High-Dose Vitamins

Jason B. Sauberan¹,²

Concentrations of most vitamins in breast milk are dependent on maternal diet.¹ Daily vitamin supplementation to achieve adequate dietary intake is thus a recommended intervention for lactating mothers who are undernourished, or for those with dietary restrictions. Even in mothers with no known dietary deficiency risks, the use of prenatal vitamins during lactation is commonplace and is recommended intervention for lactating mothers who are undernourished, or for those with dietary restrictions. Even in mothers with no known dietary deficiency risks, the use of prenatal vitamins during lactation is commonplace and is considered safe for the breastfed infant (Table 1).²,³ Some lactating mothers may elect to consume high-dose or “megadose” vitamin therapy, beyond that required for adequate daily intake. Commonly used vitamins taken in megadoses are listed in Table 2. Depending on the vitamin, dosage, and the mother’s underlying vitamin status, this practice could potentially lead to vitamin concentrations in milk that are harmful to the infant. This column briefly reviews the available published data and provides recommendations for nursing mothers considering vitamin megadosing.

Vitamin C

Average milk vitamin C concentrations are 50–80 mg/L in well-nourished mothers consuming adequate vitamin C in their diet, and their milk concentrations are not markedly increased with routine daily multivitamin supplementation. In a study of mothers given high doses between 250 and 1,000 mg daily, average milk concentrations were ~100–120 mg/L after 2 days of supplementation, but were not significantly related to dose. The maximum measured concentration was 158 mg/L in a subject taking only 250 mg/day.⁴ In a separate case, a mother taking 4,000 mg vitamin C per day during pregnancy and lactation had a milk concentration of 105 mg/L.⁵ Based on the highest milk concentration reported, an exclusively breastfeeding infant would be expected to consume ~25 mg/kg per day, which is similar to the treatment dose for infants with scurvy, and well below infant exposures known to cause harm.⁶ A once daily 500 mg vitamin C dose, along with 100 IU of vitamin E, also improves the milk biochemical antioxidant profile.⁷ Maternal use of high-dose daily vitamin C (>200 mg/day) is not a reason to discontinue breastfeeding.

Vitamin B₂ (riboflavin)

Average milk concentrations are 300–600 mcg/L in well-nourished mothers consuming adequate riboflavin in their diet. Routine 1.8–2 mg daily supplementation modestly increases milk concentrations by 30–70 mcg/L in both under- and well-nourished lactating mothers. The highest supplemental dose studied has been 10 mg/day; milk concentrations increased from 200 mcg/L at baseline to 750 mcg/L after several months of supplementation.⁸ There have been no reports of milk concentrations or breastfed infant safety during maternal high-dose riboflavin therapy. Intravenous high-dose riboflavin has been safely used in hyperbilirubinemic newborns as an adjunct to phototherapy. Riboflavin is considered to have a wide safety margin in humans and there is no established upper limit of tolerability. A common benign side effect of larger doses is bright yellow urine discoloration.⁹ Owing to a lack of data, other drugs for migraine prophylaxis with good safety records during breastfeeding (e.g., propranolol, nortriptyline) are preferred over riboflavin. However, considering the wide safety margin of riboflavin, maternal use of 400 mg/day of riboflavin is not a reason to discontinue breastfeeding.

Vitamin B₆

Pyridoxal is the dominant form of vitamin B₆ in human milk rather than pyridoxine or pyridoxamine. All three forms are equally bioactive and interconvertible in the mother’s body. Pyridoxine is used medicinally because it is the most chemically stable. Average total vitamin B₆ milk concentrations are 70–180 mcg/L in healthy mothers not taking a supplement. Modest daily maternal supplementation with 6–7.5 mg pyridoxine increases milk concentrations to 200–400 mcg/L, whereas higher daily doses of 10–20 mg increase concentrations to 400–700 mcg/L. At these higher concentrations, the breastfed infant would only be exposed to ~100 mcg/kg per day.

Pyridoxine 25 mg/day is recommended in mothers taking isoniazid and is not a reason to discontinue breastfeeding according to CDC and WHO tuberculosis management guidelines. Very high dosages of 300 mg/day can be used to treat neuritis caused by certain drugs, and 200–600 mg/day has been studied for postpartum lactation suppression by decreasing prolactin production, although it is often not effective.¹⁰ With usual dosages found in vitamin supplements, pyridoxine has no effect on prolactin or lactation. There have been no reports of milk concentrations or breastfed infant safety with the very high doses of pyridoxine, although the clinical situations in which such dosages might be used typically preclude breastfeeding. Considering the robust

¹Neonatal Research Institute, Sharp Mary Birch Hospital for Women and Newborns, San Diego, California.
²Dr. Sauberan is the author of vitamin and opioid drug records for LactMed.
response of milk vitamin B₆ concentrations to maternal supplementation, maternal megadosing (200–600 mcg/day) is very likely to expose the breastfed infant to well above their daily requirement. However, such exposures are unlikely to be greater than the 1 mcg/kg per day infant pyridoxine dose routinely used to prevent isoniazid-induced neuritis.

