

Companion Statement on Vitamin D and Sun Exposure in Pregnancy and Infancy in New Zealand

A supplement to the Consensus
Statement on Vitamin D and
Sun Exposure in New Zealand

Released 2020

Advice for health practitioners

The information provided in this statement applies to pregnancy and infancy (0–2 years) and is not designed to replace specific advice given to individuals by a medical practitioner. A separate statement on vitamin D and sun exposure in the general population (Ministry of Health and Cancer Society of New Zealand 2012) provides the background information on vitamin D and sun exposure.

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Summary

Health benefits of vitamin D

- Vitamin D helps to maintain calcium and phosphate homeostasis in our body, and optimises bone health and muscle function. Low levels are linked to hypocalcaemic seizures and bone conditions such as rickets in children, and osteoporosis and osteomalacia in adults.
- While vitamin D deficiency during pregnancy has been associated with adverse pregnancy and neonatal outcomes such as being small for gestational age, there is no convincing evidence yet that there is a causal relationship (De-Regil et al 2012). Supplementation during pregnancy has been shown to increase vitamin D levels at the end of pregnancy which is positively correlated to infant vitamin D levels but there is no strong evidence for other outcomes (Cochrane Review by De-Regil et al 2012).
- The recommendations provided in this statement assume the infant or pregnant woman is maintaining an adequate intake of calcium.

Sensible sun exposure

Pregnancy

- For pregnant women, the same sun safety messages apply as for the general population.
- Outdoor physical activity should be encouraged.
- Use of sunbeds/solaria is not recommended.

Infancy

- Sun protection is particularly important for infants. Infants should not be exposed to direct sunlight, particularly between 10 am and 4 pm from September to April.
- Shade, protective clothing, broad-brimmed hats, and sunglasses are the recommended first line of protection against sun exposure in infants and young children.
- When additional sun protection is required, a 30+ broad spectrum sunscreen is considered safe for use. For infants and children with sensitive skin, a chemically inert sunscreen (ie, that uses micronised titanium dioxide and/or zinc oxide) is recommended.

- The Cancer Society¹ recommends testing a patch of skin before applying a previously untried sunscreen to all exposed skin.
- For young children who are mobile, the same sun exposure advice applies as for the general population.

Pregnant women and infants at high risk of vitamin D deficiency

Pregnancy

During pregnancy, women at higher risk of becoming deficient in vitamin D are those who:

- have darker skin – this includes many women from Africa, the Indian subcontinent and the Middle East as well as some Māori and Pacific women
- completely avoid sun exposure for religious, personal or medical reasons; for example, women who are covered by veils and clothing over the whole body because they have had skin cancer, skin damage from the sun or are on photosensitising medications
- have liver or kidney disease, or are on certain medications (eg, some anticonvulsants) that affect vitamin D levels
- live in southern regions of New Zealand in winter (ie, south of Nelson-Marlborough) they are more likely to be vitamin D deficient in late winter or early spring.

Infancy

Infants at higher risk of vitamin D deficiency are:

- breastfed infants with one or more of the following:
 - a naturally dark skin
 - a sibling diagnosed with rickets or hypocalcaemic seizures
 - a mother who is deficient in vitamin D or is at a higher risk of becoming deficient
- all preterm infants with a body weight less than 2.5 kg
- infants who are breastfed over winter months in New Zealand.

1 <https://wellington.cancernz.org.nz/reducing-cancer-risk/what-you-can-do/sunsmart/sunscreen>
Accessed 25 August 2020.

25-hydroxyvitamin D, or 25(OH)D, testing in pregnancy and infancy

- In general, testing of asymptomatic pregnant women and infants is not recommended. Supplements should be prescribed based on risk of vitamin D deficiency (as identified above).
- The optimal level of vitamin D in pregnancy is not defined due to lack of adequate studies (Kovacs 2008).
- If testing is undertaken, then a level of 50 nmol/L or over is recommended for both pregnant women and infants.

Supplementation

Pregnancy

- The main aim of vitamin D supplementation in pregnancy is to ensure that the fetus has sufficient vitamin D and is not born vitamin D deficient.
- Pregnant women at high risk of vitamin D deficiency (as identified above) are recommended to consider vitamin D supplementation with colecalciferol oral liquid (188 µg per ml/7,500 international units IU/ml) which is available and subsidised for use in both the community and the hospital. Each drop provides approximately 10 µg (400 IU).
- The subsidised monthly 1.25 mg (50,000 IU) colecalciferol capsule^{2,3} prescribed in New Zealand for adults may be appropriate for some women who have documented vitamin D deficiency. This dose is not recommended for widespread use in pregnant women due to a lack of evidence of its safety in pregnant women who may not be vitamin D deficient. This dose is also higher than that recommended in international population-level guidelines.
- For severe deficiency, an individualised treatment programme will be required initially.

Pregnant women at lower risk of vitamin D deficiency may benefit (and are unlikely to suffer harm) from vitamin D supplementation of between 10 µg/day (400 IU) and 15 µg/day (600 IU) throughout their pregnancy but especially in the third trimester.

2 <https://medsafe.govt.nz/profs/Datasheet/v/VitD3cap.pdf>

3 Colecalciferol capsules contain soya oil. Check for allergy to soya or peanuts before prescribing.

Infancy

- Where infants are exclusively or partially breastfed (who receive less than 500 ml of formula a day (based on current recommended dietary intakes (RDIs) (NHMRC 2006)) and have one or more of the risk factors above, they may benefit from vitamin D supplementation.
- The standard subsidised preparation in New Zealand is Puria® vitamin D drops listed on the Pharmaceutical Schedule. This preparation contains vitamin D only (this is about 10 µg or 400 IU of colecalciferol per drop or 188 µg/7,500 IU colecalciferol per ml). Higher doses can be given but only after consultation with a specialist.
- It is reasonable to wait until breastfeeding is well established in full-term, high-risk infants, such as until six weeks of age, before introducing vitamin D supplementation.

Contraindications and precautions for vitamin D supplements

- Supplementation is not recommended when hypercalcaemia, hypervitaminosis D or renal osteodystrophy with hyperphosphataemia is present. Care should be taken when considering supplementation in the presence of atherosclerosis or cardiac function impairment, hypersensitivity to vitamin D, renal function impairment, or sarcoidosis.
- While problems in human pregnancy have not been documented with intake of normal daily requirements, overdose has been associated with fetal abnormalities in animals.
- Maternal hypercalcaemia during pregnancy in humans may be associated with increased sensitivity to the effects of vitamin D, suppression of parathyroid function, or a syndrome that includes craniofacial abnormalities (elfin face), mental retardation and congenital aortic stenosis in infants.

