calculated deficiency)* and a marginal requirement coverage (determined by biochemical or clinical parameters) as well as a *vitamin deficiency* (with clinical symptoms), a relatively wide range in the nutrient intake amount exists.

3.3 Vitamin oversupply

Given a typical diet of natural foods such as fruits, vegetables, bread, meat and cheese, it is almost impossible to reach a vitamin intake that is too high. However, if high-dose supplements are taken and fortified foods are also consumed, excessive intake levels may occur, which might present a health risk [6].
Fortified foods are foods which have been enriched with certain substances so that their nutrient levels can be well above what naturally occurs in the particular food. The most

common additives in fortified foods are vitamins and minerals. The best-known products include fruit juices fortified with vitamins A, C and E [7].
For some nutrients, and particularly fat-soluble vitamins A and D, the gap between the recommended intake and the tolerable upper intake level is very low. According to the Federal Institute for Risk Assessment (*Bundesinstitut für Risikobewertung, BfR*), there is a significant health risk of adverse effects associated with the use of supplements and fortified food. The BfR, therefore, suggests maximum levels of vitamins in food supplements and restrictions of vitamin supplementation on certain products [8]. Mandatory maximum levels for nutrients or other substances in food supplements currently do not exist at the national or European level. An EU-wide regulation on maximum vitamin and mineral levels in food supplements is under consideration [9].

4 Vitamin supply in Germany in different stages of life

In recent years, several research groups have conducted nutritional epidemiological studies allowing an evaluation of the vitamin supply based on intake in different stages of life and various age groups, while taking different study methods into account (Table 1).

4.1 Infants and young children

The VELS study (Consumption Survey of Food Intake among Infants and Young Children) shows that among non-breastfed or no-longer-breastfed infants between six months and one year of age, the median intake of vitamin C and folate in girls lies below their respective reference values. In infants, a slightly lower deviation was observed from the vitamin E reference values. The intake of folate was significantly below the corresponding reference value. Actual intake could, however, be higher since fortified foods were not included in this calculation. Among infants and toddlers, the median intake of vitamin A, thiamine, riboflavin, pyridoxine, niacin and vitamin B_{12} fell within the range of reference values or were significantly higher. (Table 2)

4.2 Children

The nutrition module EsKiMo of the German Health Interview and Examination Survey for Children and Adolescents (KiGGS) showed that, in children between six and twelve years of age, the intake of thiamine, riboflavin, pyridoxine, niacin, vitamin B_{12} and vitamin C were within the range or exceeded reference values. Among 7- to < 12-year-old girls, the median intake of vitamins A and E, and, for boys in the same age category, only vitamin E intake, fell below the reference values. Folate intake among both boys and girls (6 to < 12 years of age) was significantly lower than the reference values. (Table 3)

4.3 Adolescents

The EsKiMo data for adolescents 12 to < 18 years old, as well as data from the National Nutrition Survey II (*Nationale Verzehrsstudie, NVS*) for persons from 14 to < 19 years old, showed that the median intake values of vitamins A, E, C, B_{12}, thiamine, riboflavin, pyridoxine and niacin were significantly higher than the respective reference values. As with the younger age groups, adolescents did not obtain the recommended folate intake. (Table 4, Table 5)

4.4 Adults

According to the National Nutrition Survey II, median folate intake values were significantly below the reference values. For the other vitamins, the median intake values were about as high as or higher than their reference values. (Table 6)

4.5 Seniors

4.5.1 Independent seniors living in private households

The results presented in the 2000 Nutrition Report [12, 12a] showed that people aged ≥ 65 years reached the reference values for the majority of vitamins on average. The median dietary intake of folate was significantly lower than the reference value. These results were also found among seniors living in private households studied in the National Nutrition Survey II (Table 2, age group 65 to < 80 years). (Table 7)

4.5.2 Seniors in nursing homes

In the ErnSTES study (Nutrition of the Elderly in German Nursing Homes), seniors ≥ 65 years of age living in nursing homes were shown to have a median intake below the reference values for most of the vitamins considered. Only the reference values for vitamin A and niacin as well as riboflavin and vitamin B_{12} in men met or exceeded their reference values. Among elderly women, the intake of B vitamins was significantly lower than that of elderly men due to the small total quantity of food they consumed. The median intake values of vitamin C and folate were about 50 % below the respective reference values (Table 8) due to low fruit and vegetable consumption. The ErnSTES study has generally shown that the degree of dependency on care affects a person's energy and nutrient supply much more than age [10].

5 Summary – critical vitamins

Numerous studies show that, for the majority of vitamins, the median intake values of people living in private households in Germany reached or exceeded the reference values for nutrient intake [1], meaning that supply is sufficient. Exceptions include folate in all age

groups and vitamin A, vitamin E and vitamin C in particular age groups. In addition, the intake of some B vitamins is critical for nursing home residents (Table 9).
Since the population's vitamin intake may represent a wide range of values, not all individuals reach the reference values, even if the median intake is above the reference values. As described above, failure to reach reference values does not equal a deficiency.
Vitamin D has a special status among vitamins since it originates from dietary sources as well as endogenous synthesis. Regarding present living conditions, when regular time is spent outdoors, an estimated 80 % to 90 % of vitamin D in the body originates from endogenous synthesis in the skin. Only about 10 % to 20 % of vitamin D comes from one's diet [13], and few foods contain significant amounts of vitamin D. These include fatty fish (such as herring and mackerel) and, to a much lesser extent, liver, margarine (fortified with vitamin D), certain mushrooms and egg yolks. In Germany, the typical dietary intake of vitamin D is 1 to 2 µg per day in children; in adolescents and adults, it is 2 to 4 µg per day. In the absence of endogenous synthesis, this quantity is insufficient to reach the estimated value of adequate vitamin D intake (20 µg per day) that ensures the desired 25(OH)D serum concentration of at least 50 nmol/l. The difference between dietary vitamin D intake through habitual diet and the reference intake value has to be covered by endogenous synthesis and/or additional intake of vitamin D. In case of frequent exposure to sunlight, no vitamin D supplement is necessary in order to reach the desired supply [1, 1a].

