

Vitamin D Recommendations

for Perinatal Women & Healthy Term Infants (Birth - 1 year)

Background Paper for Health Professionals in British Columbia

APRIL 2018



Executive Summary

This paper discusses the current scientific evidence for vitamin D's role in health, as well as information on sources of vitamin D in British Columbia. The paper's intention is to support health professionals in providing informed recommendations to clients/ patients to ensure adequate vitamin D intakes for perinatal women and healthy, term infants (birth – 12 months).

Vitamin D is a fat-soluble vitamin and an essential pro-hormone. Pregnancy is a unique time for vitamin D metabolism and physiology. Fetal vitamin D status and maternal vitamin D status are highly correlated. Thus, an infant's vitamin status at birth is highly related to his/her mother's vitamin D status during pregnancy.

The changes in vitamin D metabolism during pregnancy give rise to the theory that vitamin D plays a unique and important physiological role, or multiple roles, for both the mother and fetus during pregnancy. However, these roles have not yet been delineated in the scientific literature. In addition, the relationship between vitamin D and a wide variety of health outcomes has been investigated. Despite the interest amongst the scientific investigation community and biological plausibility, at present there is not sufficient evidence to clearly determine the role of vitamin D in non-skeletal health outcomes.

The best indicator of vitamin D status is serum concentration of 25-hydroxyvitamin D [25(OH)D]. There is a lack of consensus regarding levels of serum 25(OH)D and its significance as it relates to health outcomes. The disagreement regarding optimal serum 25(OH)D for pregnant women and infants is reflected in differing vitamin D supplementation recommendations amongst health organizations. Until there is agreement on optimal serum vitamin D levels, there will be differing recommendations for vitamin D supplementation.

Vitamin D can be obtained from three sources: endogenous synthesis, supplements, and food and beverages containing vitamin D. However, endogenous synthesis of vitamin D, by exposing bare skin to UVB rays from the sun, is not a recommended or reliable source for women and infants due to sun safety and the many factors that block the UVB rays, such as the earth's atmosphere relative to British Columbia's position on the earth, clothing, skin pigment, and sunscreen.

Vitamin D is found in few foods; therefore, most British Columbian women will require a vitamin D supplement to achieve vitamin D recommendations. Vitamin D concentrations in breast milk are proportional to maternal vitamin D status. Vitamin D concentrations in breast milk are typically too low to achieve serum 25(OH)D sufficiency in infants exclusively fed breast milk or fed a combination of breast milk and commercial infant formula. Studies have been conducted to investigate whether it is possible to raise breast milk vitamin D levels via high dose maternal vitamin D supplementation so that adequate infant vitamin D intake is achieved solely from breast milk. However, well-designed and adequately powered clinical trials are needed to determine what dosages are required to meet infant needs and to determine the safety for mother and infant of such high doses. In Canada, it is mandatory for commercial infant formula designed for term infants to contain vitamin D. Considering how little vitamin D is found in foods and the small amount of complementary foods that most infants consume between 6 – 12 months, complementary foods cannot be relied upon to contribute a significant amount of vitamin D for most infants.

A high proportion of pregnant women in Canadian cities take a multivitamin supplement that commonly contains 400 IU (10 µg) of vitamin D. However, it is not known whether this data can be applied to all women

in British Columbia. Taking 400 IU (10 µg) of supplemental vitamin D daily (an amount that is common in prenatal multivitamins) may prevent vitamin D deficiency in most Canadian pregnant women, but may not be enough to obtain vitamin D adequacy or sufficiency.

A majority of mothers provide vitamin D supplements to their infants who receive breast milk. However, there may be populations where supplementation rates are lower. Many infants who receive daily 400 IU (10 µg) of vitamin D through supplementation or commercial infant formula will achieve serum vitamin D levels above the deficient range; however, they may not achieve sufficient/ adequate serum vitamin D levels. There may be factors, such as being born to women with vitamin D insufficiency/ deficiency, that cause some infants who receive daily 400 IU (10 µg) of vitamin D supplementation to still have deficient serum vitamin D levels.

Considering the current scientific evidence for vitamin D's role in health, as well as, information on sources of vitamin D in British Columbia, the following 10 key practice points are provided for health professionals in British Columbia. A practice support tool has been created for health professionals in British Columbia that provides these 10 key practice points, information on vitamin D supplements, and programs that assist with the purchase of vitamin D supplements (See Appendix C).

Key Practice Points

Perinatal Women

1. Most perinatal women require a vitamin D supplement of 400 IU (10 µg) – 600 IU (15 µg).
2. For perinatal women at higher risk of insufficiency/ deficiency, health professionals may recommend vitamin D supplementation to reach intake levels above 600 IU (15 µg) as a clinical decision.

Healthy, Term Infants (Birth – 1 Year)

3. For healthy, term infants who are exclusively or partially breastfed, recommend a daily liquid vitamin D supplement of 400 IU (10 µg).
4. Supplementing the mother instead of the infant is not recommended until the safety of the required high doses is known.
5. A key communication point with caregivers is that breastfeeding is the normal and unequalled method of infant feeding. Breastfeeding is the healthy first choice for both mothers and infants. The need for vitamin D supplementation is not due to a deficiency with breast milk. The need is due to limited sun exposure of the infant and mother and limited dietary sources of vitamin D.
6. Healthy, term infants fed commercial infant formula only, and who were born to mothers with adequate vitamin D status during pregnancy, do not need a liquid vitamin D supplement.
7. For healthy, term infants fed commercial infant formula, if the mother's vitamin D status during pregnancy was suspected to be insufficient/ deficient, consider a daily liquid vitamin D supplement of 400 IU (10 µg) until the infant is consuming 800 - 1000 mL of commercial infant formula daily.

8. Give healthy, term infants who are fed a combination of commercial infant formula and breast milk a liquid vitamin D supplement of 400 IU (10 µg) every day.
9. Health professionals may recommend higher doses of vitamin D for individual infants to address known or suspected insufficiency/ deficiency as a clinical decision.
10. If an infant's feeding method has changed since last assessment, re-assess vitamin D supplementation.

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Purpose

This paper discusses the current scientific evidence for vitamin D's role in health, as well as, information on sources of vitamin D in British Columbia. The paper's intention is to support health professionals in providing informed recommendations to clients/ patients to ensure adequate vitamin D intakes for perinatal women and healthy, term infants from birth to 12 months of age.

Vitamin D Physiology and Metabolism

Vitamin D is a fat-soluble vitamin and an essential pro-hormone. The two forms of vitamin D with biological activity are ergocalciferol (vitamin D₂) and cholecalciferol (vitamin D₃). Vitamin D can be produced in the skin from UVB radiation. It can also be obtained from foods and supplements. For more information see *Sources of Vitamin D* (page 12).

After entering the bloodstream from either skin synthesis or intestinal absorption, vitamin D is converted in the liver into 25-hydroxyvitamin D [25(OH)D] and then in the kidneys to its active form 1,25-dihydroxyvitamin D [1,25(OH)₂D]. In addition to the kidneys, vitamin D receptors have been found on cells throughout the body. The physiological significance of these receptors is still being investigated.

