10 Vitamins

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To determine the requirement for a nutrient, and to recommend a daily intake adequate to the needs of nearly all healthy elderly people, depend on several lines of evidence. These include the following.

1. Extrapolations from intakes of younger people that take into account physiological needs that change with advancing years. Most present national recommendations have principally adopted this approach.
2. The intakes of apparently healthy populations of elderly people.
3. Intake levels associated with certain functional problems.
4. Intake levels associated with specific nutrient deficiency syndromes.

Particular problems arise in making recommendations about vitamin intake [13,14,18] for the elderly:

1. Present needs may reflect cumulative problems, not only from current maintenance, but also from a previous dietary pattern.
2. The need to take into account how the ageing process may alter nutrient requirements and tolerance. [2,19,25]
3. The effects on nutrient requirements of age-related diseases, and their treatment for a significant proportion of the population who cannot be regarded as 'healthy'.
4. The elderly are a heterogeneous age group. Their socio-economic status, physical activity, and food practices vary widely, and there are often disparities between chronological and biological age.

The development of Recommended Dietary Intakes (RDIs) for the elderly must take into account these special considerations, either by the development of several subsets, or by way of an algorithmic approach. It is quite clear that a good deal more research is required, and that at this stage any recommendations must be interim.

Available recommendations

Despite the difficulties, several countries make recommendations of dietary intakes for people into their seventies. These countries are: Argentina, Australia, several in the Caribbean, Czechoslovakia, Italy, the Netherlands, the Philippines, Singapore, Spain, Thailand, the United Kingdom, the United States, Uruguay, and Venezuela. Japan makes recommendations for people in their eighties, and Bulgaria does for those in their nineties. [36,40]

These recommendations are primarily extrapolations from what is known about younger groups.

Table 10.1a shows the recommended vitamin intakes for older people from Australia, Sweden, the United Kingdom, and the United States. Only the United States makes recommendations for all 13 vitamins. For comparison, the recommendations of these countries for younger adults are shown in Table 10.1b.

The recommendations for energy intake from these same countries recognize that physical activity declines with advancing years, as shown in Table 10.2. For the United Kingdom only 'sedentary' recommendations are shown, although the United Kingdom makes recommendations for different levels of physical activity in the middle years of life, and implies that the stated recommendations for elderly persons could increase with increased physical activity. This raises questions about how nutrient density—nutrient mass per unit of energy—should change with advancing years. The recommended nutrient density of the diet must increase if the recommendation for a vitamin, as mass per day, does not decrease with age. For the United States, only the recommendations for thiamine, riboflavin, and niacin are less for those over 51 years than for younger adults. In these cases, a decline in recommended energy intake for older people would mean recommend nutrient densities would remain similar for younger and older groups.

The approach Sweden has taken to assist with recommendations for a heterogeneous age structure is to make direct recommendations about nutrient density, as shown in Table 10.3. Sweden has done this for retinol equivalents, vitamin D, thiamine, riboflavin, niacin, vitamin B-6, and vitamin C. For both the United States and Sweden, the calculated recommended nutrient densities for retinol equivalents and vitamin B-6 actually rise for older adults. Under these circumstances, the unifying recommended nutrient density approach will only be acceptable if it is minimally accepted for different age groups. The comparison in Table 10.3 of the Swedish direct recommendations with the United States calculated recommendations shows that there is close agreement. The Swedish direct nutrient density recommendations are common for men and women. In making recommendations, the possibility has also been raised in Sweden of incorporating findings on bioavailability with knowledge of nutrient density.[12]

Vitamin intakes and community-based elderly

Studies of community-based elderly people provide a guide to vitamin intakes satisfactory for healthy people. Table 10.4 summarizes findings from studies in: Australia,[10,11] Italy,[9] Sweden,[3,32,33] the United Kingdom,[26,27] and

Table 10.1a. RDIs* or estimated daily safe and adequate intakes† for vitamins (mass per day) for elderly people.