Introduction

Chemistry and sources

Please refer to the Consensus Statement on the general population for more details.

Health benefits of vitamin D

Vitamin D maintains calcium and phosphate homeostasis and optimises bone health and muscle function. Low levels of vitamin D are linked with bone conditions such as rickets in children and osteoporosis in adults.

The recommendations provided in this statement assume the infant or pregnant woman is maintaining an adequate intake of calcium.

Vitamin D in pregnancy

The extra calcium the fetus requires during pregnancy comes predominantly from an increase in maternal levels of 1,25-dihydroxyvitamin D (1,25(OH) D) which improves the efficiency of intestinal calcium absorption. Serum 1,25(OH) D levels and maternal calcium absorption peak in the third trimester (Specker 2004). Neonatal vitamin D status is directly related to maternal vitamin D status, through trans-placental transfer of vitamin D (Hollis 2007). Therefore, maternal vitamin D deficiency places the infant at a higher risk of vitamin D deficiency. As vitamin D stores are laid down predominantly in the third trimester, premature infants are also at a higher risk of vitamin D deficiency.

While vitamin D deficiency during pregnancy has been associated with adverse pregnancy and neonatal outcomes such as being small for gestational age, there is no convincing evidence yet that there is a causal relationship (De-Regil et al 2012). Supplementation during pregnancy has been shown to increase vitamin D levels at the end of pregnancy which is positively correlated to infant vitamin D levels but there is no strong evidence for other outcomes (De-Regil et al 2012).

Rickets

Rickets is a disorder caused by a lack of vitamin D, calcium or phosphate. It leads to softening and weakening of the bones. The peak incidence of rickets is between 3 and 18 months of age. An infant or child may be deficient for months before there are any physical signs of rickets, although children are often in pain and miserable. Symptoms and signs of rickets include: bowing of legs or knock knees, anterior bowing of the femur, painful swelling of the wrist, prominent costochondral joints ('rachitic rosary'), softening of the skull with frontal bossing, delayed closure of the fontanelle(s), spinal curvature, bone pain, and dental anomalies (delayed tooth formation, enamel hypoplasia) (Barts and the London School of Medicine and Dentistry Clinical Effectiveness Group 2011).

Hypocalcaemic seizures in infants and young children are also linked to vitamin D deficiency and rickets. Between 22 and 79 percent of rickets cases present with hypocalcaemic seizures (Blok et al 2000; Nozza and Rodda 2001; Ladhani et al 2004; Ward et al 2007). From a review of 18 children aged 3–36 months with vitamin D deficiency rickets at Auckland hospital in 1998, researchers found that most presented with bone disease (eg, delayed walking and bowed legs, swollen wrists or ankles); four children presented with hypocalcaemic seizures.

Current situation

Vitamin D levels in New Zealand

Pregnancy

There are no national New Zealand data on vitamin D levels in pregnancy. However, data from the 2008/09 New Zealand Adult Nutrition Survey show that over one-third of women of childbearing age (15–44 years) have vitamin D levels below the recommended level (50 nmol/L). The age-adjusted mean level of vitamin D for women of all ages and ethnicities in the 2008/09 New Zealand Adult Nutrition Survey was 62 nmol/L. Māori women had a significantly lower mean level of vitamin D (57 nmol/L) than non-Māori women. Similarly Pacific women had a significantly lower mean level of vitamin D (46 nmol/L) than non-Pacific women. Māori and Pacific women were significantly more likely to have a vitamin D level between 25 and 50 nmol/L than their respective comparison group. There was no significant difference between Māori and non-Māori women, or between Pacific and non-Pacific women for levels below 25 nmol/L (Ministry of Health 2012).

Infancy

A 1997–2001 study of 929 newborns in Wellington and Christchurch reported a median cord blood 25(OH)D level of 44 nmol/L. Overall, 19 percent of newborns in the study had 25(OH)D levels below 25 nmol/L, and a further 38 percent had levels between 25 and 50 nmol/L. Season of birth was the strongest predictor of 25(OH)D level (median for summer babies 85 nmol/L, autumn 65 nmol/L, winter 32 nmol/L, spring 39 nmol/L). Newborns of Pacific ethnicity (32 nmol/L) or Other (non-European, non-Māori, non-Pacific) ethnicity (31 nmol/L) had the lowest median 25(OH)D serum concentrations (Camargo et al 2010).

In a Dunedin study of 193 infants aged 12–22 months, the mean 25(OH)D concentration of 52 nmol/L was consistent with the data from the 2002 National Children's Nutrition Survey (Ministry of Health 2003), which found a mean of 50 nmol/L for children aged 5–14 years. Variance in 25(OH)D levels were largely explained by season of blood collection: almost 80 percent of the population of children had levels below 50 nmol/L in winter compared with 6 percent in summer (Houghton et al 2010).

An Auckland study reported 25(OH)D levels below 27.5 nmol/L in 46 (13 percent) of 353 children aged 6–23 months. The results were strongly correlated to season of testing: 15 percent of those sampled in winter but only 1 percent of those sampled in summer had levels below 27.5 nmol/L (Grant et al 2009).

In all three of the above studies, season of testing had the greatest influence on the vitamin D level.

Rickets

The annual incidence of vitamin D deficient rickets in New Zealand from July 2010 to June 2013 was 2.2 per 100,000 in children (aged under 15 years) and 10.5 per 100,000 in children under three years of age (Wheeler et al 2015). Key risk factors identified were darker skin pigment, Indian and African ethnicity, under three years of age, exclusive breastfeeding, and southern latitude, particularly in winter/spring.

In an Australian study (Munns et al 2012), the incidence of vitamin D deficiency rickets among children (aged 15 years or under) was 4.9 per 100,000 per year (2006/07). Of the children with rickets, 98 percent had dark (85 percent) or intermediate (13 percent) skin colour; 63 percent were born in Africa; and 75 percent were refugees. Exclusive breastfeeding for more than six months was related to lower serum vitamin D levels in children under three years of age.