During Pregnancy

Vitamin D metabolism changes during pregnancy. Pregnancy-specific tissues, such as the placenta and decidua, have vitamin D receptors and can convert 25(OH)D to active 1,25(OH)₂D.^{1,2}

25(OH)D readily crosses the placenta. Maternal and fetal levels of 25(OH)D are highly correlated, with fetal levels approximately 75% of maternal levels.³ In contrast, 1,25(OH)₂D does not cross the placenta, resulting in fetal levels much lower than maternal levels.²

Circulating levels of 25(OH)D are similar to non-pregnant circulating levels.² In contrast, 1,25(OH)₂D levels rise in pregnancy. This rise starts early in the first trimester and by the end of the third trimester, 1,25(OH)₂D concentration reaches double the non-pregnant level.⁴

Postnatally, women's serum 25(OH)D levels decrease slightly after birth whereas serum 1,25(OH)₂D levels decrease sharply.³

Summary

In summary, pregnancy is a unique time for vitamin D metabolism and physiology. Fetal vitamin D status and maternal vitamin D status are highly correlated. Women's vitamin D metabolism returns to the non-pregnant state soon after birth.

Role of Vitamin D in Maternal and Infant Health

The changes in vitamin D metabolism during pregnancy give rise to the theory that vitamin D plays a unique and important physiological role, or multiple roles, for both the mother and fetus during pregnancy.

Vitamin D helps the body absorb calcium in the intestine and control serum calcium and phosphorus levels. As such, it has an important role in the building and maintenance of strong bones and teeth.

1,25(OH)₂D has anti-inflammatory properties by inhibiting adaptive immunity and enhancing innate immunity.¹ Studies indicate that active 1,25(OH)₂D produced at the placenta and decidua in early pregnancy likely plays a local role rather than a circulating role like the 1,25(OH)₂D produced in the kidneys.² It is hypothesized that its presence at the maternal-fetal interface indicates that 1,25(OH)₂D is involved in the normal immunological adaptation of the mother required for pregnancy (i.e. successful implantation).^{1,2}

In vitro studies have found that vitamin D has antimicrobial and antiviral abilities.² *In vitro* studies also indicate that vitamin D modulates cellular growth, differentiation, and apoptosis.² Lastly, *in vitro* studies have found that vitamin D stimulates the synthesis of a number of hormones involved in pregnancy such as estradiol, progesterone, and human chorionic gonadotropin.²

Considering the potential immune system and pregnancy-related hormone functions of vitamin D, the current millennium is marked by active investigation into the role of vitamin D in a wide range of non-skeletal health outcomes for women during the perinatal period and their offspring, both during infancy and childhood. The health outcomes under investigation include the following noted in Table 1.

Table 1: Outcomes Under Investigation for Associations with Vitamin D Status

Outcomes		
Maternal Health	Infant/ Fetal	Childhood
<ul style="list-style-type: none"> ■ Pre-eclampsia and gestational hypertension ■ Gestational diabetes and impaired glucose tolerance ■ Bacterial vaginosis ■ Pregnancy-associated breast cancer ■ C-section ■ Postpartum depression ■ Maternal mortality 	<ul style="list-style-type: none"> ■ Preterm delivery ■ Birth weight, birth length, small-for-gestational age ■ Head circumference ■ APGAR score ■ Immune system strength, neonatal infection ■ Neonatal mortality 	<ul style="list-style-type: none"> ■ Eczema, atopic dermatitis ■ Allergic rhinitis ■ Food allergy ■ Wheezing, asthma, respiratory tract infections ■ Childhood infections ■ Type 1 diabetes ■ Adiposity ■ Cerebral function and diseases ■ Cognitive, motor, and language skills ■ Adaptive behaviour, socio-emotional development

Mechanisms of action for vitamin D’s role in health outcomes are being investigated using *in vitro* and animal models. Observational and epidemiological studies have been conducted looking for associations. And, supplementation trials have been undertaken looking for treatment effects.

A number of systematic reviews and meta-analyses have aimed to synthesize the findings from these numerous studies to provide direction to clinicians, policy-makers, and researchers. Appendix A lists the results found in systematic reviews, meta-analyses, and recent studies not included in the systematic reviews and meta-analyses.

The results from observational, epidemiological, and supplementation trials have been inconsistent. The systematic reviews and meta-analyses have also come to inconsistent conclusions due to varying inclusion criteria and methods. The two health conditions with the strongest evidence for an association with vitamin D are pre-eclampsia and infant birth weight.

Only one systematic review/ meta-analysis and one individual study found an increase in health risk with higher vitamin D status/ vitamin D supplementation. The Cochrane Collaboration review determined that when 200 IU vitamin D₃ supplementation was combined with 500 – 600 mg calcium carbonate supplementation, there was a small increased risk for preterm birth, although the quality of the evidence was deemed ‘low’.⁵ One individual study found that infants had a greater risk of eczema at 9 months when their mothers had serum 25(OH)D levels of greater than 75 nmol/L (30 µg/mL) in late pregnancy.⁶

Summary

In summary, the relationship between vitamin D and a wide variety of health outcomes has been investigated. Correlations between vitamin D status and this wide range of health outcomes are inconsistent. Two instances of increased risk with vitamin D supplementation/ higher serum vitamin D have been found to date. Despite the interest amongst the scientific investigation community and biological plausibility, at present there is not sufficient evidence to clearly determine the role of vitamin D in these health outcomes.

Vitamin D Status

The best indicator of vitamin D status is serum concentration of 25-hydroxyvitaminD [25(OH)D]. There is a lack of consensus regarding serum 25(OH)D levels of significance related to health outcomes. The following are three commonly cited sets of serum vitamin D levels of significance for all age groups.

The Institute of Medicine’s (IOM’s) Dietary Reference Intakes (DRIs) used by Health Canada ^{7*}	The Endocrine Society ⁸	The Canadian Pediatric Society (CPS) First Nations, Inuit and Métis Health Committee position statement ⁹
<i>At Risk of Vitamin D Deficiency:</i> Below 30 nmol/L (12 µg/mL).	<i>Deficient:</i> Below 50 nmol/L (20 µg/mL).	<i>Deficient:</i> Below 25 nmol/L (< 10 µg/mL).
<i>Generally Considered Inadequate:</i> 30 - < 50 nmol/L (12 - < 20 µg/mL).	<i>Insufficient:</i> 50 nmol/L - 75 nmol/L (20 - 30 µg/mL).	<i>Insufficient:</i> 25 – 75 nmol/L (10 – 30 µg/mL).
<i>Meets the Needs of 97.5% of the Population:</i> 50 nmol/L (20 µg/mL).	<i>Sufficient:</i> Above 75 nmol/L (30 µg/mL).	<i>Optimal:</i> 75 – 225 nmol/L (30 – 90 µg/mL).
<i>May be Reason for Concern:</i> Above 125 nmol/L (50 µg/mL).		<i>Pharmacological (Potential Side Effects):</i> Above 225 nmol/L (> 90 µg/mL). <i>Potentially Toxic:</i> Above 500 nmol/L (> 200µg/mL).
*For more information on the DRIs, see Vitamin D Recommendations (page 10) and Appendix B.		