### Vitamin B₁₂ (cobalamin)

Average milk concentrations are 400–900 ng/L in well-nourished mothers with adequate vitamin B₁₂ status. A daily 250 mcg maternal dose in B₁₂ deficient mothers increased milk concentrations by ~90 ng/L, providing exclusively breastfed infants an extra 0.013 mcg/kg per day of vitamin B₁₂.¹¹

Vegan mothers in the United States taking high-dose daily B₁₂ supplements (range 100–5,000 mcg/day) had a median milk vitamin B₁₂ level of 830 ng/L at 2 weeks postpartum, and 15% had milk concentrations at or more than the assay limit of 1,670 ng/L.¹² Even at such a high milk concentration, a breastfed infant would only be exposed to 0.25 mcg/kg per day, which is about two to three times the adequate daily intake. Vitamin B₁₂ is considered to have a wide safety margin in humans and there is no established upper limit of tolerability. Neonates with methylmalonic acidemia are given 2.5 or 5 mg K₁ increases milk concentrations to much above the minimum cutoff for deficiency during the study period without any direct infant supplementation.¹³ Since not all infants studied achieved this outcome, infant serum 25-OH-vitamin D monitoring would be prudent to confirm efficacy if a mother chooses to megadose in this range without directly supplementing her infant. Average milk concentrations in these studies were 130–370 IU/L after 1–3 months of treatment, which would not be expected to expose the breastfed infant to excessive vitamin D if the infant were to be also directly supplemented at the recommended 400 IU/day dosage. However, average milk concentrations of ~900 IU/L were reported in mothers after 7 months of 6,400 IU/day supplementation plus increased seasonal maternal sun exposure. Thus, the combination of maternal megadosing 6,400 IU/day plus copious summertime sun exposure plus infant supplementation could potentially expose the exclusively breastfed infant to excessive (>1,000 IU) daily doses of vitamin D and should be avoided or closely monitored.

### Vitamin D

Milk vitamin D concentrations are highly variable between individual mothers due to the positive effect of sunlight exposure. Those taking daily supplements with 400–2,000 IU have average milk concentrations of 50–80 IU/L. These concentrations are slightly higher than those in non-supplemented well-nourished mothers living in higher latitudes during winter months, but not necessarily in summer. In small studies, mothers with normal or borderline deficiency vitamin D given daily supplemental doses in the 4,000–6,400 IU range, or a one-time 150,000 IU dose, had their breastfed infants’ vitamin D status improve, on average, to more than the minimum cutoff for deficiency during the study period without any direct infant supplementation.¹⁴ Since not all infants studied achieved this outcome, infant serum 25-OH-vitamin D monitoring would be prudent to confirm efficacy if a mother chooses to megadose in this range without directly supplementing her infant. Average milk concentrations in these studies were 130–370 IU/L after 1–3 months of treatment, which would not be expected to expose the breastfed infant to excessive vitamin D if the infant were to be also directly supplemented at the recommended 400 IU/day dosage. However, average milk concentrations of ~900 IU/L were reported in mothers after 7 months of 6,400 IU/day supplementation plus increased seasonal maternal sun exposure. Thus, the combination of maternal megadosing 6,400 IU/day plus copious summertime sun exposure plus infant supplementation could potentially expose the exclusively breastfed infant to excessive (>1,000 IU) daily doses of vitamin D and should be avoided or closely monitored.