		Australia‡		Sweden§		United Kingdom¶		United Kingdom¶		United States††	
		65 + years	55 + years	50 + years		65–74 years	55–74 years	75 + years		51 + years	
		M	F	M	F	M	F	M	F	M	F
Retinol equivalents	(μg)*	750	750	1000	800	750	750	750	750	1000	800
Vitamin D	(μg)*	—	—	5.0	5.0	—	—	—	—	5.0	5.0
Vitamin E	(mg)*	—	—	—	—	—	—	—	—	10.0	8.0
Vitamin K	(μg)†	—	—	—	—	—	—	—	—	70–140	70–140
Thiamine	(mg)*	0.9	0.7	1.2	1.0	1.0	0.8	0.9	0.7	1.2	1.0
Riboflavin	(mg)*	1.3	1.0	1.4	1.2	1.6	1.3	1.6	1.3	1.4	1.2
Niacin equivalents	(mg)*	14–17	10–12	16	13	18	15	18	15	16	13
Vitamin B_6	(mg)*	1.0–1.5	0.8–1.1	2.2	2.0	—	—	—	—	2.2	2.0
Vitamin B_{12}	(μg)*	2.0	2.0	—	—	—	—	—	—	3.0	3.0
Folacin (total)	(μg)*	200	200	—	—	300	300	300	300	400	400
Pathothenic acid	(mg)†	—	—	—	—	—	—	—	—	4–7	4–7
Biotin	(μg)†	—	—	—	—	—	—	—	—	100–200	100–200
Vitamin C	(mg)*	30	30	60	60	30	30	30	30	60	60

*RDI means Recommended Daily Dietary Intake. The wording differs between countries; for example 'allowance' may be used instead of 'intake'.
‡National Health and Medical Research Council 1984;[21]
§Swedish National Food Administration 1982;[34]
¶Department of Health and Social Security 1968 and 1979;[6,7]
††Committee on Dietary Allowances, Food and Nutrition Board 1980.[5]

Table 10.1b. RDIs* or estimated daily safe and adequate intakes† for vitamins (mass per day) for younger adults.

		Australia‡		Sweden§		United Kingdom¶		United States††	
		19–64 yrs	19–54 yrs	23–50 years		18–64 yrs	18–54 yrs	23–50 years	
		M	F	M	F	M	F	M	F
Retinol equivalents	(μg)*	750	750	1000	800	750	750	1000	800
Vitamin D	(μg)*	—	—	5.0	5.0	—	—	5.0	5.0
Vitamin E	(mg)*	—	—	—	—	—	—	10.0	8.0
Vitamin K	(μg)†	—	—	—	—	—	—	70–140	70–140
Thiamine	(mg)*	1.1	0.8	1.4	1.0	1.0	0.9	1.4	1.0
Riboflavin	(mg)*	1.7	1.2	1.6	1.2	1.6	1.3	1.6	1.2
Niacin equivalents	(mg)*	18–20	12–14	18	13	18	15	18	13
Vitamin B_6	(mg)*	1.3–1.9	0.9–1.4	2.2	2.0	—	—	2.2	2.0
Vitamin B_{12}	(μg)*	2.0	2.0	—	—	—	—	3.0	3.0
Folacin (total)	(μg)*	200	200	—	—	300	300	400	400
Pathothenic acid	(mg)†	—	—	—	—	—	—	4–7	4–7
Biotin	(μg)†	—	—	—	—	—	—	100–200	100–200
Vitamin C	(mg)*	30	30	60	60	30	30	60	60

*RDI means Recommended Daily Dietary Intake. The wording differs between countries; for example 'allowance' may be used instead of 'intake'.
‡National Health and Medical Research Council 1984;[21]
§Swedish National Food Administration 1982;[24]
¶Department of Health and Social Security 1968 and 1979;[6,7]
††Committee on Dietary Allowances, Food and Nutrition Board 1980.[5]
± ± All UK figures used in this table are recommendations for a sedentary lifestyle.

Table 10.2. RDIs for energy according to age.

	Australia			Sweden			United Kingdom			United States		
	Age	Body mass kg	Energy kJ	Age		Energy kJ	Age	Body mass kg	Energy kJ	Age	Body mass kg	Energy kJ
Young adult	18–35	M 70 F 58	11 600 8400	19–22	M F	12 000 9000	18–34	M 65 F 55	10 500 9000	19–22	M 70 F 55	12 200 8800
Middle years	35–50	M 70 F 58	10 400 7600	23–50 Light Activity	M F	11 500 8500	35–64 Sedentary 35–54	M 65 F 55	10 000 9000	23–50	M 70 F 55	11 300 8400
Older	55–75	M 70 F 58	8800 6400	51–70 Light Activity	M F	10 000 8000	65–74 Sedentary 55–75 Sedentary	M 63 F 53	10 000 8000	51–75	M 70 F 55	10 100 7600
				71 + Sedentary	M F	9000 7000	75 + Sedentary	M 63 F 53	9000 7000	76 +	M 70 F 55	8600 6700