6 Discussion

6.1 Vitamin intake from foods

Calculations for the German Nutrition Society nutrition circle [19] have shown that reference values can be obtained with a balanced diet consisting of conventional foods (except for vitamin D and possibly iodine).
To improve the supply of dietary folate, it is recommended to eat at least two to three servings of vegetables and salads daily and to be mindful in their preparation - wash vegetables only before they are chopped, stew them instead of cooking and do not keep them warm. Whole grains and low-fat milk and milk products should also be consumed daily and liver should be eaten from time to time [14].
According to the 2008 Nutrition Report, the low intake of some vitamins in children, adolescents, and even infants can be attributed to suboptimal food choices [10]. They do not eat enough plant-based foods – especially vegetables, fruit, bread, potatoes – and eat too many high-fat, animal-based foods.
To improve the vitamin and nutrient supply as a whole, more plant-based foods should be consumed, particularly vegetables and fruits. Additionally, whole grains should be eaten, instead of products made from refined flour. In principle, healthy people can satisfy their requirements for vitamins (except Vitamin D, see above) and other essential nutrients (except possibly iodine), as well as the supply of sufficient dietary fibre and phytochemicals,

through a balanced diet with a high content of plant foods. A comparison of vitamin contents of selected foods administered for the 2004 Nutrition Report over a period of 50 years showed no decreases in vitamin concentrations [15].
Energy requirements are generally reduced among senior citizens in nursing homes. The foods eaten should therefore have a high nutrient density, meaning that they must be rich in vitamins (and minerals and protein) relative to the energy content.
1- to < 5-year-olds, 7- to < 12-year-olds and nursing home residents ≥ 65 years of age were determined to have relatively low vitamin E intake which is likely due to the incomplete consideration of all vitamin E compounds contained in foods. Vitamin E equivalents are usually calculated to assess the vitamin E intake since different vitamin E compounds have varying levels of physiological efficacy as vitamin E. The vitamin E equivalent of the German Nutrient Database is currently being compiled mainly based on α-tocopherol and without consideration of other vitamin E compounds. Therefore, the calculated values represent a significant underestimation of actual vitamin E intake.

6.2 Special life circumstances

In certain situations, it may not be possible to obtain enough essential nutrients, such as vitamins, meaning that a careful selection of fortified foods or the use of dietary supplements becomes appropriate.
These situations include:
– an increased requirement in special stages of life (such as growth, pregnancy, lactation, older age, see below),
– intolerances (i.e. lactose intolerance) or aversions to certain foods,
– certain illnesses/conditions,
– one-sided diets (i.e. vegan diet),
– long-term and unbalanced weight-loss diets and
– chronic, heavy use of alcohol and tobacco.
To treat existing deficiencies, high-dose nutrient supplements should only be taken with a doctor's prescription and under medical supervision.
Numerous nutrient fortified foods are available for consumption as part of a normal diet. Iodized table salt with fluoride is proven to be effective. The contribution that nutrient enriched foods provide to overall supply currently cannot be specified because these foods were not previously recorded in the standard nutrient tables or food databases. At this time, fortified foods are being recorded [16] in the current version of the German Nutrient Food Code and Data Base (*Bundeslebensmittelschlüssel,* BLS, version 3.01).

6.2.1 Infancy

It is assumed that infants who are exclusively breastfed are well supplied with nutrients during the first four months, when the amount of breast milk is sufficient and because certain nutrients are stored. Solid foods should not be offered before the beginning of the fifth month and should be introduced, usually, no later than the beginning of the seventh month.

Additional oral doses of vitamin D, as rickets-prophylaxis, (10 µg or 400 IU [international units] per day) and fluoride (0.25 mg per day) during the first year are recommended to breastfed and bottle fed infants. Due to the lack of vitamin K transmission through the placenta and a consequent vitamin K deficiency, bleeding can occur in newborns and young infants; this is preventable by administering prophylactic vitamin K after birth. In Germany, an oral dose of 3x2 mg of vitamin K is recommended [17, 18].

6.2.2 Pregnancy and lactation

Increased nutrient requirements during pregnancy and lactation are taken into account with corresponding increases in reference values (age group 19 to < 25 years). A considerable increase in vitamin requirements usually occurs, starting in the fourth month of pregnancy, continuing during lactation (vitamin A, thiamine, riboflavin, niacin, pyridoxine, vitamin C). For critical vitamins, the increase in recommended intakes or estimated values begins at the start of pregnancy as a precautionary measure (vitamin E, folate, vitamin B_{12}). The increase in vitamin requirements can be attained through one's diet with the exception of folate. Women who could or want to become pregnant should (in addition to consuming dietary folate) take a folic acid supplement (400 µg per day) beginning at least four weeks before conception through the end of the first trimester to reduce the child's risk of neural tube defects [1].

6.2.3 Elderly

Because of lower basal metabolic rates and typically reduced physical activity among the elderly, their energy intake must be reduced. The reference values for the elderly are generally comparable to recommended intakes indicated for middle-aged adults. The reference values for the intake of B-complex vitamins are only slightly lower in men due to reduced energy expenditure that accompanies aging. This means that foods with a high nutrient density should be preferred.