The disagreement regarding optimal serum 25(OH)D for pregnant women and infants is reflected in differing vitamin D supplementation recommendations amongst health organizations.

Summary

In summary, there is a lack of consensus regarding serum 25(OH)D levels of significance related to health outcomes. Until there is agreement on optimal serum vitamin D levels, there will be differing recommendations for vitamin D supplementation.

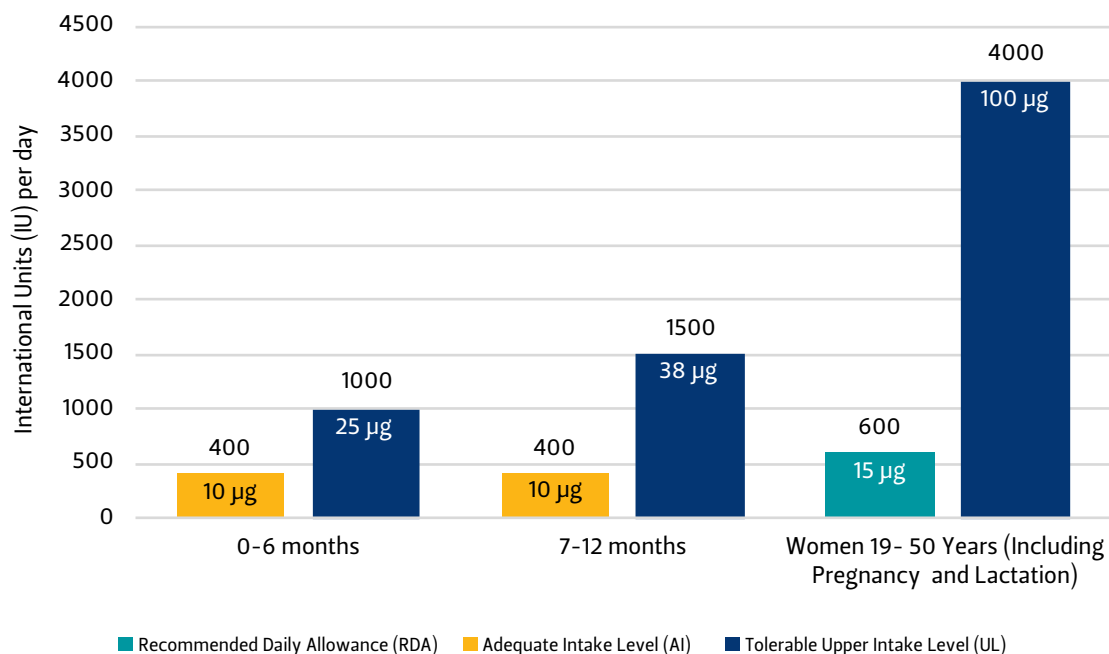
Varying Vitamin D Recommendations

There are several different sets of vitamin D recommendations published by agencies in Canada and around the world. This is not surprising with the current state of the scientific literature regarding the role of vitamin D in health outcomes, as well as a lack of consensus regarding target 25(OH)D levels. For the purpose of this document we will be discussing vitamin D recommendations from *The Dietary Reference Intakes*, used by Health Canada. Also included in this backgrounder is the guidance on vitamin D in *Nutrition for Healthy Term Infants*¹⁰ as well as The Canadian Pediatric Society's First Nations, Inuit and Métis Health Committee position statement.⁹ There are additional health organizations, both in Canada and world-wide, with differing vitamin D recommendations. However, these are too numerous to include in this document.

The Dietary Reference Intakes (DRI's) are a comprehensive set of nutrient reference values for healthy populations. They are developed by American and Canadian scientists through a process overseen by the Institute of Medicine (IOM). See more details on the DRI's in Appendix B.

In 2011, the IOM revised their nutrient standards for vitamin D. Currently the nutrient standards for vitamin D are in Table 2. The Recommended Dietary Allowance is based on the amount of intake thought necessary to sustain serum 25(OH)D levels above 50 nmol/L (20 µg/mL) for populations with minimal sunlight exposure.

Table 2: Dietary Reference Intakes for Vitamin D⁷



*Nutrition for Healthy Term Infants*¹⁰, a joint statement from Health Canada, Canadian Paediatric Society, Dietitians of Canada and Breastfeeding Committee For Canada, recommends a daily vitamin D supplement of 400 IU (10 µg) for infants and young children who are breastfed or receiving breast milk. The statement also indicates that infants who are not breastfed or receiving breast milk do not require a vitamin D supplement as commercial infant formula has vitamin D added during manufacturing.

The Canadian Pediatric Society (CPS) First Nations, Inuit and Métis Health Committee’s position statement has the following two recommendations for all Canadian women and infants⁹:

1. Consideration should be given to administering 2000 IU of vitamin D daily to pregnant women, especially during the winter months, to maintain vitamin D sufficiency. The effectiveness of this regimen and possible side effects should be checked with periodic assays for 25(OH)D and calcium.
2. ...vitamin D dosage should be 400 IU/day for all infants during the first year, with an increase to 800 IU/day from all sources between October and April north of the 55th parallel (approximate latitude of Edmonton) and between the 40th and 55th parallel in individuals with risk factors for vitamin D deficiency other than latitude alone.

Summary

In summary, there exist different vitamin D recommendations. Recommendations for infants range from 400 – 800 IU (10 - 20 µg) per day. Recommendations for women range from 600 IU – 2000 IU (15 - 50 µg) per day.

Sources of Vitamin D

Vitamin D can be obtained from three sources:

- Endogenous synthesis (i.e. sun exposure)
- Consuming supplements
- Consuming food and beverages containing vitamin D

Endogenous Synthesis

Endogenous synthesis of vitamin D, by exposing bare skin to UVB rays from the sun, is not a recommended or reliable source for British Columbians for the following reasons:

- Sunscreen, skin pigment, clothing, windows, smog, and clouds block UVB rays.
- UVB is also blocked by the earth's atmosphere in the winter months; October to March for most of British Columbia. This is not due to weather conditions, but because of the low angle of the sun relative to British Columbia's position on the earth. The low angle increases the amount of atmosphere that sunlight has to pass through, which significantly blocks UVB rays, except at high altitudes. The further north the community, the longer the period where UVB is blocked from stimulating vitamin D synthesis.
- For infants, direct sun exposure is not recommended during their first 12 months.

Supplements

Vitamin D supplements are available as vitamin D₂ and vitamin D₃. The common supplements available in British Columbia contain vitamin D₃ manufactured from lanolin. Vitamin D₂ is manufactured from plant and/or fungal sources. Vegan supplements sold in Canada are made from vitamin D₂. Supplements from other countries may be vitamin D₂. The Institute of Medicine reports that at typical liquid vitamin D supplement doses, the efficacy of vitamin D₂ and vitamin D₃ are equivalent.⁷ However, the evidence is conflicting regarding whether vitamin D₂ is as effective as vitamin D₃.^{7,11,12}

Vitamin D supplements are available in several formulations. They may provide vitamin D alone or in conjunction with other vitamins.