Use of supplementation in New Zealand

Pregnancy

Colecalciferol oral liquid (188 µg per ml/7,500 international units IU/ml), Puria® vitamin D drops, are available and subsidised for use in both the community and the hospital and should be considered for pregnant women identified as at risk of vitamin D deficiency. Each drop provides approximately 10 µg (400 IU).

No data are available on colecalciferol use in pregnancy.

Infancy

Puria® vitamin D drops has replaced Vitadol C as the subsidised medicine of choice for prevention and treatment of vitamin D deficiency. Vitadol C has been delisted from the Pharmaceutical Schedule (from 1 August 2019) due to a supplier discontinuation notified to PHARMAC in 2017. Each drop of Puria® vitamin D provides approximately 10 µg (400 IU).

Recommended vitamin D intakes

Nutrient reference values (NRVs) refer to a range of intakes, including an upper level of intake, for essential nutrients such as vitamins (including vitamin D) and minerals. The NRVs are a joint initiative of the Australian Commonwealth Department of Health and Ageing and the New Zealand Ministry of Health (NHMRC 2006).

In Australia and New Zealand the current recommended adequate intake (AI) for pregnant and lactating women, as well as for all children from birth, is 5 µg/day (NHMRC 2006). The NHMRC (2006) recommends a supplement of 10 µg/day for pregnant and lactating women who have little exposure to sunlight.

Table 1: Recommended dietary intake of vitamin D

	Australia and New Zealand (NHMRC 2006)	United States and Canada (Institute of Medicine 2011)	UK (Department of Health 1991)	Germany, Austria and Switzerland (Deutsche Gesellschaft für Ernährung 2012)
Pregnancy	5 µg/day (200 IU) AI or 10 µg/day (400 IU) supplement	15 µg/day (600 IU)	10 µg/day (400 IU)	20 µg/day (800 IU)
Infants	5 µg/day (200 IU)	10 µg/day (400 IU)	7–8.5 µg/day (280–340 IU)	10 µg/day (400 IU)

This recommendation is lower than that identified by a number of other countries and organisations (Table 1). Most countries assume little or no exposure to sunlight when setting vitamin D levels. It is also important to note that food fortification practices vary between countries.

Reviewing or altering the NRVs is beyond the scope of this Companion Statement. A joint Australian and New Zealand project to develop a methodological framework for reviewing NRVs is under way. Vitamin D has been identified as a priority nutrient for review.

Vitamin D

Vitamin D in the diet

Food sources

Table 2: Sample of foods containing vitamin D

Food	Amount of vitamin D
Fatty fish (eg, canned tuna, canned pink salmon, canned mackerel, canned sardines)	1.4–9.9 µg per 100g (56–396 IU)
Salmon fillet (farmed)	22.9–30.6 µg per 100g (916–1224 IU)
Cows' milk (standard, 3.3% fat)	0.3–0.6 µg per 100g (12–24 IU)
Egg (equivalent to 2 large eggs)	1.5 µg (60 IU)
Fortified foods (eg, margarine and some milks)	0.4–19.2 µg (16–768 IU)

Source: The New Zealand Institute for Plant and Food Research Limited and the Ministry of Health (2019)

Unlike in many northern hemisphere countries, only a few foods in New Zealand are fortified with vitamin D. Foods that are permitted to be fortified with vitamin D in New Zealand include edible oil spreads at 1.0 µg/10g (40 IU), dairy products and some analogues derived from legumes and cereals at 4–12.5 µg/L (160–500 IU) (FSANZ 2012). Given that fortification is rare, adequate intakes of vitamin D are hard to achieve through diet alone.

Data on dietary intake from the National Nutrition Survey were analysed for vitamin D in 1992. The main sources of dietary vitamin D intake in adults in 1992 were margarine, fish, eggs and milk (LINZ Activity and Health Research Unit 1992).

Infant formula

Infant formula was not initially fortified with vitamin D. It was only in the middle of the 20th century that vitamin D was added on a widespread basis, after rickets was recognised as a significant health problem in young children (Greer 2004).

Infant formula in New Zealand is supplemented with vitamin D (9 µg/L) (Cormack 2007). Just over 500 ml of infant formula per day should provide an infant with the recommended dietary intake of vitamin D.

Follow-on formula, designed for use from six months of age is also supplemented with vitamin D (9.3–11 µg/L) (Cormack 2007). Toddler milks contain vitamin D (5–8 µg/L) (Cormack 2007). By comparison, standard (blue top) cows' milk contains 0.3 µg/L.

Breast milk

Breastfeeding is the recommended form of infant feeding (Ministry of Health 2008). However, it has long been recognised that breast milk is not a good source of vitamin D, and prolonged exclusive breastfeeding (over six months) may increase the risk of vitamin D deficiency in an infant (Barts and the London School of Medicine and Dentistry Clinical Effectiveness Group 2011).

Most breastfed infants do not develop clinical vitamin D deficiency rickets. This is likely to be because they obtain adequate vitamin D through incidental sun exposure (Weisberg et al 2004). Infants and young children at highest risk of vitamin D deficiency rickets and hypocalcaemic seizures are those with dark skin who are breastfed (Weisberg et al 2004).

Approximately 20 to 30 percent of maternal circulating vitamin D (in the form of 25(OH)D₃) is transferred into breast milk (Haggerty 2011).

The vitamin D content of breast milk in a mother with serum vitamin D levels above 50 nmol/L is approximately 0.55 µg (22 IU) per litre (Reeves et al 1982). This amount is substantially lower than the recommended adequate intake (AI) of 5 µg (200 IU) per day (NHMRC 2006) for infants.

Studies have shown that a lactating mother consuming supplements in the order of 160 µg (6400 IU) per day may supply an infant with vitamin D as effectively as if the infant was directly receiving supplementation of 7.5 µg (300 IU) per day (Wagner et al 2006). Although studies to date have produced no evidence of toxicity or side effects from maternal supplementation at high levels, it is not currently recommended.

What serum level of vitamin D is adequate?

Please refer to the Consensus Statement on the general population for more details.

There are a number of different assays available to measure vitamin D, which can give different results. Vitamin D is produced in two forms: vitamin D₂ (from plant sources together with some fraction of D₃) and vitamin D₃ (formed from 7-dehydrocholesterol in the skin by UVB light). Hydroxylation and further metabolism result in the formation of pharmacologically active metabolites. Binding proteins show a higher affinity for 25(OH)D₃ than 25(OH)D₂ (Shah et al 2011).