### Vitamin K

Concentrations of vitamin K₁ (phyloquinone, phytomenadione) in breast milk are 1–3 mcg/L in most studies of well-nourished women not taking a supplement. Single large oral vitamin K₁ doses of 20 mg can transiently increase milk K₁ concentrations to ~130 mcg/L within 12–24 hours after dosing, but concentrations return to baseline after 1 week. Daily administration of 2.5 or 5 mg K₁ increases milk

### Table 1. Vitamin Reference Values

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>RDA</th>
<th>PNV</th>
<th>UL</th>
<th>Infant AI</th>
</tr>
</thead>
<tbody>
<tr>
<td>B₂</td>
<td>1.6 mg</td>
<td>2 mg</td>
<td>NE</td>
<td>0.3 mg</td>
</tr>
<tr>
<td>B₆</td>
<td>2 mg</td>
<td>2 mg</td>
<td>100 mcg</td>
<td>100 mcg</td>
</tr>
<tr>
<td>B₁₂</td>
<td>2.8 mcg</td>
<td>4 mcg</td>
<td>NE</td>
<td>0.4 mcg</td>
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<tr>
<td>Biotin</td>
<td>35 mcg</td>
<td>30 mcg</td>
<td>NE</td>
<td>5 mcg</td>
</tr>
<tr>
<td>C</td>
<td>120</td>
<td>100 mg</td>
<td>2,000 mg</td>
<td>40</td>
</tr>
<tr>
<td>D</td>
<td>600 IU</td>
<td>400 IU</td>
<td>4,000 IU</td>
<td>400 IU</td>
</tr>
<tr>
<td>K</td>
<td>90 mcg</td>
<td>—</td>
<td>NE</td>
<td>2 mcg</td>
</tr>
</tbody>
</table>

*Recommended dietary allowance (RDA) per day for lactating women >18 years of age.

Typical prenatal vitamin (PNV) content may vary slightly among different products.

Upper limit (UL) of daily tolerability for lactating adult women, from NIH.

Adequate daily intake (AI) for infants 0–6 months of age.

### Table 2. High-Dose Oral Vitamin Uses

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Use</th>
<th>Daily high dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>B₂</td>
<td>Migraine</td>
<td>400 mcg</td>
</tr>
<tr>
<td>B₆</td>
<td>Neuritis</td>
<td>200–600 mcg</td>
</tr>
<tr>
<td>B₁₂</td>
<td>Anemia, CV health, vegetarianism</td>
<td>250–5,000 mcg</td>
</tr>
<tr>
<td>Biotin</td>
<td>Skin and hair health</td>
<td>2.5 mg</td>
</tr>
<tr>
<td>C</td>
<td>Common cold</td>
<td>250–1,000 mcg</td>
</tr>
<tr>
<td>D</td>
<td>Bone health, cancer prevention</td>
<td>2,000–6,000 IU</td>
</tr>
<tr>
<td>K</td>
<td>Bone health, CV health</td>
<td>1–5 mg</td>
</tr>
</tbody>
</table>

*Purported benefits in the mother, not necessarily endorsed by the author. See NIH for more information.

Typical doses likely to be encountered, see text and NIH.

CV, cardiovascular.
concentrations to 60–80 mcg/L. Such concentrations would provide the exclusively breastfed infant with ~10 mcg/kg per day of K1, which is more than the adequate intake, but very similar to the intake of formula-fed infants. One study found that a 5 mg daily oral maternal K1 supplement improved the infant biochemical vitamin K status and lowered the infant risk of K1 deficiency compared with no maternal supplementation, in exclusively breastfed infants who also received a standard birth intramuscular 1 mg dose.15 High-dose maternal vitamin K (1–5 mg) is, therefore, safe for the breastfed infant, but available data do not support maternal supplementation as a substitute for direct administration of vitamin K for the prevention of vitamin K deficiency bleeding.

Although K1 is the dominant form of vitamin K in the diet and in human milk, vitamin K2 is also naturally present in milk, predominantly as the K2 subtype menaquinone-4, also called MK-4. Very high MK-4 doses of 15–45 mg/day are commonly promoted for bone health based on studies conducted in postmenopausal women to lower the risk of osteoporosis. No published information regarding vitamin K milk levels in mothers taking any dose of MK-4 supplements could be located. MK-4 has a higher reported milk–plasma ratio than K1, which is consistent with its known wider distribution throughout the body. There are also multiple forms of K2 besides MK-4 that may be contained within products marketed or labeled as “vitamin K2.” Lactating mothers should be discouraged from taking very high dose K2 or MK-4 until better data are available. Low maternal vitamin K2 doses (<1,000 mcg) taken as a daily supplement to maintain normal dietary intake would not be a reason to discontinue breastfeeding.

**Summary**

Although megadosing of vitamins is usually unnecessary for the mother or infant, there is little evidence of infant harm from this practice. Extremely high doses of pyridoxine might suppress milk production.

**Disclosure Statement**

No competing financial interests exist.

**References**


Address correspondence to:

Jason B. Sauberan, PharmD
Neonatal Research Institute
Sharp Mary Birch Hospital for Women and Newborns
303 Health Center Drive
San Diego, CA 92123

E-mail: jason.sauberan@sharp.com