As people age, it is possible for some organs to exhibit a loss of function (i.e. chewing and swallowing, gastritis, decreased peristalsis), prevalence of illness increases, and medication is often necessary. These factors may reduce the availability of or increase the requirement for nutrients. In general, however, the elderly represent a very heterogeneous group from those who are healthy and fit to frail seniors with multiple morbidities. Generally applicable reference values for population groups therefore pertain less and less to the elderly on an individual basis. Consequently, it is desirable to raise the nutritional status and dietary habits of seniors and to make individualized recommendations as a part of nutritional counselling.

If dietary modifications prove insufficient to meet the requirements for vitamins (and other essential nutrients and possibly energy) as a person ages, supplementation should be provided as soon as possible by means of a balanced, liquid diet. With age, the skin's ability to synthesise vitamin D decreases significantly, and endogenous synthesis declines further if the time spent outside decreases, since this limits UVB light exposure; this is often the case among older people with restricted mobility, chronic illness and care dependency (nursing home residents, geriatric patients). As such, there is a greater need for taking a vitamin D supplement in this age group [1, 1a].

6.2.4 Special situations

Adequate vitamin supply may be at risk for people with allergies or aversions to certain foods; long-term weight reduction diets and unbalanced, one-sided diets, such as a vegan diet; certain illnesses or chronic, heavy alcohol or tobacco use. The use of fortified foods or dietary supplements may be appropriate based on an individualized assessment of nutrient supply.

7 Conclusion and scientifically based recommendations

Germany is not a country characterised by vitamin deficiency. Vitamin deficiency diseases occur extremely rarely in Germany among healthy adults. Healthy people, who consume a balanced diet, are usually well supplied with essential nutrients like vitamins (exception: Vitamin D, if endogenous synthesis is absent or insufficient). The intake of dietary supplements is unnecessary for those people. Furthermore, unfavourable dietary habits cannot be compensated for by taking vitamin supplements or other dietary supplements.
Healthy individuals with an adequate supply of essential nutrients such as vitamins may be at risk only in certain situations where targeted supplementation of the diet might be useful using individual nutrients. The positive list in the next summary gives an overview for which people and nutrients the use of fortified foods or dietary supplements is recommended.

Summary: Population groups for whom the use of fortified foods or dietary supplements is recommended

- **Entire population:**
  The use of iodized and fluoridated table salt and foods prepared with iodized salt
- **Children, adolescents, adults:**
  in the absence of endogenous synthesis, a daily dose of vitamin D is recommended, that compensates the difference between intake from the diet (1 to 2 µg per day in children, 2 to 4 µg per day in adolescents and adults) and the estimated value (20 µg per day).
- **Newborns:**
  oral administration of 3 x 2 mg of vitamin K
- **During the first year:**
  10 µg of vitamin D and 0.25 mg of fluoride daily
- **Women who could or want to become pregnant:**
  400 µg of folic acid daily, preferably prior to conception (at least four weeks before the beginning of pregnancy) and during the first trimester
- **Pregnant and nursing women:**
  following consultation with a doctor, iodide (100 [-150] µg per day), as well as iron in cases of proven iron deficiency in the first trimester, 400 µg of folic acid daily during the first trimester of pregnancy

8 Literature

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9 Figures

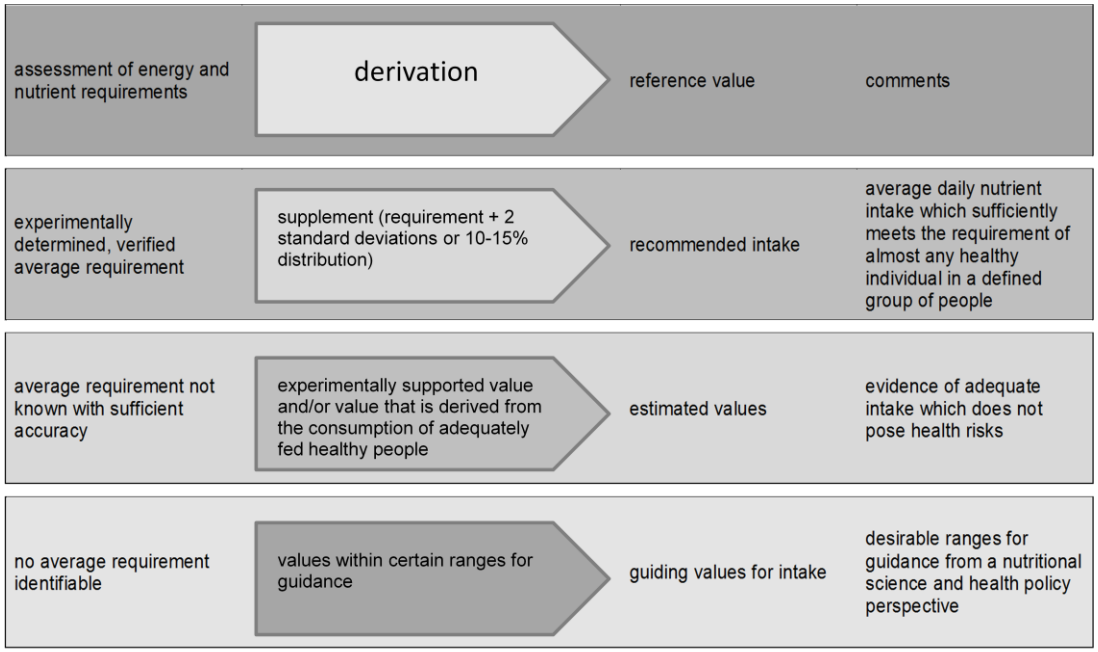

Figure 1: **Derivation and validity of reference values for nutrient intake** (according to [2])