Adult tablet vitamin D supplements usually provide 400 IU (10 µg) or 1000 IU (25 µg) per dosage. Liquid vitamin D supplements formulated for adults usually provide 1000 IU (25 µg) per dosage. Prenatal multivitamins currently on the market commonly provide 200 IU (5 µg) - 800 IU (20 µg) per dosage.

Infant liquid vitamin D₃ supplements provide 400 IU (10 µg) per dosage. These supplements come in various formulations. Three common formulations are:

- 400 IU (10 µg) in a single drop (0.028 mL)
- 400 IU (10 µg) in 0.25 mL

- 400 IU (10 µg) in 1 mL

Cases of vitamin D toxicity (hypervitaminosis D) have been reported when caregivers provide the incorrect product or incorrect dosage over a period of time.^{13,14} Hypervitaminosis D causes hypercalcemia.

Dietary Sources

Vitamin D is found in few foods. Some foods are natural sources of vitamin D and some foods are fortified with vitamin D.¹⁵ Examples are listed in Table 3.¹⁵

Table 3: Food Sources of Vitamin D

Food/ Beverage	Serving Size	Vitamin D	Notes
Fluid Cow Milk and Goat Milk (Fortified)	250 mL (1 cup)	100 IU (2.5 µg)	Fluid cow milk and fortified goat milk are not recommended until 9 – 12 months of age. Once introduced, intake should not exceed 750 mL (3 cups) per day. Unfortified goat milk is not a source of vitamin D. Most yogurt and cheese are made with unfortified milk so they are not sources of vitamin D.
Fortified Plant-Based Milk Alternatives (e.g. Soy, Rice, Almond)	250 mL (1 cup)	100 IU (2.5 µg)	Unfortified options are available. Plant-based milk alternatives are not recommended for infants.
Salmon	75 g (2.5 oz) Food Guide Serving	205 – 387 IU (5.1 – 9.7 µg)	
Rainbow Trout	75 g (2.5 oz) Food Guide Serving	192 – 208 IU (4.8 – 5.2 µg)	
Pacific Sardines (Canned)	75 g (2.5 oz) Food Guide Serving	145 IU (3.6 µg)	
Pacific Mackerel (Cooked)	75 g (2.5 oz) Food Guide Serving	343 IU (8.6 µg)	
Cod Liver Oil ¹⁶	15 mL (1 tablespoon)	1360 IU (34 µg)	Cod liver oil is not recommended for infants.
Egg Yolk	Per yolk	32 IU (0.8 µg)	
Fortified Orange Juice	125 mL (1/2 cup)	50 IU (1.2 µg)	If juice is given to infants older than 6 months, no more than 125 mL (1/2 cup) a day is recommended.
Margarine	5 mL (1 teaspoon)	25 IU (0.6 µg)	

Dietary sources may contribute to a woman's vitamin D intake. However, most British Columbian women will require a vitamin D supplement to achieve the IOM's recommendation of 600 IU per day and the higher recommendation of 2000 IU per day by the CPS.

Considering how little vitamin D is found in foods and the small amount of complementary foods that most infants consume between 6 – 12 months, complementary foods cannot be relied upon to contribute a significant amount of vitamin D for most infants.

Breast milk

Vitamin D concentrations in breast milk are proportional to maternal vitamin D status. Vitamin D concentrations of breast milk are typically too low to achieve serum 25(OH)D sufficiency in infants exclusively fed breast milk or fed a combination of breast milk and commercial infant formula. Therefore, liquid vitamin D supplements at 400 IU (10 µg) per day are required for both breastfed infants and infants fed a combination of breast milk and commercial infant formula to achieve the minimum recommendation of 400 IU (10 µg) per day of vitamin D. The upper level for vitamin D increases for infants from 1000 IU (25 µg) at birth - 6 months (25 µg) to 1500 IU (38 µg) at 7 – 12 months. As such, there is little concern for toxicity with supplementation at 400 IU (10 µg) per day in addition to vitamin D intake from a combination of breast milk and commercial infant formula and/or complementary foods.

High-Dose Vitamin D Supplementation of Breastfeeding Mothers

Studies have been conducted to investigate whether it is possible to raise breast milk vitamin D levels through high dose maternal vitamin D supplementation so that adequate infant vitamin D intake is achieved solely from breast milk.¹⁷⁻²⁶ These studies have been conducted to:

- Address concern that the recommendation to supplement infants with vitamin D undermines efforts to promote breastfeeding. That is, the perception that the recommendation suggests that breast milk is inadequate.
- Optimize the health of both women and infants during pregnancy and lactation.
- Address the preference that some mothers express for supplementing themselves rather than their breastfeeding infants.²⁷

Studies have involved vitamin D supplementation ranging from daily 2000 IU (50 µg) – 6400 IU (160 µg) or a monthly dose of 60,000 IU (1500 µg), using either vitamin D₂ or vitamin D₃. Research outcomes suggest that breast milk vitamin D levels can be raised through such means. However, the maternal supplementation rates required to meet infant vitamin D needs are above the IOM's Tolerable Upper Intake Level (UL) of 4000 IU (100 µg) per day for adult women. While no adverse effects were seen in the studies, study sample sizes have been small, studies have been short in duration, and both women and infants have been closely monitored for toxicity risk.

Commercial Infant Formula

In Canada, it is mandatory for commercial infant formula designed for term infants to contain between 40 – 100 IU (1 – 2.5 µg), of vitamin D per 100 kilocalories (27 – 67 IU per 100 mL). Most commercial infant formulas for term infants currently on the market contain 40 IU (1 µg) per 100 mL. However, commercial infant formulas typically contain 25% more vitamin D than indicated on the product's label as overage to ensure the labeled amount is present.²⁸ Considering this fortification rate, infants consuming approximately 800 – 1000 mL per day of commercial infant formula designed for term infants are meeting the recommendation of 400 IU (10 µg) of vitamin D per day. In setting the recommendation for infants, the Institute of Medicine indicated that 400 (10 µg) of vitamin D represents an overall intake for the first year of life, assuming a gradual increase in commercial infant formula intake to approximately 800 – 1000 mL per day during infancy.⁷

The upper level for vitamin D increases from 1000 IU (25 µg) at birth – 6 months (25 µg) to 1500 IU (38 µg) at 7 – 12 months. Therefore, there is little concern for toxicity with vitamin D intake from commercial infant formula in addition to vitamin D intake from complementary foods.

Summary

In summary, endogenous synthesis of vitamin D, by exposing bare skin to UVB rays from the sun, is not a recommended or reliable source for women and infants in British Columbia. Vitamin D is found in few foods; therefore, most British Columbian women and infants will require a vitamin D supplement to achieve vitamin D recommendations. Vitamin D concentrations of breast milk are typically too low to achieve serum 25(OH) D sufficiency in infants fed breast milk or a combination of breast milk and commercial infant formula. More well-designed and adequately powered clinical trials are needed to determine what dosages are required to raise vitamin D levels in breastmilk to meet infant needs and to determine the safety for mother and infant of such high doses. Most infants receiving commercial infant formula (and no breast milk) do not need vitamin D supplementation.