Inter-laboratory and inter-method variations in vitamin D have been reported (Shah et al 2011). A study by Heijboer et al (2012) reported that the proportion of pregnant women who have sufficient levels of vitamin D can range from 25 to 65 percent depending on the assay used.

Liquid chromatography tandem mass spectrometry (LC-MS/MS) is currently the best technique available for assessing 25(OH)D₃ and 25(OH)D₂. It overcomes most of the problems with protein binding assays. However, LC-MS/MS is influenced by epimers (non-mirror images that only differ in the configuration of one carbon atom). Epimers and isomers are compounds with the same molecular weight as vitamin D metabolites and form the same mass to charge parent and product ion pairs upon ionisation. Epimers and isomers can give false estimates of true vitamin D levels. 3-epi-25(OH)D₃ is the most prevalent epimer of 25(OH)D₃. In neonates and children (under 12 months), 3-epi-25(OH)D₃ can make up a significant proportion of the total circulating 25(OH)D (Singh et al 2006). It is unclear whether 3-epi-25(OH)D₃ has biological functionality (SACN 2012).

Results vary across assays depending on ability to identify vitamin D₂, vitamin D-binding protein and epimers. The type of assay used should be considered when interpreting laboratory results.

Vitamin D testing

Vitamin D testing is considerably more expensive than vitamin D supplementation (Bolland et al 2012). In general, asymptomatic, at-risk people should be prescribed vitamin D without testing. Routine testing of vitamin D levels is not usually necessary before or after starting vitamin D supplementation. If there is clinical suspicion of severe symptomatic vitamin D deficiency, it is appropriate to investigate with serum calcium, phosphate, alkaline phosphatase, parathyroid hormone and vitamin D levels, plus other tests as indicated.

Pregnancy

Vitamin D testing is appropriate for pregnant women with:

- unexplained raised serum alkaline phosphatase, or low calcium or phosphate
- atypical osteoporosis
- unexplained bone pain, unusual fractures, or other evidence suggesting metabolic bone disease (consider specialist advice for people in this category) (BPAC 2007).

Infancy

Vitamin D testing is appropriate for infants with:

- seizures where hypocalcaemia is implicated
- unexplained raised serum alkaline phosphatase.

Specialist treatment is recommended for people identified as having metabolic bone disease other than simple vitamin D deficiency. The most appropriate measure of vitamin D status is almost always 25(OH)D. Measurement of 1,25(OH)₂D is rarely required, as it is very expensive and the results do not necessarily provide a better measurement of vitamin D status.

Sun exposure

Please refer to the Consensus Statement on the general population for more details.

Sun exposure is the main activator of pre-vitamin D for most people in New Zealand. A person needs to be exposed to low levels of radiation in the UVB range in order to produce vitamin D. UVA does not contribute to vitamin D production.

Exposure to ultraviolet radiation (both UVA and UVB; IARC 2012) is the likely cause of over 90 percent of all skin cancer cases in countries with high levels in summer, such as Australia and New Zealand (IARC 1992; Armstrong 2004). In addition, it is the major contributor to photo ageing of the skin.

There is no scientifically validated safe threshold level of UV exposure from the sun that allows for maximal vitamin D synthesis without increasing skin cancer risk (American Academy of Dermatology and AAD Association 2010).

Being exposed to ultraviolet radiation has **both** beneficial **and** detrimental effects. A balance is required between avoiding an increase in the risk of skin cancer by excessive sun exposure and achieving enough sun exposure to maintain adequate vitamin D levels.

The intensity of UVA rays remains relatively consistent during all daylight hours throughout the year, and can penetrate clouds and glass. UVB intensity varies throughout the year and time of day. The peak UVB period, and hence the time of greatest risk from sun exposure, is between 10 am and 4 pm from September to April, when the UVB levels are 3 or above on the Ultraviolet Index, which measures ultraviolet radiation. However, UVB rays can burn and damage the skin year-round, especially at high altitudes and on reflective surfaces such as snow or ice, which reflect up to 80 percent of the rays. UVB rays do not significantly penetrate glass.

UV information

There are two sources of advice to the public on the Ultraviolet Index. The daily Sun Protection Alert (www.sunsmart.org.nz) outlines the times of day when the Ultraviolet Index is over 3. A more detailed daily Ultraviolet Index regional forecast service for New Zealand is available on the National Institute for Water and Atmospheric Research (NIWA) website (www.niwa.co.nz/our-services/online-services/uv-and-ozone/forecasts).

Sun exposure advice

Pregnancy

The advice for sensible sun exposure for pregnant women is the same as for the general population.

Please refer to the Consensus Statement on the general population for more details.

- Between September and April, sun protection is recommended (shade, clothing coverage and a hat that shades the face and neck, sunscreen and sunglasses), especially between 10 am and 4 pm. A daily walk or some other form of outdoor physical activity in the early morning or late afternoon is recommended.
- Between May and August, some sun exposure is important. A daily walk or another form of outdoor physical activity in the hours around noon, with face, arms and hands exposed, is recommended.

Infants

Historically, it was recommended that infants and young children be exposed to direct sunlight (sun baths) for a few minutes each day so that they could make sufficient vitamin D (US Department of Labor 1931).

There is now evidence that an infant's skin barrier remains immature throughout at least the first two years of life and that accumulation of UVR-induced changes in the skin may begin as early as the first summer of life (Paller et al 2011).

Caution is also required when infants and young children are travelling in vehicles for long periods as side and rear windows are usually made from non-laminated glass which allows significant UVA (but not UVB) exposure.

There is very little policy advice around sun exposure for infants, particularly from six months to two years of age. The American Academy of Pediatrics (Balk et al 2011) recommends no direct sun exposure for infants under six months of age but does not provide any advice for those over six months. The Canadian Dermatology Association recommends that children younger than one year should avoid direct sunlight and also use sunscreens (Godel et al 2007). Draft Canadian recommendations (Health Canada et al 2012) note that current practice advises that infants under one year avoid direct sunlight due to the risk of skin cancer.

Based on clinical practice, New Zealand culture and environment, and balancing risks (skin cancer), benefits (predominantly vitamin D and outdoor physical activity) and practicality (once independently mobile it is difficult to keep an active toddler out of direct sun), a prudent approach is to recommend that infants are not left in direct sunlight, particularly between 10 am and 4 pm from September to April.