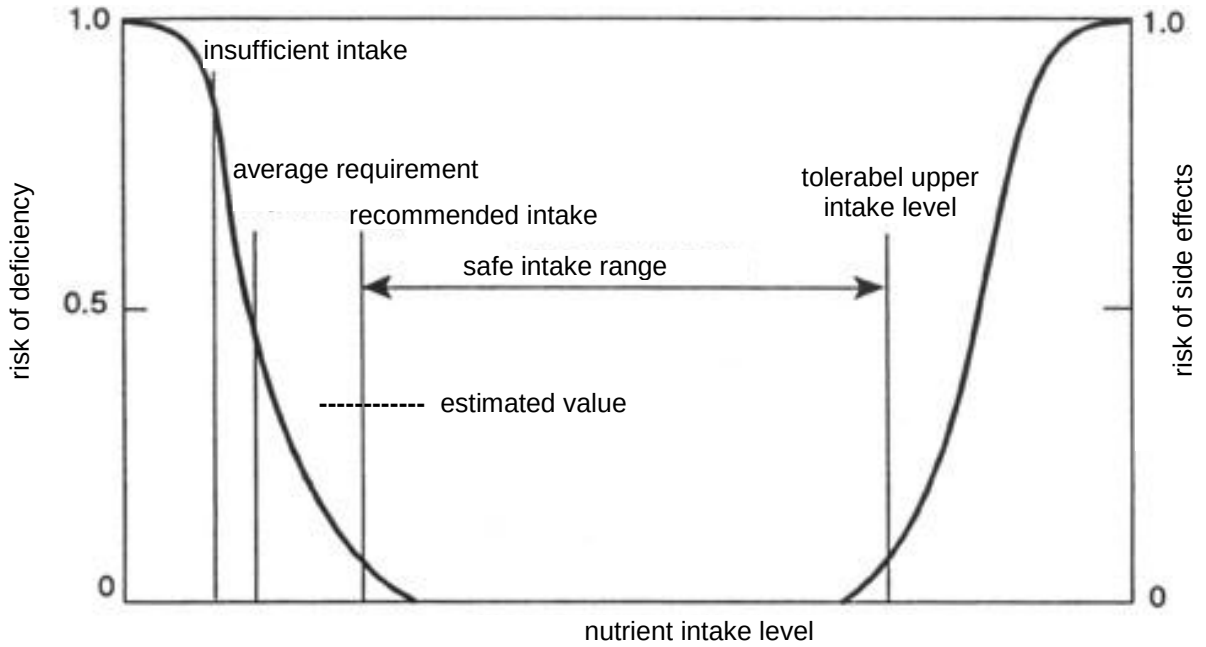

Figure 2: **Individual nutrient intake and risk of deficiency or side effects due to oversupply. Within the safe intake range, the probability of both deficiency and side effects from excessive intake is very low** [2].

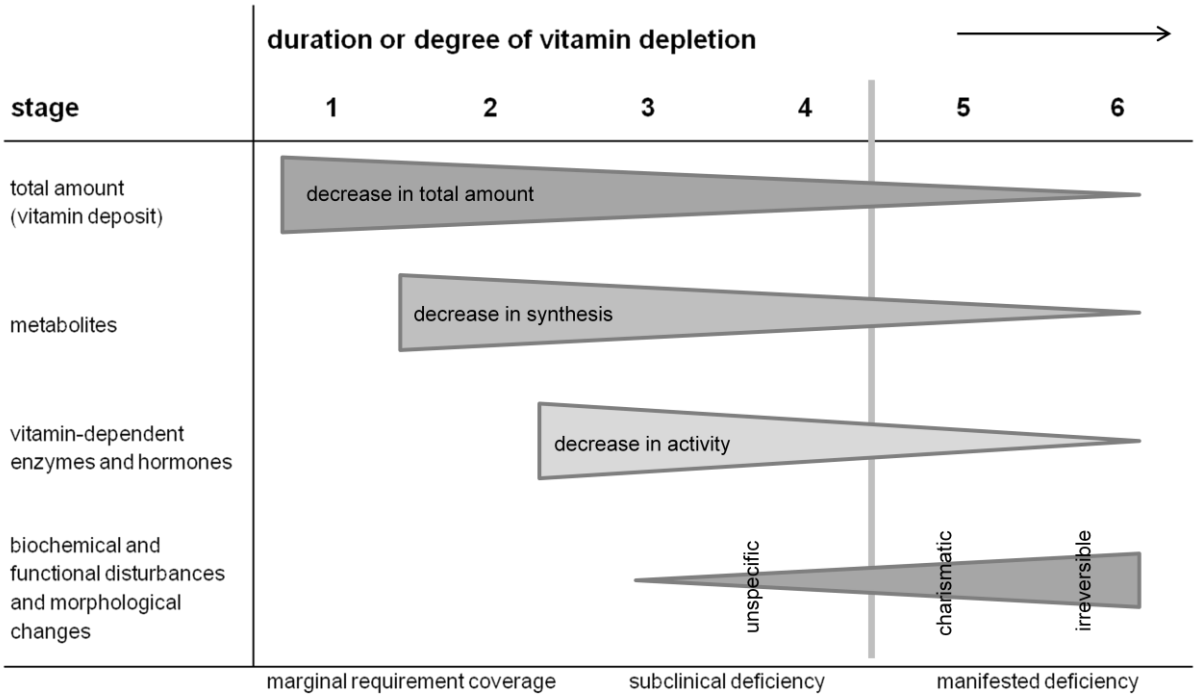

Figure 3: **Stages of vitamin depletion according to BRUBACHER** [5].