Table 10.3. RDIs* or estimated daily safe and adequate intake† for vitamins, expressed as Recommended Nutrient Density (RND; mass of vitamin per unit food energy)

		Sweden Heterogeneous		United States 51–75 years	
		M	F	M	F
Retinol equivalents*					
	μg/1000 cal	400	400	417	444
	μg/mJ	100	100	99	105
Vitamin D*					
	μg/1000 cal	3	3	2.1	2.8
	μg/mJ	0.7	0.7	0.50	0.66
Vitamin E*					
	mg/1000 cal	—	—	4.2	4.4
	mg/mJ	—	—	1.0	1.1
Vitamin K†					
	g/1000 cal	—	—	29–58	39–78
	g/mJ	—	—	6.9–13.9	9.2–18.4
Thiamine*					
	mg/1000 cal	0.5	0.5	0.50	0.56
	mg/mJ	0.13	0.13	0.12	0.13
Riboflavin*					
	mg/1000 cal	0.7	0.7	0.58	0.67
	mg/mJ	0.16	0.16	0.14	0.16
Niacin equivalents*					
	mg/1000 cal	7	7	6.7	7.2
	mg/mJ	1.7	1.7	1.6	1.7
Vitamin B_6					
	mg/1000 cal	1.1	1.1	0.92	1.11
	mg/mJ	0.26	0.26	0.22	0.26
Vitamin B_{12}					
	μg/1000 cal	—	—	1.3	1.7
	μg/mJ	—	—	0.3	0.4
Folacin*					
	μg/1000 cal	—	—	167	222
	μg/mJ	—	—	40	53
Pantothenic Acid†					
	mg/1000 cal	—	—	1.7–2.9	2.2–3.9
	mg/mJ	—	—	0.4–0.7	0.5–0.9
Biotin†					
	g/1000 cal	—	—	42–83	56–111
	g/mJ	—	—	10–20	13–26
Vitamin C*					
	mg/1000 cal	33	33	25	33
	mg/mJ	8.0	8.0	5.9	7.9

For Sweden, recommendations are made directly in nutrient density terms; the recommendations are for groups of individuals with a heterogeneous age structure. For the United States, these have been derived from daily energy and specific nutrient recommendations.

Table 10.4. Vitamin intakes of representative community-based elderly in selected countries (Mean ! S.D. are shown).

		Australia* (Geelong, 1979) 70 +		Italy† (1981) 65–69.9		70 +		Sweden‡ Dalby (1969) 67		Gothenburg (1971–1972) 70		United Kingdom§ (Department of Health and Social Security, 1972–1973) under 80		80 and over		United States¶ 65–75 yrs	
		M (10)	F (17)	M (41)	F (54)	M (60)	F (52)	M (16)	F (19)	M (191)	F (199)	M (111)	F (125)	M (58)	F (71)	Whites (2762)	Blacks (577)
Retinol equivalents	(μg)	1024 !3488	1693 !1737	679 !704	857 !899	675 !755	656 !733			1505 !802	1357 !684	1120 !728	1050 !1161	1050 !689	980 !776	1098 !2979	1107 !2832
Vitamin D	(μg)	1.3 !0.8	1.6 !0.9														
Vitamin E	(mg)	4.2 !1.1	3.9 !0.9														
Vitamin K	(μg)																
Thiamine	(mg)	1.1 !0.4	1.2 !0.3	0.93 !0.28	0.76 !0.25	0.88 !0.36	0.71 !0.20			1.4 !0.35	1.2 !0.43	1.0 !0.27	0.8 !0.27	0.9 !0.26	0.7 !0.20	1.01 !0.05	0.97 !1.2
Riboflavin	(mg)	2.0 !0.7	2.0 !0.7	0.95 !0.30	0.94 !0.34	0.96 !0.40	0.88 !0.31			1.8 !0.61	1.6 !0.54	1.5 !0.62	1.3 !0.53	1.4 !0.47	1.1 !0.40	0.55 !0.1	0.86 !0.4
Niacin equivalents	(mg)	17.2 !6.7	17.1 !6.0	28 !8	24 !7	27 !9	22 !6					14.4 !5.97	10.3 !3.45	12.3 !4.02	9.7 !2.86		
Vitamin B_6	(mg)	1.2 !0.2	1.1 !0.2									1.3 !0.41	0.9 !0.26	1.2 !0.37	0.9 !0.29		
Vitamin B_{12}	(μg)							5.3 !4.5	4.5 !3.7								
Folacin	(μg)	204 !53.7	215 !41.2					175 !87	145 !94								
Pantothenic Acid	(mg)	4.8 !1.1	4.1 !1.1														
Biotin	(μg)	26.5 !10.4	22.9 !9.6														
Vitamin C	(mg)	84.6 !54.4	89.8 !43.2	55 !27	56 !26	62 !30	58 !26			82 !41.7	87 !53.7	46 !28.2	40 !29.3	38 !31.1	37 !25.1		