Young children, once mobile, should follow the same sun prevention advice as for the general population. Sunburn should always be avoided.

Sunscreen and sun protection

Infants and children (direct contact)

Toxicity in infants and children from absorption of sunscreen ingredients through the skin has not been reported (Balk et al 2011). However, researchers have recommended caution in infants and young children because:

- the stratum corneum of the epidermis is thinner and a less effective barrier (particularly in preterm infants) (Balk et al 2011)
- infants have a greater ratio of surface area to body weight compared with older children and adults (West et al 1981)
- children may have differences in absorption, metabolism, distribution and excretion of topically applied products compared with adults
- there may be developmental differences in vital organs that may differ in end organ effects (Mancini 2004).

Shade, clothing and broad-brimmed hats, and sunglasses are the recommended first-line protection from sun exposure in babies and infants. When additional sun protection is required, a 30+ broad spectrum sunscreen is considered safe for use (Australasian College of Dermatologists undated; American Academy of Pediatrics 2003, cited in Balk et al 2011).

For babies and children with sensitive skin, titanium dioxide or zinc oxide based sunscreens are less likely to cause skin irritation (Australasian College of Dermatologists undated).

Who is at risk of vitamin D deficiency?

Sun exposure is the main activator of pre-vitamin D for most people in New Zealand. People who have reduced exposure to sunlight are most at risk of vitamin D deficiency.

Pregnancy

Pregnant women at high risk of vitamin D deficiency are those:

- with darker skin (Fitzpatrick skin type V and VI – see Appendix 1), including many women from Africa, the Indian subcontinent and the Middle East. Māori and Pacific women have also been shown to be at increased risk of having vitamin D levels below the recommended level
- who completely avoid sun exposure for religious, personal or medical reasons; for example, women who are covered by veils and clothing over the whole body because they have had skin cancer or skin damage from the sun, or are on photosensitising medications
- who have liver or kidney disease, or are on certain medications (eg, some anticonvulsants) that affect vitamin D levels.

There are strong seasonal differences in vitamin D levels in New Zealand. Adults are more likely to be vitamin D deficient in late winter and early spring (August to October). The trend is most marked in the South Island (excluding Nelson Marlborough DHB) where 18 percent of adults had levels below 25 nmol/L, and a further 46 percent had levels between 25 and 50 nmol/L, between August and October (Ministry of Health 2012).

People with naturally dark skin (Fitzpatrick skin type V and VI) have high melanin levels in the skin. Melanin reduces absorption of ultraviolet radiation. Although they rarely or never burn and are better protected from skin cancer, people with darker skin are at greater risk of vitamin D deficiency. This link may have implications for the vitamin D status of African, Indian and Middle Eastern women in particular, especially those living in the south of New Zealand.

Māori and Pacific women are more likely to be below the recommended level of vitamin D than non-Māori and non-Pacific women respectively (Ministry of Health 2012).

Overweight and obesity have been linked to lower serum 25(OH)D concentrations (Institute of Medicine 2011). In New Zealand, people who were obese had a lower mean level of vitamin D than people who were overweight or normal weight (Ministry of Health 2012). Supplementation should only be considered if there are other risk factors as well, such as sun avoidance.

Infancy

As direct sun exposure is not recommended for infants, and breast milk is not a good source of vitamin D, breastfed infants are at risk of vitamin D deficiency. However, for most breastfed infants, vitamin D levels increase as they are weaned and become more mobile, which increases their incidental sun exposure. What is not clear is whether short-term or seasonal fluctuations in vitamin D level have an effect on long-term bone health.

An evaluation of the effect of vitamin D prophylaxis in healthy infants found that healthy infants without vitamin D prophylaxis had lower circulating concentrations of 25(OH)D at three and six months of age; the lowest were in three-month-old breastfed infants (Alonso et al 2011). The researchers concluded that this finding was of little clinical relevance as serum 25(OH)D levels spontaneously increased with age and were not associated with high serum parathyroid hormone.

Evidence (Lerch and Meissner 2007; Munns et al 2012) suggests that infants who are both dark skinned (including many people from the Indian subcontinent, Africa and the Middle East) and breastfed are at the highest risk of vitamin D deficiency, rickets and hypocalcaemic seizures.

As with the population in general, infants experience an increased risk of vitamin D deficiency over winter months (Camargo et al 2010; Wall et al 2013).

Other risk factors that have been identified are infants whose mother is veiled or vitamin D deficient and breastfed infants with a sibling diagnosed with rickets.

Preterm infants

Over 80 percent of calcium and other bone minerals are deposited in the third trimester. Preterm birth is thus a significant issue for bone mineralisation. In the preterm infant, calcium and phosphate absorption is less dependent on vitamin D than at other phases of life; however, maintaining 25(OH)D stores is important. Given the comparatively low mineral content of human milk and the gut's inefficiency in absorbing mineral at extremes of gestation, breastfeeding is much less efficient than the placenta at supplying mineral. Because of these factors it is generally recommended that all preterm babies are supplemented for a minimum of three months post discharge or until infants are established on solids (Auckland District Health Board 2012).

Recommendations about supplementation

There is a significant correlation between the 25(OH)D plasma levels of mothers and their newborns (Andiran et al 2002). As transplacental passage of maternal 25-OH vitamin D₃ is the only source of vitamin D in the developing fetus, infants born to mothers deficient in vitamin D will be vitamin D deficient. Ensuring pregnant women have sufficient levels of vitamin D will reduce the likelihood of the infant being vitamin D deficient.

Appropriate advice on vitamin D supplementation must balance the benefits of breastfeeding, the risks and benefits of sun exposure, and the risks and benefits of vitamin D supplementation.

Historically, infants in most regions of the world have synthesised vitamin D from exposing skin to the sun. There is now evidence that infant skin is more vulnerable to the sun than adult skin. In New Zealand the sun is especially strong in summer, which increases the risk of skin damage and skin cancers. There is international agreement that infants should not be deliberately exposed to direct sunlight for at least the first six months of life.

While the benefits of breast milk and breastfeeding to the infant and mother are well established, it is recognised that breast milk is a poor source of vitamin D. If infants are breastfed and avoid the sun, they may be at risk of vitamin D deficiency. In practice, research suggests that small amounts of incidental sun exposure in summer are sufficient to maintain vitamin D levels. However, in cooler months in New Zealand vitamin D levels of exclusively breastfed babies, and of the population in general, decline (Grant et al 2009; Camargo et al 2010; Houghton et al 2010). What is not clear is how a short-term decline in vitamin D levels affects this age group.