Vitamin D Status and Supplementation Rates for Pregnant Women and Infants in British Columbia/ Canada

Pregnant Women

The Canadian Health Measures Survey (2009 – 2011) found an average vitamin D serum level of 67 nmol/L (24 µg/mL) for women in Canada aged 20 – 39 years.²⁹ The IOM identifies this as nutritional adequacy for 97.5% of the population; however, both the CPS and Endocrine Society categorize this as insufficient.

Surveillance data on maternal serum vitamin D levels is not available, nor is British Columbia-specific data available.

Studies indicate that a high proportion of women (85% – 97%) in Canadian cities take a multivitamin supplement containing 400 IU (10 µg) of vitamin D during pregnancy.^{22,30-33} There is evidence that taking 400 IU (10 µg) of supplemental vitamin D may prevent vitamin D deficiency in most Canadian pregnant women, but may not be enough to obtain vitamin D adequacy or sufficiency.^{22,34-37} These Canadian results are similar to those of studies conducted elsewhere, such as New Zealand³⁸ and Oakland, California.³⁹

Three studies have investigated supplementing pregnant women with higher doses of vitamin D.^{22,40,41} Daily doses of 1000 IU (25 µg), 2000 IU (50 µg), and 4000 IU (100 µg) have been studied.^{22,40,41} Note that 4000 IU (100 µg) is the Tolerable Upper Intake Level for vitamin D as defined by the IOM (for supplemental and dietary sources combined). These studies varied in the vitamin D status of women at enrolment, gestational timing of initiating vitamin D supplementation, and vitamin D supplementation protocols. Higher supplementation dosages were associated with higher maternal serum vitamin D levels.^{22,40,41} In the only study that looked at infant vitamin D levels, higher supplementation levels were associated with higher infant serum vitamin D at 8 weeks postpartum.²²

Infants

The mother is the fetus's sole source of vitamin D, with 25(OH)D freely crossing the placenta. As previously mentioned, maternal and fetal levels of 25(OH)D are highly correlated, with fetal levels approximately 75% of maternal levels.³³

There are no surveillance data on the serum 25(OH)D levels of infants in British Columbia, or the incidence of vitamin D deficiency rickets. However, the Canadian Pediatric Surveillance Program reported 104 cases of vitamin D deficiency rickets (10 cases in British Columbia) between 2002 – 2004.⁴² In a study conducted in Manitoba, a retrospective chart review covering a 2.5 year period found severe vitamin D deficiency in six exclusively formula-fed infants from First Nations communities in the northern part of the province (approximately 54th parallel of latitude).⁴³ The results from small studies in Saskatoon and St John's, Newfoundland have found that a small proportion of infants were born vitamin D deficient and a greater proportion were inadequate/insufficient despite mothers taking prenatal multivitamins containing vitamin D.^{32,35} See Risk Factors for Vitamin D Deficiency (page 17) for a discussion of factors that may have increased the risk for vitamin D deficiency for the infants in these studies.

In the 2009 – 2010 Canadian Community Health Survey, 76.1% of women in British Columbia who exclusively breastfed their infants reported giving their infants a vitamin D supplement.⁴⁴ According to the 2011 – 2012 Canadian Community Health Survey, 85.1% of British Columbian mothers gave a vitamin D supplement to their infant fed breast milk.⁴⁵ Studies performed in Canadian cities indicate that the supplementation rate for infants receiving breast milk (exclusive breastfeeding or combined breast milk and commercial infant formula) is in the range of 79 – 91%, with the exception of a sample of refugees where the rate was 48%.^{46,47}

Studies indicate that most infants who receive 400 IU (10 µg) of vitamin D achieve serum 25(OH)D levels above the deficient range.⁴⁸⁻⁵¹ The Canadian Pediatric Surveillance Program's finding is in agreement in that none of the breastfed children who had rickets received the recommended 400 IU (10 µg) of vitamin D.⁴² However, despite the findings that most infants who receive 400 IU (10 µg) of vitamin D achieve serum

25(OH)D levels above the deficient range (as defined by the IOM or CPS), some infants who receive 400 IU (10 µg) of vitamin D have serum 25(OH)D levels in the Endocrine Society's insufficient range.^{50,51}

Summary

In summary, taking 400 IU (10 µg) of supplemental vitamin D daily may prevent vitamin D deficiency in most Canadian pregnant women but may not be enough to obtain vitamin D adequacy or sufficiency. Maternal daily supplementation of 400 IU (10 µg) of vitamin D may leave a small proportion of infants vitamin D deficient and a greater proportion with vitamin D inadequacy/ insufficiency. A majority of mothers provide vitamin D supplements to their infants who receive breast milk. Many infants who receive daily 400 IU (10 µg) of vitamin D through supplementation or commercial infant formula will achieve serum vitamin D levels above the deficient range; however, they may not achieve sufficient/ adequate serum vitamin D levels. There may be factors that cause infants who receive daily 400 IU (10 µg) of vitamin D supplementation to still have deficient serum vitamin D levels.

Risk Factors for Vitamin D Deficiency

There is evidence for the following risk factors for maternal vitamin D deficiency and insufficiency⁵²⁻⁵⁴:

- Latitude (increased risk with higher latitude)
- Season (lower vitamin D status in winter)
- Darker skin tone (exact skin tone where risk increases is not known currently)
- Covering skin with clothing when outdoors
- Not taking supplemental vitamin D (as a single nutrient supplement or as a multivitamin)

The scientific evidence is conflicting regarding increased risk of deficiency with the following⁵²⁻⁵⁴:

- Higher BMI
- Smoking during pregnancy
- Lower socioeconomic status
- Younger maternal age
- Lower physical activity

Mothers with insufficient or deficient serum vitamin D levels are at increased risk for giving birth to infants with inadequate serum vitamin D levels. In addition, a recent study involving 466 maternal-infant pairs in China found that maternal depression was associated with low serum vitamin D levels in infants born in winter-spring.⁵²⁻⁵⁵ Because surveillance data of serum 25(OH)D is not available for pregnant women in British

Columbia it is not known how many fetuses are at risk for not receiving adequate vitamin D in utero and consequently are born with low vitamin D status.