Dietary methodologies: *Dietary history 24-hr recall. †Dietary history only.
‡Swedish National Food Administration 1982;[24]
§Report by the Committee on Medical Aspects of Food Policy 1979;[7] Report by the Panel Nutrition of the Elderly 1972;[27]
¶National Center for Health Statistics 1974;[20] Kerr *et al.* 1982.[16]

the United States.[16,20,24] There are other reports.[8,31]

It is clear from the standard deviations of the mean intakes that certain vitamins are ingested much more variably within and between populations than are others. Vitamin A intakes are particularly variable, which may mean either that vitamin A homeostasis can be achieved despite wide variation in intake, or that a wide range of intakes may have implications for a wide range of functional outcomes. Which of these interpretations is correct depends on greater knowledge of vitamin A physiology and pathophysiology in elderly people including, for example, the determinants of serum retinol and beta-carotene, the determinants of dark adaptation, and the relationship between vitamin A status and epithelial tumours.

These findings in community-based elderly can be related to the RDIs already developed by various countries, and provide a guide to maximal and minimal permissible intakes. The RDIs, or safe and adequate ranges of intakes, for vitamin A, riboflavin, and vitamin C are exceeded, and the RDIs for vitamin D, folacin, and biotin are not reached in Australia by community-based elderly, using United States reference information where necessary. The question arises: should the RDI or the intake be adjusted?

Table 10.5 summarizes the estimated vitamin densities of a typical diet consumed by healthy elderly Australians. Vitamin B_6 and folacin do not meet the recommendations of Sweden and the United States when expressed as Recommended Nutrient Density (Table 10.3).

Table 10.5. Estimated vitamin densities of typical diets consumed by elderly Australians.

	per 1000 Kcal	per mj
Retinol equivalent (μg)	506	120
Thiamin (mg)	1.1	0.2
Riboflavin (mg)	0.7	0.16
Niacin equivalent (mg)	9.0	2.1
Vitamin B_6 (mg)	0.54	0.12
Folacin (μg)	103.4	24.6
Vitamin C (mg)	34.6	8.2

Vitamin intakes of vulnerable groups of elderly

Clinically, specific nutrient deficiencies are seen more among certain subsets of elderly people, especially where a combinations of factors operate:

1. socio-economically deprived,[35]
2. isolated
3. institutionalized,[10,37]

4. mental and physical handicaps,[4,22];
5. use of medication which has nutrient interaction
6. alcohol abuse;[29]
7. limited educational background.[32,33]

Among institutionalized elderly, vitamin intakes significantly lower than their community counterparts include folacin and vitamin C (Table 10.6) in an Australian study[10] (and unpublished observations); and vitamin D and vitamin B_6 in a Northern Ireland study.[37] Although such observations are not proof of their biological consequence, they are strongly suggestive that this is so.

Table 10.6. Vitamin intakes of institutionalized elderly, Geelong, Australia, 1979 (Mean ± S.D.) - Compare with Table 10.4

		M (n = 17)	F (n = 70)
Retinol equivalents	(μg)	874.2 ± 212.2	905.6 ± 303.3
Vitamin D	(μg)	1.7 ± 1.0	2.0 ± 1.2
Vitamin E	(mg)	3.4 ± 1.2	3.2 ± 1.1
Vitamin K	(μg)	—	—
Thiamine	(mg)	0.72 ± 0.18	1.02 ± 0.8
Riboflavin	(mg)	1.04 ± 0.42	1.16 ± 0.43
Niacin equivalents	(mg)	9.2 ± 3.3	9.1 ± 3.9
Vitamin B_6	(mg)	0.87 ± 0.28	0.78 ± 0.24
Vitamin B_{12}	(μg)	—	—
Folacin	(μg)	147 ± 49[2]	123 ± 33[3]
Panthothenic acid	(mg)	3.1 ± 1.2	3.1 ± 0.8
Biotin	(μg)	21.6 ± 15.9	21.6 ± 7.9
Vitamin C	(mg)	54[1] ± 8	41[3] ± 3