All international policy statements that were reviewed identified a role for supplementation in maintaining adequate vitamin D levels for pregnant women and infants at risk of vitamin D deficiency. There is no universally accepted dose or frequency of dose.

Pregnancy

There is little current evidence that supplementing with vitamin D is beneficial for those who are not vitamin D deficient. In New Zealand it is not cost-effective to undertake widespread blood testing, because the cost of testing is far greater than the cost of treatment (Bolland et al 2012). Therefore, it is important to use a risk factor profile to identify those at greatest risk of vitamin D deficiency.

Pregnant women may benefit (and are unlikely to suffer harm) from vitamin D supplementation. The main aim of vitamin D supplementation in pregnancy is to ensure that the fetus has sufficient levels of vitamin D and is not born vitamin D deficient.

If a pregnant woman is taking vitamin D, a dose of between 10 µg per day (400 IU) (NHMRC 2006) and 15 µg per day (600 IU) (Institute of Medicine 2011) is recommended. High-risk women are most likely to benefit from vitamin D supplementation.

Colecalciferol oral liquid (188ug per ml/ 7,500 IU/ml), Puria® vitamin D drops, are available and subsidised for use in both the community and hospital and should be considered for pregnant women identified at higher risk of vitamin D deficiency.

The standard subsidised monthly 1.25 mg (50,000 IU) colecalciferol capsule^{4,5} is not recommended for widespread use in pregnant women due to a lack of evidence of its safety in pregnant women who may not be vitamin D deficient. The monthly 1.25 mg dose is also higher than that recommended in international population-level guidelines. It may be considered appropriate for some women who have documented vitamin D deficiency.

Other (non-subsidised) vitamin D supplements are available. Some antenatal supplements also contain vitamin D.

Vitamin D preparations that also contain vitamin A should not be taken during pregnancy as excessive vitamin A is teratogenic and associated with malformations of the fetal central nervous system (Barts and the London School of Medicine and Dentistry Clinical Effectiveness Group 2011).

For severe deficiency, an individualised treatment programme may be required initially.

While the therapeutic index is wide, caution should be taken with vitamin D supplementation, as vitamin D toxicity can be caused by excessive oral intake through supplementation but not by prolonged exposure of the skin to UV light. Symptoms of vitamin D toxicity (hypervitaminosis D) include dehydration, vomiting, decreased appetite, irritability, constipation, fatigue and muscle weakness.

4 <https://medsafe.govt.nz/profs/Datasheet/v/VitD3cap.pdf>

5 Colecalciferol capsules contain soya oil. Check for allergy to soya or peanuts before prescribing.

Infancy

Infants who are exclusively or partially breastfed (who receive less than 500 ml of formula a day) **and** have one or more of the risk factors above may benefit from vitamin D supplementation.

- The current subsidised preparation is Puria® vitamin D drops, which provide 188 ug per ml/7,500 IU/ml vitamin D.
- Vitamin D dosing for young children with severe symptomatic and/or refractory vitamin D deficiency should be on the advice of a paediatrician.
- It would be reasonable to wait until breastfeeding is well established in full-term, high-risk infants, such as until six weeks of age, before introducing vitamin D supplementation.
- For severe deficiency, an individualised treatment programme may be required initially.

Vitamin D toxicity

Vitamin D toxicity (hypervitaminosis D) usually presents as signs of hypercalcaemia: poor appetite, nausea and vomiting. Weakness, frequent urination and kidney problems may also occur. Hypervitaminosis D can occur through oral intake of vitamin D (through supplementation or fortification) but not by prolonged exposure of the skin to UV light.

There are case reports of toxicity occurring at daily doses from 1.25 mg per day (50,000 IU) for six weeks, or one-off accidental overdosage in excess of 25 mg (one million IU) (Institute of Medicine 2011). Additionally, a report of over-fortification of milk with vitamin D in Massachusetts from 1988 to 1991 linked it to 19 cases of hypervitaminosis D (Blank et al 1995). The cumulative incidence rate of hypervitaminosis D at a supplementation level of 1.25 mg per cup (50,000 IU) for the estimated 33,000 dairy customers was 5.76 cases per 10,000 people.

Contraindications and precautions with vitamin D supplementation

There are a number of contraindications and precautions for vitamin D supplements. Supplementation is generally not recommended when hypercalcaemia, hypervitaminosis D or renal osteodystrophy with hyperphosphatemia is present. Care should be taken when considering supplementation in the presence of atherosclerosis or cardiac function impairment, hypersensitivity to vitamin D, renal function impairment, or sarcoidosis (PSM Healthcare Ltd 2012).

There are no documented problems with intake of colecalciferol to the level of normal daily requirements in human pregnancy. However, maternal hypercalcaemia during pregnancy in humans may be associated with increased sensitivity to the effects of vitamin D, suppression of parathyroid function, or a syndrome of elfin faces, mental retardation and congenital aortic stenosis in infants (PSM Healthcare Ltd 2012).

Colecalciferol is a Food and Drug Administration (FDA) Pregnancy Category C: Animal reproduction studies have shown an adverse effect on the fetus and there are no adequate and well-controlled studies in humans, but potential benefits may warrant use of the drug in pregnant women despite potential risks (Otugo et al 2012).

References

Alonso A, Rodriguez J, Carvajal I, et al. 2011. Prophylactic vitamin D in healthy infants: assessing the need. *Metabolism*. 60: 1719–25.

American Academy of Dermatology and AAD Association. 2010. *Position Statement on Vitamin D*. URL: www.aad.org/stories-and-news/news-releases/academy-issues-updated-position-statement-on-vitamin-d (accessed 15 February 2013).

Andiran N, Yordam N, Ozön A. 2002. Risk factors for vitamin D deficiency in breast-fed newborns and their mothers. *Nutrition* 18: 47–50.

Armstrong BK. 2004. How sun exposure causes skin cancer. In D Hill, JM Elwood, DR English (eds). *Prevention of Skin Cancer*. Dordrecht: Kluwer Academic Publishers.