10 Tables

study [source]	time frame	sample	age	survey method
VELS (Consumption Survey of Food Intake among Infants and Young Children) [10]	June 2001 to Sep-tember 2002	732 infants and young children who are no longer breastfed	6 months to < five years	3-day weighed dietary record, repeat measurement after 3-6 months, 4-8 months for infants
EsKiMo (nutrition module of the KiGGS study) [10]	2006	2,506 children and adolescents (approx. 100 girls and 100 boys per yearly age group)	6 to <18 years	6 to <18 years: 3-day dietary record completed by both parents and children; 12 to < 18 years of age: diet history of past four weeks (DISHES Junior)
NVS II (National Nutrition Survey II) [11]	November 2005 to November 2006	15,371 adolescents and adults, (7,093 men and 8,278 women)	14 to 80 years	diet history interview (DISHES) from the past four weeks (additionally there are 24-hour recalls from 13,926 people and weighed dietary records from 976 people)
Nutrition Report 2000 – nutrition of the elderly (part of national study) [12]	1998	1,550 independent residents living in private households over 65 years of age from 10 nursing homes within seven federal states (654 men and 896 women); of which 1,372 have useful nutrition records)	men 74.3 ±7.4 years, women 76.8 ± 8.0 years	3-day dietary record
ErnSTES (nutrition in in-patient facilities for seniors) [10]	March to October 2006	773 residents over 65 years of age from 10 nursing homes within 7 federal states (153 men and 620 women)	men 81 years of age ± 8 years, women 86 years of age ± 7 years	3- day dietary record administered by trained personnel

Table 1: **Epidemiological studies to assess nutrient supply in different life stages**

age: 6 to under 12 months	**boys (n = 52)**			**girls (n = 43)**		
	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]
vitamin A [RE mg][2]	0.93	0.6 (R)	155	0.87	0.6 (R)	145
vitamin E [TE mg][2]	4.5	4 (E)	113	4.4	4 (E)	110
thiamine (B_1) [mg]	0.44	0.4 (R)	110	0.37	0.4 (R)	93
riboflavin (B_2) [mg]	0.88	0.4 (R)	220	0.71	0.4 (R)	178
niacin [NE mg][2]	0.77	0.3 (R)	257	0.61	0.3 (R)	203
pyridoxine (B_6) [mg]	78.0	80 (R)	98	61.8	80 (R)	77
folate [FE µg][2]	7.9	5 (R)	158	6.4	5 (R)	128
vitamin B_{12} [µg]	1.7	0.8 (R)	213	1.2	0.8 (R)	150
vitamin C [mg]	40.8	55 (R)	74	32.5	55 (R)	59
age: 1 to under 4 years	**boys (n = 242)**			**girls (n = 246)**		
	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]
vitamin A [RE mg][2]	0.69	0.6 (R)	115	0.61	0.6 (R)	102
vitamin E [TE mg][2]	5.0	6 (E)	83	4.7	5 (E)	94
thiamine (B_1) [mg]	0.66	0.6 (R)	110	0.61	0.6 (R)	102
riboflavin (B_2) [mg]	1.00	0.7 (R)	143	0.87	0.7 (R)	124
niacin [NE mg][2]	0.94	0.4 (R)	235	0.85	0.4 (R)	213
pyridoxine (B_6) [mg]	128.2	200 (R)	64	116.4	200 (R)	58
folate [FE µg][2]	11.9	7 (R)	170	11.2	7 (R)	160
vitamin B_{12} [µg]	2.5	1.0 (R)	250	2.3	1.0 (R)	230
vitamin C [mg]	63.6	60 (R)	106	57.6	60 (R)	96
age: 4 to under 5 years	**boys (n = 74)**			**girls (n = 75)**		
	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]
vitamin A [RE mg][2]	0.74	0.7 (R)	106	0.72	0.7 (R)	103
vitamin E [TE mg][2]	5.7	8 (E)	71	5.5	8 (E)	69
thiamine (B_1) [mg]	0.77	0.8 (R)	96	0.73	0.8 (R)	91
riboflavin (B_2) [mg]	1.05	0.9 (R)	117	1.00	0.9 (R)	111
niacin [NE mg][2]	1.05	0.5 (R)	210	0.99	0.5 (R)	198
pyridoxine (B_6) [mg]	146.8	300 (R)	49	142.5	300 (R)	48
folate [FE µg][2]	14.4	10 (R)	144	14.0	10 (R)	140
vitamin B_{12} [µg]	2.7	1.5 (R)	180	2.5	1.5 (R)	167
vitamin C [mg]	76.8	70 (R)	110	69.0	70 (R)	99

[1]D-A-CH Reference Values for Nutrient Intake (1), recommended intake (R), estimated value (E) per day for the corresponding age group

[2]RE: retinol equivalent, TE: tocopherol equivalent, FE: folate equivalent, NE: niacin equivalent

Table 2: **Daily median vitamin intake by diet of infants and young children (age 6 months to under 5 years) in comparison to D-A-CH Reference Values for Nutrient Intake [1]. Data from the VELS study (Consumption Survey of Food Intake among Infants and Young Children** [10]**).**