Infants born with very low serum 25(OH)D levels may be at risk of not achieving the sufficient range with supplementation of 400 IU (10 µg) of vitamin D.⁵¹ This is seen in the Gross study.⁴³ Of the six exclusively formula-fed infants with vitamin D deficiency rickets (infants who would have received 400 IU (10 µg) of vitamin D from formula), none of their mothers reported taking prenatal supplements.⁴³ The two mothers in this study for whom serum 25(OH)D was available, were vitamin D deficient.⁴³ Three infants with vitamin D deficiency rickets in the Canadian Pediatric Surveillance Program received standard amounts of commercial infant formula [thus would have received 400 IU (10 µg) of vitamin D] and still experienced vitamin D deficiency.⁴² Vitamin D status of the infants' mothers was not reported.⁴²

Summary

In summary, a number of factors increase a woman's risk for vitamin D deficiency during the perinatal period. Infants born to women with vitamin D deficiency are at increased risk for low vitamin D serum levels, including deficiency. Considering the evidence that infants at risk for low vitamin D status at birth may not achieve vitamin D sufficiency with daily intakes of 400 IU (10 µg) of vitamin D (either from vitamin D supplementation or commercial infant formula), health professionals may choose to recommend vitamin D supplementation above 400 IU (10 µg).

Conclusions for Practice

The following 10 key practice points result from the scientific evidence herein reviewed, as well as, information on sources of vitamin D in British Columbia. A practice support tool has been created that provides these 10 key practice points, information on vitamin D supplements, and programs that assist with the purchase of vitamin D supplements (See Appendix C).

Key Practice Points

Perinatal Women

1. Most perinatal women require a vitamin D supplement of 400 IU (10 µg) – 600 IU (15 µg).
2. For perinatal women at higher risk of insufficiency/ deficiency, health professionals may recommend vitamin D supplementation to reach intake levels above 600 IU (15 µg) as a clinical decision.

Healthy, Term Infants (Birth – 1 Year)

3. For healthy, term infants who are exclusively or partially breastfed, recommend a daily liquid vitamin D supplement of 400 IU (10 µg).

4. Supplementing the mother instead of the infant is not recommended until the safety of the required high doses is known.
5. A key communication point with caregivers is that breastfeeding is the normal and unequalled method of infant feeding. Breastfeeding is the healthy first choice for both mothers and infants. The need for vitamin D supplementation is not due to a deficiency with breast milk. The need is due to limited sun exposure of the infant and mother and limited dietary sources of vitamin D.
6. Healthy, term infants fed commercial infant formula only, and who were born to mothers with adequate vitamin D status during pregnancy, do not need a liquid vitamin D supplement.
7. For healthy, term infants fed commercial infant formula, if the mother's vitamin D status during pregnancy was suspected to be insufficient/ deficient, consider a daily liquid vitamin D supplement of 400 IU (10 µg) until the infant is consuming 800 - 1000 mL of commercial infant formula daily.
8. Give healthy, term infants who are fed a combination of commercial infant formula and breast milk a liquid vitamin D supplement of 400 IU (10 µg) every day.
9. Health professionals may recommend higher doses of vitamin D for individual infants to address known or suspected insufficiency/ deficiency as a clinical decision.
10. If an infant's feeding method has changed since last assessment, re-assess vitamin D supplementation.

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Project Advisory Committee

Cynthia Buckett, MBA, RD, Provincial Manager, Healthy Eating Resource Coordination, Population and Public Health, BC Centre for Disease Control, PHSA

Vanessa Perrodou, RD, Acting Provincial Manager, Healthy Eating Resource Coordination, Population and Public Health, BC Centre for Disease Control, PHSA

Margaret Yandel, BHE, RD, Manager, Nutrition Policy & Promotion, Office of the Provincial Dietitian, BC Ministry of Health

Kristen Yarker, MSc, RD, Project Consultant

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Appendix A: Findings From Systematic Reviews and Meta-Analyses Regarding the Association Between Vitamin D and Health Outcomes

Table 4: Association Between Vitamin D and Health Outcomes - Systematic Review and Meta-Analysis Findings

Health Outcome	Systematic Review and Meta-Analysis Finding		
	Association Found Between Vitamin D and Health Outcome	No Association Found Between Vitamin D and Health Outcome	Too Little Evidence to Complete Analysis
Maternal Outcomes			
Pre-Eclampsia	<ul style="list-style-type: none"> ■ Aghajafari et al, 2013⁵⁶ ■ De-Regil et al, 2016⁵ ■ Hyppönen et al, 2013⁵⁷ ■ Karras et al, 2015⁵⁸ ■ Mirzakhani et al, 2016^{59*} ■ Palacios et al, 2016⁶⁰ ■ Tabesh et al, 2013⁶¹ ■ Thorne-Lyman & Fawzi, 2012⁶² ■ Wei, 2014⁶³ 	Pérez-López et al, 2015 ⁶⁴	Theodoratou et al, 2014 ⁶⁵
Gestational Diabetes	<ul style="list-style-type: none"> ■ Aghajafari et al, 2013⁵⁶ ■ Palacios et al, 2016⁵⁹ ■ Theodoratou et al, 2014⁶⁵ ■ Wei, 2014⁶³ 	<ul style="list-style-type: none"> ■ Karras et al, 2015⁵⁸ ■ Pérez-López et al, 2015⁶⁴ 	

Health Outcome	Systematic Review and Meta-Analysis Finding		
	Association Found Between Vitamin D and Health Outcome	No Association Found Between Vitamin D and Health Outcome	Too Little Evidence to Complete Analysis
Impaired Glucose Tolerance			Palacios et al, 2016 ⁵⁹
Gestational Hypertension			Palacios et al, 2016 ⁵⁹
Bacterial Vaginosis	<ul style="list-style-type: none"> Aghajafari et al, 2013⁵⁶ 		Theodoratou et al, 2014 ⁶⁵
Pregnancy Associated Breast Cancer			Theodoratou et al, 2014 ⁶⁵
C-Section		<ul style="list-style-type: none"> Aghajafari et al, 2013⁵⁶ Pérez-López et al, 2015⁶⁴ 	Palacios et al, 2016 ⁵⁹ Thorne-Lyman & Fawzi, 2012 ⁶²
Postpartum Depression	<ul style="list-style-type: none"> Wei, 2014⁶³ 		Theodoratou et al, 2014 ⁶⁵
Maternal Mortality			Palacios et al, 2016 ⁵⁹ Pérez-López et al, 2014 ⁶⁴ Thorne-Lyman & Fawzi, 2012 ⁶²
Fetal/ Infant Outcomes			
Preterm Delivery	<ul style="list-style-type: none"> Bodnar et al, 2015^{66*} De-Regil et al, 2016⁵ Wagner et al, 2016^{67*} Wei, 2014⁶³ 	Pérez-López et al, 2015 ⁶⁴	Theodoratou et al, 2014 ⁶⁵ Thorne-Lyman & Fawzi, 2012 ⁶²
Birth Weight	<ul style="list-style-type: none"> Aghajafari et al, 2013⁵⁶ De-Regil et al, 2016⁵ Harvey et al, 2014⁶⁸ Pérez-López et al, 2015⁶⁴ Theodoratou et al, 2014⁶⁵ Thorne-Lyman & Fawzi, 2012⁶² 	Gould et al, 2017 ^{69*}	