Auckland District Health Board. 2012. ADHB Newborn Services Clinical Guidelines: Neonatal Nutrition Guideline. URL: www.adhb.govt.nz/newborn/Guidelines/Nutrition/Nutrition.htm (accessed 10 December 2012).

Australasian College of Dermatologists. Undated. A–Z of skin: baby and toddler protection. URL: www.dermcoll.asn.au/public/a-z_of_skin-baby_toddler_protection.asp (accessed 18 June 2012).

Balk SJ, Council on Environmental Health, Section on Dermatology. 2011. Ultraviolet radiation: a hazard to children and adolescents. *Paediatrics* 127: e791–e817.

Barts and the London School of Medicine and Dentistry Clinical Effectiveness Group. 2011. *Summary Guideline: Vitamin D guidance*. London: Clinical Effectiveness Group, Barts and the London School of Medicine and Dentistry. URL: www.icms.qmul.ac.uk/chs/Docs/42772.pdf (accessed 15 February 2013).

Blank S, Scanlon KS, Sinks TH, et al. 1995. An outbreak of hypervitaminosis D associated with the overfortification of milk from a home-delivery dairy. *American Journal of Public Health* 85(5): 656–9.

Blok B, Grant CC, McNeil AR, Reid IR. 2000. Characteristics of children with florid vitamin D deficient rickets in the Auckland region in 1998. *New Zealand Medical Journal* 113: 374–6.

Bolland M, Grey A, Davidson J, et al. 2012. Should measurement of vitamin D and treatment of vitamin D insufficiency be routine in New Zealand? *New Zealand Medical Journal* 125(1349): 83–91.

BPAC. 2007. *BNP, Haemochromatosis, Vitamin D: Testing in primary care*. URL: www.bpac.org.nz/resources/campaign/b_h_v/bpac_bnp_haemochromatosis_vit_d_poem_2006_pf.pdf (accessed 15 February 2013).

Camargo CA Jr, Ingham T, Wickens K, et al. 2010. Vitamin D status of newborns in New Zealand. *British Journal of Nutrition* 104(7): 1051–7.

Cormack B. 2007. *Neonatal and Infant Nutrition Handbook. A nutrition handbook for health professionals* (3rd ed). Auckland: Auckland District Health Board.

Department of Health. 1991. *Report on Health and Social Subjects 41. Dietary Reference Values for Food Energy and Nutrients for the United Kingdom*. Report of the Panel on Dietary Reference Values of the Committee on Medical Aspects of Food Policy. London: The Stationery Office.

De-Regil LM, Palacios C, Ansary A, et al. 2012. Vitamin D supplementation for women during pregnancy. *Cochrane Database of Systematic Reviews* Issue 2. Art no. CD008873. DOI: 10.1002/14651858.CD008873. pub2

Deutsche Gesellschaft für Ernährung, Österreichische Gesellschaft für Ernährung, Schweizerische Gesellschaft für Ernährungsforschung, Schweizerische Vereinigung für Ernährung. 2012. *Referenzwerte für die Nährstoffzufuhr. Vitamin D. 1. Auflage, 4. Korrigierter Nachdruck 2012*. Bonn: Deutsche Gesellschaft für Ernährung.

FSANZ. 2012. *Australia and New Zealand Food Standards Code*. Issue 124. Standard 1.3.2. Victoria: ANSTAT.

Godel JC, Canadian Paediatric Society, First Nations, Inuit and Métis Health Committee. 2007. Position Statement: Vitamin D supplementation: recommendations for Canadian mothers and infants. *Paediatric Child Health* 12(7): 583–9. URL: www.cps.ca/en/documents/position/vitamin-d (accessed 15 February 2013).

Grant CC, Wall CR, Crengle S, Scragg R. 2009. Vitamin D deficiency in early childhood: prevalent in the sunny South Pacific. *Public Health Nutrition* 12(10): 1893–1901.

Greer FR. 2004. Issues in establishing vitamin D recommendations for infants and children. *American Journal of Clinical Nutrition* 80(suppl): 1759S–62S.

Haggerty L. 2011. Maternal supplementation for prevention and treatment of vitamin D deficiency in exclusively breastfed infants. *Breastfeeding Medicine* 6(3): 137–44.

Health Canada, Canadian Paediatric Society, Dietitians of Canada, and Breastfeeding Committee. 2012. *DRAFT – Nutrition for Healthy Term Infants: Recommendations from birth to six months – A joint statement of Health Canada, Canadian Paediatric Society, Dietitians of Canada, and Breastfeeding Committee for Canada*. URL: www.hc-sc.gc.ca/fn-an/consult/infant-nourrisson2/recommendations/index-eng.php#s3 (accessed 28 June 2012).

Heijboer AC, Blankenstein MA, Kema IP, Buijs MM. 2012. Accuracy of 6 routine 25-hydroxyvitamin D assays: influence of vitamin D binding protein concentration. *Clinical Chemistry* 58(3): 543–8.

Hollis BW. 2007. Vitamin D requirement during pregnancy and lactation. *Journal of Bone and Mineral Research* 22(Suppl 2): V39–44.