age: 6 to under 7 years	**boys (n = 106)**			**girls (n = 102)**		
	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]
vitamin A [RE mg][2]	0.7	0.7 (R)	100	0.7	0.7 (R)	100
vitamin E [TE mg][2]	8.8	8 (E)	110	8.3	8 (E)	104
thiamine (B_1) [mg]	1.1	0.8 (R)	138	0.9	0.8 (R)	113
riboflavin (B_2) [mg]	1.4	0.9 (R)	156	1.2	0.9 (R)	133
niacin [NE mg][2]	1.4	0.5 (R)	280	1.3	0.5 (R)	260
pyridoxine (B_6) [mg]	189.6	300 (R)	63	160.7	300 (R)	54
folate [FE µg][2]	19.5	10 (R)	195	17.9	10 (R)	179
vitamin B_{12} [µg]	3.6	1.5 (R)	240	2.8	1.5 (R)	187
vitamin C [mg]	85.0	70 (R)	121	78.4	70 (R)	112
age: 7 to under 10 years	**boys (n = 321)**			**girls (n = 308)**		
	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]
vitamin A [RE mg][2]	0.8	0.8 (R)	100	0.7	0.8 (R)	88
vitamin E [TE mg][2]	9.3	10 (E)	93	8.5	9 (E)	94
thiamine (B_1) [mg]	1.3	1.0 (R)	130	1.1	1.0 (R)	110
riboflavin (B_2) [mg]	1.5	1.1 (R)	136	1.3	1.1 (R)	118
niacin [NE mg][2]	1.6	0.7 (R)	227	1.4	0.7 (R)	200
pyridoxine (B_6) [mg]	204.0	300 (R)	68	188.1	300 (R)	63
folate [FE µg][2]	22.5	12 (R)	188	19.3	12 (R)	161
vitamin B_{12} [µg]	3.8	1.8 (R)	211	3.3	1.8 (R)	183
vitamin C [mg]	96.9	80 (R)	121	93.1	80 (R)	116
age: 10 to under 12 years	**boys (n = 199)**			**girls (n = 198)**		
	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]
vitamin A [RE mg][2]	0.9	0.9 (R)	100	0.7	0.9 (R)	78
vitamin E [TE mg][2]	9.2	13 (E)	71	9.7	11 (E)	88
thiamine (B_1) [mg]	1.2	1.2 (R)	100	1.2	1.0 (R)	120
riboflavin (B_2) [mg]	1.5	1.4 (R)	107	1.5	1.2 (R)	125
niacin [NE mg][2]	1.5	1.0 (R)	150	1.5	1.0 (R)	150
pyridoxine (B_6) [mg]	204.9	400 (R)	51	203.5	400 (R)	51
folate [FE µg][2]	22.0	15 (R)	147	21.7	13 (R)	167
vitamin B_{12} [µg]	4.2	2.0 (R)	210	3.6	2.0 (R)	180
vitamin C [mg]	99.2	90 (R)	110	100.0	90 (R)	111

[1]D-A-CH Reference Values for Nutrient Intake (1), recommended intake (R), estimated value (E) per day for the corresponding age group

[2]RE: retinol equivalent, TE: tocopherol equivalent, FE: folate equivalent, NE: niacin equivalent

Table 3: **Daily median vitamin intake by diet of children (age 6 to under 12 years) in comparison to D-A-CH Reference Values for Nutrient Intake [1]. Data from the nutrition module EsKiMo of the German Health Interview and Examination Survey for Children and Adolescents (KiGGS) [10].**

age: 12 to under 13 years	**boys (n = 144)**			**girls (n = 103)**		
	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]
vitamin A [RE mg][2]	1.2	0.9 (R)	133	1.3	0.9 (R)	144
vitamin E [TE mg][2]	14.3	13 (E)	110	13.1	11 (E)	119
thiamine (B_1) [mg]	1.7	1.2 (R)	142	1.4	1.0 (R)	140
riboflavin (B_2) [mg]	1.9	1.4 (R)	136	1.7	1.2 (R)	142
niacin [NE mg][2]	2.0	1.0 (R)	200	1.8	1.0 (R)	180
pyridoxine (B_6) [mg]	272.4	400 (R)	68	272.0	400 (R)	68
folate [FE µg][2]	29.9	15 (R)	199	26.9	13 (R)	207
vitamin B_{12} [µg]	4.7	2.0 (R)	235	4.1	2.0 (R)	205
vitamin C [mg]	136.0	90 (R)	151	158.0	90 (R)	176
age: 13 to under 15 years	**boys (n = 214)**			**girls (n = 230)**		
	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]
vitamin A [RE mg][2]	1.3	1.1 (R)	118	1.4	1.0 (R)	140
vitamin E [TE mg][2]	15.0	14 (E)	107	13.8	12 (E)	115
thiamine (B_1) [mg]	1.9	1.4 (R)	136	1.4	1.1 (R)	127
riboflavin (B_2) [mg]	2.2	1.6 (R)	138	1.7	1.3 (R)	131
niacin [NE mg][2]	2.3	1.4 (R)	164	1.8	1.4 (R)	129
pyridoxine (B_6) [mg]	295.9	400 (R)	74	273.0	400 (R)	68
folate [FE µg][2]	35.7	18 (R)	198	26.9	15 (R)	179
vitamin B_{12} [µg]	5.8	3.0 (R)	193	4.3	3.0 (R)	143
vitamin C [mg]	155.0	100 (R)	155	167.0	100 (R)	167
age: 15 to under 18 years	**boys (n = 294)**			**girls (n = 317)**		
	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]
vitamin A [RE mg][2]	1.5	1.1 (R)	136	1.3	0.9 (R)	144
vitamin E [TE mg][2]	16.6	15 (E)	111	13.6	12 (E)	113
thiamine (B_1) [mg]	2.2	1.3 (R)	169	1.4	1.0 (R)	140
riboflavin (B_2) [mg]	2.3	1.5 (R)	153	1.7	1.2 (R)	142
niacin [NE mg][2]	2.8	1.6 (R)	175	1.9	1.2 (R)	158
pyridoxine (B_6) [mg]	339.7	400 (R)	85	276.0	400 (R)	69
folate [FE µg][2]	42.7	17 (R)	251	26.8	13 (R)	206
vitamin B_{12} [µg]	7.1	3.0 (R)	237	4.1	3.0 (R)	137
vitamin C [mg]	171.0	100 (R)	171	175.0	100 (R)	175

[1]D-A-CH Reference Values for Nutrient Intake (1), recommended intake (R), estimated value (E) per day for the corresponding age group

