Sanford Medical Center

Aunt Cathy's Guide to:

Choosing Appropriate Infant Milks and Formulas

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Part 1: Nutrition Issues in Breastfeeding.

The ideal food for most babies is **human milk.** Even for this nearly Universal Truth however, there are exceptions (e.g. infants with the rare inborn metabolic error "galactosemia" may not have human milk.) Formulas are attempts to provide similar nutrition for healthy babies who are not breast-fed, or to meet the nutritional requirements of infants with special health problems. The American Academy of Pediatrics recommends human milk for at least the first year of life.

Although it is less common in America than in other nations, nursing through the second year (or even longer) is also beneficial and the practice is increasing. [However, it is important to note that, for reasons described later, it is not recommended to breastfeed the baby exclusively without the addition of selected other foods after six months, and without vitamin D supplementation throughout breastfeeding.]

This part of the paper will focus primarily on some evolving issues regarding the assurance of macronutrient and micronutrient adequacy in human milk. Commercial formulas and cow's/goat's milk issues in infant feeding will follow.

[For a more complete discussion of the many benefits of human milk and a review of the data now available that demonstrates its clear superiority to any formula for most babies, please see my separate paper entitled "Some Issues in Breastfeeding."]

Macronutrients: Protein, Carbohydrate and Lipids

The best infant diets are those which provide adequate but not excessive amounts of calories, protein, vitamins, minerals and fluid, with a distribution of calories from carbohydrate, protein and fat in the "desirable range". This is the range within which babies have been seen to grow well without excessive metabolic stress (Fomon, 1974.) It appears that most babies are fairly flexible little people and tend to do well within a fairly broad range of feeding practices.

Percent of calories from:	CHO	PRO	FAT
Desirable range:	35 - 65	7 - 16	30 - 55
Human milk:	38	7	55

Protein

Why is human milk at the lower end of the range in protein?

Human milk has a protein content on the lower end of the range and a fat content on the upper end. This is acceptable because the forms of protein and fat are so perfectly suited to baby's immature digestive and metabolic systems that absorption and utilization of these nutrients is optimal. The protein content of human milk will continue to stay in the appropriate range even when mothers are protein deficient. This is because protein goes into the milk at mother's expense if there is an inadequacy.

No other food has protein that is so well absorbed or well utilized, so it is best to avoid the extremes of the "desirable range" if something other than human milk is fed. In other words, a diet that provides only 7% of calories as protein from formula or any other source could be inadequate for optima growth.

As discussed in a later section, commercial formulas do provide a more generous percentage of calories as protein for that reason (milk-based formulas provide ~9-11 % of calories as protein, and soy products provide 11-13%. But both human milk and formula protein adequacy can be compromised by practices such as adding lots of additional carbohydrate or fat calories for babies with higher calorie needs, or giving a substantial amount of cereals, fruits or juices to the diet.

Neither the protein nor calcium content of human milk is greatly affected by current maternal diet, but that does mean that maternal dietary inadequacies will be compensated for by a loss from the mother's stores or tissues. For that reason, a poor intake is certainly not optimal for mother's health. **Mother and baby should not be in competition for nutrients**. There are also specific examples of the many benefits associated with assuring the adequacy and absorbability of maternal calcium intake during both pregnancy and breastfeeding.

For example, the adequacy of current calcium intake and absorption has been shown to decrease the developing baby's exposure to harmful substances that may be stored in the mother's bones. This includes **heavy metals like lead.** If the mother has to mobilize her bone calcium to replace blood calcium lost to the fetus or the milk, any lead present in her bones would be freed and enter the bloodstream along with the calcium. It would therefore reach both mother and baby.

Carbohydrate

The carbohydrate of human milk is lactose …a combination of glucose and another simple sugar (a monosaccharide) called galactose. The lactose is broken apart by lactase enzyme and the two monosaccharides are then small enough to be absorbed. Failure to break it apart means the lactose will not be absorbed. If the problem is severe enough this can result in wasted calories, diarrhea and intestinal gassiness … the classical picture of "lactose intolerance."