Health Outcome	Systematic Review and Meta-Analysis Finding		
	Association Found Between Vitamin D and Health Outcome	No Association Found Between Vitamin D and Health Outcome	Too Little Evidence to Complete Analysis
Birth Length	<ul style="list-style-type: none"> ■ Pérez-López et al, 2015⁶⁴ 	<ul style="list-style-type: none"> ■ Aghajafari et al, 2013⁵⁶ ■ Gould et al, 2017^{69*} ■ Theodoratou et al, 2014⁶⁵ 	
Small-for-Gestational Age	<ul style="list-style-type: none"> ■ Aghajafari et al, 2013⁵⁶ ■ Theodoratou et al, 2014⁶⁵ ■ Wei, 2014⁶³ 	<ul style="list-style-type: none"> ■ Gould et al, 2017^{69*} ■ Pérez-López et al, 2015⁶⁴ ■ Thorne-Lyman & Fawzi, 2012⁶² 	
Head Circumference	<ul style="list-style-type: none"> ■ Theodoratou et al, 2014⁶⁵ 	<ul style="list-style-type: none"> ■ Aghajafari et al, 2013⁵⁶ ■ Gould et al, 2017^{69*} 	
Anthropometry	<ul style="list-style-type: none"> ■ Karras et al, 2015⁵⁸ 		
Immune System			Karras et al, 2015 ⁵⁸
Apgar Score			Pérez-López et al, 2015 ⁶⁴
Neonatal Infection, Neonatal Sepsis	<ul style="list-style-type: none"> ■ Cetinkaya et al, 2015^{70*} 		Pérez-López et al, 2015 ⁶⁴
Stillbirth, Neonatal Mortality			Pérez-López et al, 2015 ⁶⁴
Childhood Outcomes			
Eczema, Atopic Dermatitis		Litonjua et al, 2016 ^{71*}	Theodoratou et al, 2014 ⁶⁵
Allergic Rhinitis			Theodoratou et al, 2014 ⁶⁵
Wheezing, Asthma		Litonjua et al, 2016 ^{71*}	Theodoratou et al, 2014 ⁶⁵
Respiratory Tract Infections	<ul style="list-style-type: none"> ■ Lai et al, 2017^{72*} 	Omand et al, 2017 ^{73*}	
Childhood Infections			Theodoratou et al, 2014 ⁶⁵
Type 1 Diabetes	<ul style="list-style-type: none"> ■ Zipitis & Akobeng, 2008⁷⁴ 		Theodoratou et al, 2014 ⁶⁵
Cerebral Function and Diseases			Theodoratou et al, 2014 ⁶⁵
Language Skills	<ul style="list-style-type: none"> ■ Gould et al, 2017^{69*} 		

Health Outcome	Systematic Review and Meta-Analysis Finding		
	Association Found Between Vitamin D and Health Outcome	No Association Found Between Vitamin D and Health Outcome	Too Little Evidence to Complete Analysis
Cognitive, Motor, Adaptive Behaviour, Socio-Emotional Development		Gould et al, 2017 ^{69*}	
Adiposity		Theodoratou et al, 2014 ⁶⁵	

* Individual studies published recently; therefore not included in systematic reviews or meta-analyses.

Appendix B: Dietary Reference Intakes (DRI)⁷⁵

The Dietary Reference Intakes (DRIs) are a comprehensive set of scientifically based nutrient reference values for healthy populations. They are a standard established by the Institute of Medicine (IOM) for use in Canada and the United States.

DRI is a term that describes four types of reference values:

- Estimated Average Requirement (EAR)
- Recommended Dietary Allowance (RDA)
- Adequate Intake (AI)
- Tolerable Upper Intake Level (UL)

EAR

The EAR is the median usual intake that is estimated to meet the requirement of half the healthy individuals in a specific life-stage and gender group (the other half of the individuals in the group would not have their needs met). The EAR is used to calculate the RDA.

RDA

The RDA is the average daily intake level that is sufficient to meet the nutrient requirement of 97 to 98 percent of healthy individuals in a particular life-stage and gender group.

The RDA is used as a goal for usual intake of individuals. An RDA can only be set for a particular nutrient if there is sufficient scientific evidence to establish an EAR for that nutrient.

AI

The AI is a recommended average daily intake level based upon observed and experimentally calculated estimates of nutrient intake by a group (or groups) of apparently healthy people. In these cases, the groups are assumed to be in an adequate nutritional state.

An AI is derived for a nutrient if sufficient scientific evidence is not available to establish an EAR and set an RDA. An AI incorporates substantially more judgment than is used in establishing an EAR and RDA. An AI meets or exceeds the needs of most individuals in a particular life-stage and gender group. The AI can be used as the goal for an individual's intake but has limited use to assess.

UL

The UL is the highest level of continuing daily nutrient intake that is likely to pose no risk of adverse health effects in almost all individuals in the specific life-stage group. Intake at the UL is, by definition, safe but not intended to be a recommended level of intake.

- As intake increases above the UL, the potential risk of adverse effects increases.
- At intakes between the RDA and UL, the risks to the individual of inadequacy and of excess are both close to zero.

Appendix C: Maternal & Healthy Term Infant (Birth – 12 Months) Vitamin D Practice Support Tool for Healthcare Professionals in British Columbia

Vitamin D Recommendations

for Perinatal Women & Healthy Term Infants (Birth - 1 year)

Practice Support Tool for Health Professionals in British Columbia

About This Practice Support Tool

This is a quick reference tool. Its purpose is to share with health professionals information related to vitamin D in order to provide informed recommendations to clients/ patients to ensure adequate vitamin D intakes for perinatal women and healthy, term infants (birth – 12 months).

This tool is based on the scientific literature reviewed in *Vitamin D Recommendations for Perinatal Women & Healthy Term Infants (Birth - 1 year): Background Paper for Health Professionals in British Columbia* available at [INSERT URL]. This tool also includes additional practice information related to vitamin D supplements available in BC, as well as, programs assisting with the purchase of vitamin D supplements.

Perinatal Women

Key Practice Point: Most perinatal women require a vitamin D supplement of 400 IU (10 µg) – 600 IU (15 µg).

Key Practice Point: For perinatal women at higher risk of insufficiency/ deficiency, health professionals may recommend vitamin D supplementation to reach intake levels above 600 IU (15 µg) as a clinical decision.

Rationale/Details:

- To promote the health of both women and their infants, it is recommended that all pregnant women achieve a minimum of 600 IU (15 µg) per day of vitamin D from a combination of supplements and dietary sources. Regardless of lactation status, it is recommended that postpartum women achieve a minimum of 600 IU (15 µg) per day of vitamin D from a combination of supplements and dietary sources.
- Vitamin D production from sun exposure is limited in Canada.
- Vitamin D is found in few dietary sources.
- The Recommended Dietary Allowance for women 19 – 50 years (including pregnancy and lactation) is 600 IU (15 µg) per day.
- The Tolerable Upper Intake Level for women 19 – 50 years (including pregnancy and lactation) is 4000 IU (100 µg) per day.
- Risk factors for maternal vitamin D insufficiency/ deficiency with **strong evidence** include: Latitude, season, darker skin tone, minimal skin exposure due to clothing choices, and not taking supplemental vitamin D.
- Risk factors for maternal vitamin D insufficiency/ deficiency with **weak or mixed evidence** include: Higher BMI, smoking during pregnancy, lower socioeconomic status, younger maternal age, and lower physical activity.
- There is a fee for serum vitamin D testing unless ordered by a specialist. For more information, see the Vitamin D Testing Protocol at BCGuidelines.ca (in the Endocrinology section).

