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Nutrient Reference Values for Australia and New Zealand
Including Recommended Dietary Intakes

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NIACIN

BACKGROUND

Niacin is a generic descriptor for the closely related compounds, nicotinic acid and its amide nicotinamide, which act similarly as nutrients. The amino acid tryptophan is converted to nicotinamide with an average conversion efficiency of 60:1 and can thus contribute to requirements (Horwitt et al 1981) although this can vary depending on a number of dietary and metabolic factors (McCormick 1988).

Niacin intakes and requirements are often expressed as niacin equivalents where 1 mg niacin equivalent is equal to 1 mg niacin or 60 mg tryptophan.

Niacin functions as a component of the reduced and oxidised forms of the coenzyme nicotinamide adenine dinucleotide ($NADH_2$ and NAD, respectively), both of which are involved in energy metabolism, and nicotinamide adenine dinucleotide phosphate ($NADPH_2$ and NADP, respectively). These coenzymes function in dehydrogenase-reductase systems involving the transfer of a hydride ion (McCormick 1988, 1997). NAD is also needed for non-redox adenosine diphosphate-ribose transfer reactions involved in DNA repair and calcium mobilisation. It functions as part of the intracellular respiration system and with enzymes involved in oxidation of fuel substrates. Because of their role in energy metabolism, niacin requirements are, to some extent, related to energy requirements

Niacin is found in a wide range of foods. Important sources of preformed niacin include beef, pork, wholegrain cereals, eggs and cow's milk. Human milk contains a higher concentration of niacin than cows' milk. In unprepared foods, niacin is present mainly as cellular NAD and NADP. Enzymatic hydrolysis of the coenzymes can occur during the course of food preparation. In mature grains, most of the niacin is bound and is thus only 30% available, although alkali treatment of grain increases availability (Carpenter & Lewin 1985, Carter & Carpenter 1982). The niacin in meats is in the form of NAD and NADP and is more bioavailable. Some foods, such as beans and liver, contain niacin in the free form that is highly available.

The requirement for preformed niacin depends to some extent on the availability of tryptophan. Inadequate iron, riboflavin or vitamin B_6 status decreases the conversion of tryptophan to niacin (McCormick 1989).

Deficiency of niacin causes the disease pellagra which is associated with inflammation of the skin on exposure to sunlight, resembling severe sunburn except that the affected skin is sharply demarcated (McCormick 1988, 1997). These skin lesions progress to pigmentation, cracking and peeling. Often the skin of the neck is involved. Pellagra is the disease of 'three Ds', namely dermatitis, diarrhoea and (in severe cases) delirium or dementia. There is also likely to be an inflamed tongue (glossitis). In mild chronic cases, mental symptoms are not prominent. Pellagra was a major problem in the Southern states of the US in poor Blacks and Whites whose diet consisted of maize (American corn) and little else. Unlike other cereals maize is low in bioavailable niacin and tryptophan is the first limiting amino acid. Pellagra only disappeared after niacin was discovered and mandatory fortification of maize meal was introduced in 1941.

Indicators that have been used to assess niacin requirements include urinary excretion, plasma concentrations, erythrocyte pyridine nucleotides, transfer of adenosine diphosphate ribose and appearance of pellagra. Biochemical changes appear well before overt signs of deficiency. The most reliable and sensitive measures are urinary excretion of N1-methyl nicotinamide and its derivative, N1-methyl-2-pyridone-5-carboxyamide.

RECOMMENDATIONS BY LIFE STAGE AND GENDER

Infants	**AI**	**Niacin**
0–6 months	**2 mg/day of preformed niacin**	
7–12 months	**4 mg/day of niacin equivalents**	

***Rationale*:** The AI for 0–6 months was calculated by multiplying the average intake of breast milk (0.78 L/day) by the average concentration of niacin in breast milk, and rounding (FNB:IOM 1998). The figure for breast milk concentration of preformed niacin used was 1.8 mg/L based on the studies of Ford et al (1983). The tryptophan content of breast milk is 210 mg/L (Committee on Nutrition, 1985). The standard conversion rate is likely to overestimate tryptophan conversion from milk because of the high protein turnover and the net positive nitrogen retention in infancy. The AI was therefore set on the preformed niacin figure and rounded up. Because of limited data, the AI for 7–12 months was derived from the recommended intake for adults on a body weight basis accounting for growth needs and as such is expressed on a niacin equivalence base.

Children & adolescents	**EAR**	**RDI**	**Niacin (as niacin equivalents)**
All			
1–3 yr	**5 mg/day**	**6 mg/day**	
4–8 yr	**6 mg/day**	**8 mg/day**	
Boys			
9–13 yr	**9 mg/day**	**12 mg/day**	
14–18 yr	**12 mg/day**	**16 mg/day**	
Girls			
9–13 yr	**9 mg/day**	**12 mg/day**	
14–18 yr	**11 mg/day**	**14 mg/day**	

***Rationale*:** As there are limited data to set an EAR for these ages, the children's and adolescents' EARs were set by extrapolation from the adult data on a body weight basis accounting for growth needs (FNB:IOM 1998). The RDI was set using a CV of 15% for the EAR.