[2]RE: retinol equivalent, TE: tocopherol equivalent, FE: folate equivalent, NE: niacin equivalent

Table 4: **Daily median vitamin intake by diet of adolescents (age 12 to under 18 years) in comparison to D-A-CH Reference Values for Nutrient Intake [1]. Data from the nutrition module EsKiMo of the German Health Interview and Examination Survey for Children and Adolescents (KiGGS) [10].**

age: 14 to under 19 years	**boys (n = 712)**			**girls (n = 700)**			
	intake	D-A-CH-reference value[1]		supply [%-D-A-CH]	intake	D-A-CH-reference value[1]		supply [%-D-A-CH]
vitamin A [RE mg][2]	1.5	1.1	(R)	136	1.4	1	(R)	140
vitamin E [TE mg][2]	16.2	14/15	(E)	116/108	13	12	(E)	108
thiamine (B_1) [mg]	1.9	1.4/1.3	(R)	136/146	1.4	1.1/1.0	(R)	127/140
riboflavin (B_2) [mg]	2.2	1.6/1.5	(R)	138/147	1.7	1.3/1.2	(R)	131/142
niacin [NE mg][2]	36.1	18/17	(R)	201/212	25.2	15/13	(R)	168/194
pyridoxine (B_6) [mg]	2.6	1.4/1.6	(R)	186/163	2	1.4/1.2	(R)	143/167
folate [FE µg][2]	317	400	(R)	79	259	400	(R)	65
vitamin B_{12} [µg]	5.8	3	(R)	193	3.6	3	(R)	120
vitamin C [mg]	138	100	(R)	138	139	100	(R)	139

[1]D-A-CH Reference Values for Nutrient Intake (1), recommended intake (R), estimated value (E) per day for the corresponding age group
[2]RE: retinol equivalent, TE: tocopherol equivalent, FE: folate equivalent, NE: niacin equivalent

Table 5: **Daily median vitamin intake by diet of adolescents (age 14 to under 19 years) in comparison to D-A-CH Reference Values for Nutrient Intake [1]. Data from the National Nutrition Survey II (NVS II) [11].**

age: 19 to under 25 years	**men (n = 510)**			**women (n = 510)**			
	intake	D-A-CH-reference value[1]		supply [%-D-A-CH]	intake	D-A-CH-reference value[1]		supply [%-D-A-CH]
vitamin A [RE mg][2]	1.5	1	(R)	150	1.4	0.8	(R)	175
vitamin E [TE mg][2]	14.3	15	(E)	95	12	12	(E)	100
thiamine (B_1) [mg]	1.8	1.3	(R)	138	1.3	1	(R)	130
riboflavin (B_2) [mg]	2.1	1.5	(R)	140	1.6	1.2	(R)	133
niacin [NE mg][2]	39.9	17	(R)	235	25.4	13	(R)	195
pyridoxine (B_6) [mg]	2.6	1.5	(R)	173	1.8	1.2	(R)	150
folate [FE µg][2]	298	400	(R)	75	257	400	(R)	64
vitamin B_{12} [µg]	6.3	3	(R)	210	3.7	3	(R)	123
vitamin C [mg]	127	100	(R)	127	123	100	(R)	123
age: 25 to under 35 years	**men (n = 690)**				**women (n = 972)**			
	intake	D-A-CH-reference value[1]		supply [%-D-A-CH]	intake	D-A-CH-reference value[1]		supply [%-D-A-CH]
vitamin A [RE mg][2]	1.8	1	(R)	180	1.5	0.8	(R)	188
vitamin E [TE mg][2]	14.5	14	(E)	104	12.7	12	(E)	106
thiamine (B_1) [mg]	1.7	1.2	(R)	142	1.3	1	(R)	130
riboflavin (B_2) [mg]	2	1.4	(R)	143	1.6	1.2	(R)	133
niacin [NE mg][2]	39.7	16	(R)	248	27.7	13	(R)	213
pyridoxine (B_6) [mg]	2.3	1.5	(R)	153	1.9	1.2	(R)	158
folate [FE µg][2]	288	400	(R)	72	258	400	(R)	65
vitamin B_{12} [µg]	6	3	(R)	200	3.9	3	(R)	130

vitamin C [mg]	125	100 (R)	125	130	100 (R)	130
age: 35 to under 51 years	**men (n = 2,079)**			**women (n = 2,694)**		
	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]
vitamin A [RE mg][2]	1.8	1 (R)	180	1.7	0.8 (R)	213
vitamin E [TE mg][2]	13.9	14 (E)	99	11.9	12 (E)	99
thiamine (B_1) [mg]	1.6	1.2 (R)	133	1.2	1 (R)	120
riboflavin (B_2) [mg]	1.9	1.4 (R)	136	1.5	1.2 (R)	125
niacin [NE mg][2]	38.4	16 (R)	240	27.9	13 (R)	215
pyridoxine (B_6) [mg]	2.3	1.5 (R)	153	1.8	1.2 (R)	150
folate [FE µg][2]	289	400 (R)	72	255	400 (R)	64
vitamin B_{12} [µg]	5.8	3 (R)	193	4	3 (R)	133
vitamin C [mg]	132	100 (R)	132	131	100 (R)	131
age: 51 to under 65 years	**men (n = 1,633)**			**women (n = 1,840)**		
	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]
vitamin A [RE mg][2]	1.8	1 (E)	180	1.6	0.8 (E)	200
vitamin E [TE mg][2]	13.4	13 (E)	103	11.9	12 (E)	99
thiamine (B_1) [mg]	1.5	1.1 (E)	136	1.2	1 (R)	120
riboflavin (B_2) [mg]	1.8	1.3 (R)	138	1.5	1.2 (R)	125
niacin [NE mg][2]	35.4	15 (R)	236	27.2	13 (R)	209
pyridoxine (B_6) [mg]	2.2	1.5 (R)	147	1.8	1.2 (R)	150
folate [FE µg][2]	280	400 (R)	70	259	400 (R)	65
vitamin B_{12} [µg]	5.7	3 (R)	190	4.1	3 (R)	137
vitamin C [mg]	132	100 (R)	132	141	100 (R)	141
age: 65 to under 80 years	**men (n = 1,469)**			**women (n = 1,562)**		
	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]	intake	D-A-CH-reference value[1]	supply [%-D-A-CH]
vitamin A [RE mg][2]	1.8	1 (R)	180	1.5	0.8 (R)	188
vitamin E [TE mg][2]	12.4	12 (E)	103	11.3	11 (E)	103
thiamine (B_1) [mg]	1.3	1 (R)	130	1.1	1 (R)	110
riboflavin (B_2) [mg]	1.6	1.2 (R)	133	1.4	1.2 (R)	117
niacin [NE mg][2]	31.5	13 (R)	242	24.7	13 (R)	190
pyridoxine (B_6) [mg]	2	1.4 (R)	143	1.7	1.2 (R)	142
folate [FE µg][2]	261	400 (R)	65	238	400 (R)	60
vitamin B_{12} [µg]	5.5	3 (R)	183	4	3 (R)	133
vitamin C [mg]	128	100 (R)	128	132	100 (R)	132