Healthy, Term Infants (Birth – 1 Year) Receiving Breast Milk

Key Practice Point: For healthy, term infants who are exclusively or partially breastfed, recommend a daily liquid vitamin D supplement of 400 IU (10 µg).

Key Practice Point: Health professionals may recommend higher doses of vitamin D as a clinical decision for individual infants to address known or suspected insufficiency/ deficiency.

Key Practice Point: A key communication point with caregivers is that breastfeeding is the normal and unequalled method of infant feeding. Breastfeeding is the healthy first choice for both mothers and infants. The need for vitamin D supplementation is not due to a deficiency with breast milk. The need is due to limited sun exposure of the infant and mother and limited dietary sources of vitamin D.

Key Practice Point: If an infant's feeding method has changed since last assessment, re-assess vitamin D supplementation.

Rationale/Details:

- These practice points include infants who are fed a combination of breast milk and commercial infant formula, as well as older infants who are consuming complementary foods.
- Start a liquid vitamin D supplement in the first few days after birth as breastfeeding is established.
- The Tolerable Upper Intake Level for infants 0 – 6 months is 1000 IU (25 µg) per day.
- The Tolerable Upper Intake Level for infants 7 - 12 months is 1500 IU (38 µg) per day.
- The risk factor for infants to have insufficient/ deficient vitamin D status is being born to a mother with vitamin D insufficiency/ deficiency.

Supplementing Lactating Mothers Instead of Breastfed Infants

Key Practice Point: Supplementing the mother instead of the infant is not recommended until the safety of the required high doses is known.

Rationale/Details:

- For infants exclusively receiving breast milk, mothers may be interested in supplementing themselves with vitamin D instead of infants.
- Studies indicate that maternal doses of vitamin D much higher than the Tolerable Upper Intake Level for mothers are required to raise breast milk vitamin D levels in order for infants to receive the recommended dose via breast milk.
- The Tolerable Upper Intake Level for women 19 – 50 years (including pregnancy and lactation) is 4000 IU (100 µg) per day.
- For more information on hypervitaminosis D, see the Vitamin D Testing Protocol at BCGuidelines.ca (in the Endocrinology section).

Healthy, Term Infants (Birth – 1 Year) Receiving Commercial Infant Formula

Key Practice Point: Healthy, term infants fed commercial infant formula only, and who were born to mothers with adequate vitamin D status during pregnancy, do not need a liquid vitamin D supplement.

Key Practice Point: For healthy, term infants fed commercial infant formula only, if the mother's vitamin D status during pregnancy was suspected to be insufficient/ deficient, consider a daily liquid vitamin D supplement of 400 IU (10 µg) until the infant is consuming 800 - 1000 mL of commercial infant formula daily.

Key Practice Point: Give healthy, term infants who are fed a combination of commercial infant formula and breast milk a liquid vitamin D supplement of 400 IU (10 µg) every day.

Key Practice Point: Health professionals may recommend higher doses of vitamin D for individual infants to address known or suspected insufficiency/ deficiency as a clinical decision.

Key Practice Point: If an infant's feeding method has changed since last assessment, re-assess vitamin D supplementation.

Rationale/Details:

- These practice points include older infants who are consuming complementary foods.
- The Tolerable Upper Intake Level for infants 0 – 6 months is 1000 IU (25 µg) per day.
- The Tolerable Upper Intake Level for infants 7 - 12 months is 1500 IU (38 µg) per day.
- In Canada, it is mandatory for commercial infant formula designed for term infants to be fortified with vitamin D. Considering the fortification level, infants consuming approximately 800 - 1000 mL per day of commercial infant formula designed for term infants are meeting the recommendation of 400 IU (10 µg) of vitamin D per day.

Important Points About Vitamin D Supplements

D₂ and D₃:

Vitamin D supplements are available as vitamin D₂ and vitamin D₃. The common supplements available in British Columbia contain vitamin D₃. Vegan supplements sold in Canada are made from vitamin D₂. There is mixed evidence regarding whether vitamin D₃ is more effective than vitamin D₂. Vitamin D supplements are available in several formulations. They may provide vitamin D alone or in conjunction with other vitamins.

Adults:

Adult tablet vitamin D supplements usually provide 400 IU (10 µg) or 1000 IU (25 µg) per dosage. Liquid vitamin D supplements formulated for adults usually provide 1000 IU (25 µg) per dosage. Prenatal multivitamins currently on the market commonly provide 200 IU (5 µg) - 800 IU (20 µg) per dosage.

Infants:

Supplements for infants provide 400 IU (10 µg) per dosage. To prevent vitamin D toxicity, check the label to ensure that a supplement provided to an infant is labeled as an infant product. Check that caregivers are providing the correct dosage volume for infants for the formulation (e.g. 1 drop, 0.25 mL, or 1 mL).

Three common formulations are:

- 400 IU (10 µg) in a single drop (0.028 mL).
- 400 IU (10 µg) in 0.25 mL.
- 400 IU (10 µg) in 1 mL.

Note that the market is always evolving so caregivers may use formulations different from the three described here.

Accidental Double Dose & Hypervitaminosis D:

For infants, an isolated double dose of vitamin D, i.e. 800 IU (20 µg), is not a cause for concern. The Tolerable Upper Intake Level (UL) for infants 0 – 6 months is 1000 IU (25 µg) per day and the UL for infants 7 – 12 months is 1500 IU (38 µg) per day. However, cases of vitamin D toxicity (hypervitaminosis D) have been reported when caregivers provide the incorrect product or incorrect dosage over a period of time. Hypervitaminosis D causes hypercalcemia. Medical attention is required if hypervitaminosis D is suspected. For more information on hypervitaminosis D, see the Vitamin D Testing Protocol at BCGuidelines.ca (in the Endocrinology section).

Missed Dose:

If caregivers forget to give an infant vitamin D on occasion, advise caregivers to provide their usual daily dose when they remember. There is no need to give a “make-up” double dose. If caregivers frequently forget to provide an infant with vitamin D, discuss a strategy with caregivers to help them be successful with daily supplementation.

Programs Assisting with Purchase of Vitamin D Supplements:

Two programs in BC can assist eligible perinatal women and caregivers with the purchase of supplements:

- The First Nations Health Authority Health Benefits Program covers prenatal multivitamins for eligible pregnant and breastfeeding women and 400 IU (10 µg) liquid vitamin D supplements for eligible infants. See fnha.ca/benefits for details.
- The [BC Association of Pregnancy Outreach Programs](#) currently provides for eligible clients, 400 IU (10 µg) for pregnant women based on prenatal intakes and 400 IU (10 µg) liquid vitamin D supplements for breastfed infants.