Adults	**EAR**	**RDI**	**Niacin (as niacin equivalents)**
Men			
19–30 yr	**12 mg/day**	**16 mg/day**	
31–50 yr	**12 mg/day**	**16 mg/day**	
51–70 yr	**12 mg/day**	**16 mg/day**	
>70 yr	**12 mg/day**	**16 mg/day**	
Women			
19–30 yr	**11 mg/day**	**14 mg/day**	
31–50 yr	**11 mg/day**	**14 mg/day**	
51–70 yr	**11 mg/day**	**14 mg/day**	
>70 yr	**11 mg/day**	**14 mg/day**	

***Rationale*:** The EAR for adults was set on a number of studies of niacin intake and urine N_1-methylnicotinamide (Goldsmith et al 1952, 1955, Horwitt et al 1956, Jacob et al 1989) with a 10% decrease for energy in women (FNB:IOM 1998). The RDI was set using a CV of 15% for the EAR derived from these studies.

Pregnancy	**EAR**	**RDI**	**Niacin (as niacin equivalents)**
14–18 yr	**14 mg/day**	**18 mg/day**	
19–30 yr	**14 mg/day**	**18 mg/day**	
31–50 yr	**14 mg/day**	**18 mg/day**	

***Rationale*:** There is no direct evidence to suggest a change in requirements in pregnancy, but an additional 3 mg/day would be needed to cover increased energy utilisation and growth (FNB:IOM 1998). This was added to the unrounded EAR for non pregnant women and the RDI was derived assuming a CV of 15% for the EAR.

Lactation	**EAR**	**RDI**	**Niacin (as niacin equivalents)**
14–18 yr	**13 mg/day**	**17 mg/day**	
19–30 yr	**13 mg/day**	**17 mg/day**	
31–50 yr	**13 mg/day**	**17 mg/day**	

***Rationale*:** An extra 1.4 mg of preformed niacin is secreted daily during lactation. This, together with the additional amount of 1 mg to cover additional energy needs, gives an additional 2.4 mg/day of niacin equivalents for women (FNB:IOM 1998). This was added to the unrounded EAR for non lactating women and the RDI was derived assuming a CV of 15% for the EAR.

UPPER LEVEL OF INTAKE - NIACIN AS NICOTINIC ACID

For intake from fortified foods or supplements

Infants	
0–12 months	**Not possible to establish; source of intake should be breast milk, formula or food only**
Children and adolescents	
1–3 yr	**10 mg/day**
4–8 yr	**15 mg/day**
9–13 yr	**20 mg/day**
14–18 yr	**30 mg/day**
Adults 19+ yr	
Men	**35 mg/day**
Women	**35 mg/day**
Pregnancy	
14–18 yr	**30 mg/day**
19–50 yr	**35 mg/day**

Lactation	
14–18 yr	**30 mg/day**
19–50 yr	**35 mg/day**

***Rationale*:** There are no data to set a NOAEL. The data used to set an LOAEL for nicotinic acid were based on flushing reactions (FNB:IOM 1998). A LOAEL of 50 mg/day was set based on the study of Sebrell & Butler (1938) supported by data from Spies et al (1938). An uncertainty factor of 1.5 was selected as the flushing is transient. After rounding, a UL of 35 mg/day was therefore set for adults. The only reports of flushing associated with the ingestion of nicotinic acid with food have occurred following the addition of free nicotinic acid to the food prior to consumption. For infants, a UL could not be set as there were few data. No data were found to show that other age groups or physiological states had increased sensitivity, so the limits for pregnancy and lactation were set at those for other adults and the limits for children and adolescents were set on a body weight basis.

UPPER LEVEL OF INTAKE - NIACIN AS NICOTINAMIDE

For total intake from all sources

Infants	
0–12 months	**Not possible to establish; source of intake should be breast milk, formula or food only**
Children and adolescents	
1–3 yrs	**150 mg/day**
4–8 yrs	**250 mg/day**
9–13 yrs	**500 mg/day**
14–18 yrs	**750 mg/day**
Adults 19+ yrs	
Men	**900 mg/day**
Women	**900 mg/day**
Pregnancy	
14–18 yrs	**Not possible to establish, source of intake should be from food only**
19–50 yrs	**Not possible to establish, source of intake should be from food only**
Lactation	
14–18 yrs	**Not possible to establish, source of intake should be from food only**
19–50 yrs	**Not possible to establish, source of intake should be from food only**

***Rationale*:** Nicotinamide is not a vasodilator (so does not cause the flushing that occurs with nicotinic acid) and has potential therapeutic value (Knopp 2000). For nicotinamide taken in supplemental form, a UL of 900 mg/day for men and non-pregnant, adult women is suggested. This is in line with recommendations from the European Commission (2002).

Large doses of nicotinamide (up to 3,000 mg/day for periods of up to 3 years) appear to be well tolerated, as reported in trials on the possible benefits of nicotinamide in patients with, or at risk of developing, diabetes. The NOAEL from these studies is approximately 1,800 mg/day. This value represents the lowest reported dose in a number of high quality trials of (Lampeter et al 1998, Pozilli et al 1995). Many of these used sensitive biomarkers of hepatic function and glucose homeostasis, and included a range of age groups, with some subjects treated with up to 3,600 mg/day. A UF of 2 was used to allow for the fact that adults may eliminate nicotinamide more slowly than the study groups, many of which were children, and that data for children would not reflect the full extent of intersubject variability that could occur in an older population.

There is a lack of data on the safety of nicotinamide in pregnancy and lactation, and no relevant animal data. This level does not therefore apply to pregnant and lactating women.

Infants should get all their niacin from food, breast milk or formula only.

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