- Houghton LA, Szymlek EA, Gray AR, et al. 2010. Predictors of vitamin D status and its association with parathyroid hormone in young New Zealand children. *American Journal of Clinical Nutrition* 92: 69–76.
- IARC. 1992. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Solar ultraviolet radiation*. Lyon: International Agency for Research on Cancer.
- IARC. 2012. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: A review of human carcinogens: Radiation*. Volume 100D. Lyon: International Agency for Research on Cancer. URL: www.monographs.iarc.fr/ENG/Monographs/vol100D/mono100D.pdf
- Institute of Medicine. 2011. *Dietary Reference Intakes for Calcium and Vitamin D*. Washington, DC: National Academies Press.
- Kovacs CS. 2008. Vitamin D in pregnancy and lactation: maternal, fetal, and neonatal outcomes from human and animal studies. *American Journal of Clinical Nutrition* 88: 520S–8S.
- Ladhani S, Srinivasan L, Buchanan C, Allgrove J. 2004. Presentation of vitamin D deficiency. *Archives of Disease in Childhood*. 89(8): 781–4.
- Lerch C, Meissner T. 2007. Interventions for the prevention of nutritional rickets in term born children (Review). *Cochrane Database of Systematic Reviews* Issue 4. Art no. CD006164. DOI: 10.1002/14651858. CD006164.pub2
- LINZ Activity and Health Research Unit. 1992. *Twenty Four Hour Diet Recall: Nutrient analysis based on 1992 DSIR database*. Dunedin: University of Otago. Mancini AJ. 2004. Skin. *Paediatrics* 113 (4suppl): 1114–19.
- Ministry of Health. 2003. *NZ Food, NZ Children: Key results of the 2002 National Children's Nutrition Survey*. Wellington: Ministry of Health.
- Ministry of Health. 2008. *Food and Nutrition Guidelines for Healthy Infants and Toddlers (Aged 0–2). A background paper* (4th ed). Wellington: Ministry of Health.
- Ministry of Health. 2012. *Vitamin D Deficiency in New Zealand Adults in 2008/09*. Wellington: Ministry of Health.
- Ministry of Health and Cancer Society of New Zealand. 2012. *Consensus Statement on Vitamin D and Sun Exposure in New Zealand*. Wellington: Ministry of Health.
- Munns CF, Simm PJ, Rodda CP, et al. 2012. Incidence of vitamin D deficiency rickets among Australian children: an Australian Paediatric Surveillance Unit study. *Medical Journal of Australia* 196: 466–8.
- NHMRC. 2006. *Nutrient Reference Values for Australia and New Zealand Including Recommended Dietary Intakes*. Canberra and Wellington: National Health and Medical Research Council and Ministry of Health. URL: www.nrv.gov.au/nutrients/vitamin%20d.htm
- Nozza JM, Rodda CP. 2001. Vitamin D deficiency in mothers of infants with rickets. *Medical Journal of Australia* 175(5): 253–5.

- Otugo O, Ogundare O, Vaughan C, et al. 2012. *Consistency of Pregnancy Labeling across Different Therapeutic Classes*. Office of Women's Health R & D, US Food and Drug Administration. URL: www.fda.gov/downloads/ScienceResearch/SpecialTopics/WomensHealthResearch/UCM308982.pdf (accessed 15 February 2013).
- Paller AS, Hawk JLM, Honig P, et al. 2011. New insights about infant and toddler skin: implications for sun protection. *Pediatrics* 128(92): 92–102.
- PSM Healthcare Ltd. 2012. *Data Sheet: Cal.D.Forte*. URL: www.medsafe.govt.nz/profs/Datasheet/c/CalDFortetab.pdf (accessed 15 February 2013).
- Reeves LE, Chesney RW, DeLuca HF. 1982. Vitamin D content of human milk: identification of the biologically active forms. *American Journal of Clinical Nutrition* 36(1): 122–6.
- SACN (Scientific Advisory Committee on Nutrition). 2012. 3rd Meeting. Vitamin D Working Group. 28 March 2012, Wellington House, London. URL: www.sacn.gov.uk/pdfs/sacn_vitamin_d_minutes_28_march_2012_draft.pdf (accessed on October 2012).
- Shah I, James R, Barker J, et al. 2011. Misleading measures in vitamin D analysis: a novel LCMS/MS assay to account for epimers and isobars. *Nutrition Journal* 10: 46.
- Singh RJ, Taylor RL, Reddy GS, Grebe SK. 2006. C-3 epimers can account for a significant proportion of total circulating 25-hydroxyvitamin D in infants, complicating accurate measurement and interpretation of vitamin D status. *Journal of Clinical Endocrinology and Metabolism* 91(8): 3055–61.
- Specker B. 2004. Vitamin D requirements during pregnancy. *American Journal of Clinical Nutrition* 80(6): 1740S–47S.
- The New Zealand Institute for Plant and Food Research Limited and the Ministry of Health. 2019. New Zealand Food Composition Database: New Zealand FOODfiles™ 2018 Version 01. The New Zealand Institute for Plant and Food Research Limited and the Ministry of Health. URL: www.foodcomposition.co.nz/foodfiles/ (accessed 26 August 2020).
- US Department of Labor. 1931. *Sunlight for Babies* (Pamphlet). Children's Bureau Folder No.5. America: US Government Printing Office.
- Wagner CL, Hulsey TC, Fanning D, et al. 2006. High-dose vitamin D₃ supplementation in a cohort of breastfeeding mothers and their infants: a 6-month follow-up pilot study. *Breastfeeding Medicine* (1): 59–71.
- Wall CR, Grant CG, Jones I. 2013. Vitamin D status of exclusively breastfed infants aged 2–3 months. *Archives of Disease in Childhood* URL: www.adc.bmj.com/content/early/2013/01/08/archdischild-2012-302351.abstract?sid=ffeb0cd1-20d6-4d87-a53f-219dbf1fcb52 (accessed 15 February 2013).
- Ward LM, Gaboury I, Ladhani M, et al. 2007. Vitamin D – deficiency rickets among children in Canada. *Canadian Medical Association Journal* 177(2): 161–6.

Weisberg P, Scanlon KS, Li R, Cogswell ME. 2004. Nutritional rickets among children in the United States: review of cases reported between 1986 and 2003. *American Journal of Clinical Nutrition* 80 (suppl): 1697S–705S.

West DP, Worobec S, Solomon LM. 1981. Pharmacology and toxicology of infant skin. *Journal of Investigative Dermatology* 76(3): 147–50.

Wheeler BJ, Dickson NP, Houghton LA, et al. 2015. Incidence and characteristics of vitamin D deficiency rickets in New Zealand children: a New Zealand Paediatric Surveillance Unit study. *Australian and New Zealand Journal of Public Health* 39(4): 380–3.

Appendix 1

The Fitzpatrick skin type (or phototype) is a commonly used classification system to assist people to determine their risk of sun burn, and sun damage, based on the amount of melanin pigment in the skin. This is determined by constitutional colour (white, brown or black skin) and the result of exposure to ultraviolet radiation (tanning). In this document, dark skin refers to Fitzpatrick skin types V and VI.

Table 3: Fitzpatrick skin type

Skin type	Typical features	Tanning ability
I	Pale white skin, blue/hazel eyes, blond/red hair	Always burns, does not tan
II	Fair skin, blue eyes	Burns easily, tans poorly
III	Darker white skin	Tans after initial burn
IV	Light brown skin	Burns minimally, tans easily
V	Brown skin	Rarely burns, tans darkly easily
VI	Dark brown or black skin	Never burns, always tans darkly

Source: Derm Net NZ. URL: www.dermnetnz.org/reactions/phototype.html (accessed 22 November 2012).



New Zealand Government