Significance of difference from community elderly shown by
[1] $P < 0.05$
[2] $P < 0.01$
[3] $P < 0.001$

Recognized vitamin deficiency syndromes in elderly people are as listed below:[29]

Deficiency	Syndrome
Vitamin A	Failure of dark adaptation
Vitamin D	Osteomalacia
Vitamin K	Haemorrhagic states
Thiamine	Wernickes-Korsakoff's syndrome; beri-beri
Riboflavin	Angular stomatitis; glossitis; dermatitis
Vitamin B_6	Dermatitis; peripheral neuritis; depression; sideroblastic anaemia

Folacin	Macrocytic anaemia; organic brain syndrome
Vitamin B_{12}	Anaemia; gastrointestinal (glossitis, anorexia, etc.); neurological (sub-acute combined degeneration of the cord and peripheral neuropathy)
Vitamin C	Non-specific (e.g., confusional state, lassitude and fatigue); scurvy

Biochemical indices of vitamin status

There are a number of limitations to the use of biochemical indices as a guide to what should be done about nutrient intake:

1. There may be other determinants of nutrient biochemistry than the nutrient in question.
2. Reference values for comparison may not be well established. This applies especially to measurements in the elderly, since an age-matched healthy population may not be available, or may not have been studied.
3. The functional significance of an apparently high or low value may not be defined. In the final analysis, the critical question as far as RDIs are concerned is how an intake relates to a function.
4. Standardization between laboratories and quality control of methods may not justify comparison of data. For vitamins, these procedures are not well-established.

Nevertheless, nutrition surveys of the elderly often include biochemical data on vitamin studies.[3,17,23,27,28,42]

An algorithmic approach to RDIs for the elderly

1. Recommended nutrient densities (RNDS)
   Mass of vitamin per unit of food energy (RNDs are usually available for younger rather than older adults, and can be used in the interim)
2. Assess energy intake and cross-check against level of physical activity
3. Calculate RDI as mass of vitamin per day
4. Consider any factor likely to compromise specific nutrient status, e.g., cooking method, medication, alcohol, lack of sunlight, disease state
5. Provide increment to RDI for relevant vitamin
6. Consider food intake pattern
7. Translate into food intake recommendations.

Vitamin supplements in the elderly

Vitamin supplement practice is now widespread among adults, including the elderly, in developed countries.[30,38,39,41] In one United States study, Whanger found that, among persons older than 65, 37 per cent of men and 63 per cent of women consumed nutrient supplements, and that the prevalence rose with

age. Similar findings were obtained by Schneider and Nordlund in Ohio, where 49 per cent of elderly people used vitamin or mineral supplements and, of these, 77 per cent were taking a multiple-vitamin preparation. Women were more likely to use the supplements than men, 53 per cent versus 38 per cent, and again, supplement use increased with age.

It is worth noting that biochemical responsiveness to nutrient supplementation does not of itself indicate that a functional vitamin problem has existed.[1,15]

The fact that most detoxification and clearance mechanisms are impaired with advancing years must be taken into account in setting upper limits for nutrient supplements. RDIs must ultimately serve as a guide for supplement use as well as for food. Another problem in this regard is the growing interest in the potential for certain nutrients, such as vitamins C and E, to slow the ageing process; at present, evidence is lacking for application of these ideas.

Summary

Several countries make recommendations for vitamin intakes for people over the age of 50 years, but none adequately address the problem of how allowances should change in subsequent years. Moreover, only one country, the United States, recommends allowances or adequately estimates daily intakes for all 13 vitamins. There are studies in the United Kingdom, Europe, North America, and Australia of apparently healthy elderly populations that provide some indication of what might constitute adequate vitamin intakes. But even here, it is apparent that the elderly are more heterogeneous than perhaps any other age group on grounds of socio-economic group, physical activity, and food practice. Added to this (for many) are the effects of chronic disease, use of medication, and institutionalization. Clinically, it is common experience to recognize the disparity between chronological and biological age. The need for recommendations for sub-sets of the elderly population is clear. An algorithmic approach to adjustment of basic recommendations is proposed.

For some vitamins, there are special problems because of limited food analytical and bioavailability data; examples are folacin, and vitamins A and K. As the practice of megavitamin use in the elderly community grows, especially of those like vitamins C and E, which are promoted as slowing the ageing process, upper limits to vitamin intakes must also be defined. Prospective studies to assess the relationship between vitamin intakes from food and supplements are limited. More studies are required, with several age-starting points and population sub-groups, before confident recommendations can be made about vitamin intakes for elderly people.

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