[1]D-A-CH Reference Values for Nutrient Intake (1), recommended intake (R), estimated value (E) per day for the corresponding age group
[2]RE: retinol equivalent, TE: tocopherol equivalent, FE: folate equivalent, NE: niacin equivalent

Table 6: **Daily median vitamin intake by diet of adults (age 19 to under 80 years) in comparison to D-A-CH Reference Values for Nutrient Intake [1]. Data from the National Nutrition Survey II (NVS II [11]).**

age: ≥ 65 years	men (n = 510)				women (n = 862)			
	intake	D-A-CH-reference value[1]		supply [%-D-A-CH]	intake	D-A-CH-reference value[1]		supply [%-D-A-CH]
vitamin A [RE mg][2]	1.1	1.0	(R)	106	1.2	0.8	(R)	148
vitamin E [TE mg][2]	11.9	12	(E)	99	13.0	11	(E)	118
thiamine (B_1) [mg]	1.5	1.0	(R)	153	1.4	1.0	(R)	139
riboflavin (B_2) [mg]	1.6	1.2	(R)	133	1.5	1.2	(R)	126
pyridoxine (B_6) [mg]	2.1	1.4	(R)	151	2.0	1.2	(R)	167
vitamin B_{12} [µg]	5.9	3.0	(R)	197	4.8	3.0	(R)	160
vitamin C [mg]	119.7	100	(R)	120	144.3	100	(R)	144

[1]D-A-CH Reference Values for Nutrient Intake (1), recommended intake (R), estimated value (E) per day for the corresponding age group
[2]RE: retinol equivalent, TE: tocopherol equivalent

Table 7: **Daily median vitamin intake by diet of independent seniors living in private households (age ≥ 65 years) in comparison to D-A-CH Reference Values for Nutrient Intake [1]. Data from the 2000 Nutrition Report [12, 12a].**

age: ≥ 65 years	men (n = 148)				women (n = 606)			
	intake	D-A-CH-reference value[1]		supply [%-D-A-CH]	intake	D-A-CH-reference value[1]		supply [%-D-A-CH]
vitamin A [RE mg][2]	1.0	1.0	(R)	100	0.9	0.8	(R)	113
vitamin E [TE mg][2]	7.0	12	(E)	58	6.3	11	(E)	57
thiamine (B_1) [mg]	0.9	1.0	(R)	90	0.7	1.0	(R)	70
riboflavin (B_2) [mg]	1.2	1.2	(R)	100	1.1	1.2	(R)	92
niacin [NE mg][2]	18.8	13	(R)	145	15.7	13	(R)	121
pyridoxine (B_6) [mg]	1.2	1.4	(R)	86	1.0	1.2	(R)	83
folate [FE µg][2]	220.0	400	(R)	55	196.0	400	(R)	49
vitamin B_{12} [µg]	3.1	3.0	(R)	103	2.5	3.0	(R)	83
vitamin C [mg]	54.6	100	(R)	55	50.0	100	(R)	50

[1]D-A-CH Reference Values for Nutrient Intake (1), recommended intake (R), estimated value (E) per day for the corresponding age group
[2]RE: retinol equivalent, TE: tocopherol equivalent, FE: folate equivalent, NE: niacin equivalent

Table 8: **Daily median vitamin intake by diet of seniors in nursing homes (age ≥ 65 years) in comparison to D-A-CH Reference Values for Nutrient Intake [1]. Data from the the ErnSTES study (Nutrition of the Elderly in German Nursing Homes) [10].**

age groups	vita-min D	folate	vita-min E	vita-min A	vita-min C	thia-mine	ribo-flavin	pyri-doxine	vita-min B_{12}
infants/toddlers									
6 to under 12 months	X	X (♀)			X				
1 to under 4 years	X	X	X						
4 to under 5 years	X	X	X						
children									
6 to under 7 years	X	X							
7 to under 10 years	X	X	X	X (♀)					
10 to under 12 years	X	X	X	X (♀)					
adolescents									
12 to under 13 years	X	X							
13 to under 15 years	X	X							
15 to under 18 years	X	X							
adults									
19 to under 80 years	X	X							
seniors over 65 years									
in private households	X	X							
in nursing homes	X	X	X		X	X	X (♀)	X	X (♀)

(♀observed in female study participants

Table 9: **Critical vitamins. Summary of reference values below median vitamin intake by age group**