So how common is lactose intolerance in infants? Actually, babies all around the world are rarely truly "lactose intolerant" even in populations who become less able to digest lactose as they get older. Babies can be temporarily lactose intolerant due to intestinal damage due to malnutrition, infection, or certain diseases like unrecognized celiac disease (after gluten has been introduced.) But even then, the benefits of continuing to provide human milk far outweigh any potential problem with lactose in most instances.

The popular conception that lactose intolerance is a big problem with infants is very overblown, and it is primarily a marketing opportunity. As discussed later, many formulas that are advertised as lactose free also have other changes in their construction that can contribute to baby's tolerance.

Lipids: Fats and Sterols

Cholesterol One of the components of human milk that is not in any formula is ready-made cholesterol. Cholesterol is actually a very important structural sterol, being a key component of all cell membranes and the myelin around nerves. Babies need to grow rapidly so they need to make lots of new cell membranes, and they need to myelinate their nervous system in utero and in the first two years after delivery. Several hormones and bile are also made out of cholesterol.

We have always assumed that babies could simply make their own cholesterol from the other substances in formula. However, if a baby had difficulty making the optimal amount of cholesterol, no commercial formulas would help him/her out. But human milk would provide that extra boost.

[There is a rare genetic condition of severe inability to produce cholesterol called Smith-Lemli-Opitz Syndrome. Impairment of cholesterol production is so severe that even the human milk pre-formed cholesterol content is insufficient to solve the problems for several reasons. However, babies having difficulty producing optimal cholesterol temporarily for reasons of serious illness or prematurity might truly benefit from having some delivered "ready-made."]

Essential fatty acids **The fatty acid distribution depends on the mother's diet,** and in most instances in America, people take in generous total fat (or other calorie sources,) and sufficient amounts of linoleic and alpha-linolenic acids from plant oils (the "essential" fatty acids.) It is not difficult to assure caloric adequacy and adequate amounts of these two essential fatty acids for the fetus and for human milk.

However, it now appears that some <u>other</u> fatty acids may also be "essential" because the ability of some people to make enough of them on their own is insufficient. Pregnancy and lactation in particular appear to be periods where some people fail to make an optimal amount from the two 18-carbon essential vegetable oils.

One example of a potentially essential form of fat is the 22-carbon omega-3 fat called **DHA** (DocosaHexaenoic Acid). **DHA is critical to brain and retinal development.** Our assumptions have been that this fat can be readily made from alpha-linolenic acid by way of an intermediate 20-carbon fat called EPA (Eicosapentaenoic Acid.). Now it appears that the omega-3 fats EPA and DHA, and the 20 carbon omega-6 fat ARA (Arachidonic Acid) are "conditionally essential." In other words, some people can make enough on their own and some people cannot, and they are especially unable to do it during pregnancy and lactation when providing DHA is so important for brain development.

Milk DHA levels can be quite variable depending on the mother's current intake and stores, and worldwide the DHA content of human milk has been found to be decreasing. This is now seen to be a serious issue during pregnancy as well. **Bottom line: It is now recognized that the ability of most humans to produce DHA from the essential plant fatty acid linolenic acid via EicosaPentaenoic Acid (EPA) is much less than was presumed.**

Long-Chain Omega 3 Fats in Mother's Milk:

Fetal and Infant Development Issues:

The discussion of omega-3 fats in particular is included here because it is unrelated to the macronutrient (calorie) function of fat discussed later. Oils rich in omega-3 fatty acids perform many specific important metabolic functions. They have important implications in pregnancy and infant nutrition in particular. As described, DHA is a major fat of the brain, and research is growing that providing some pre-formed DHA is advantageous. Other health benefits continue to be identified, including the (so far) a possibility of decreased risk of preterm delivery and decreased risk of allergies.

> [There are <u>many</u> additional health benefits identified for other age groups as well, including maintaining cognition as we age, and issues related to attention and mood. These are described in some detail in my paper "All Those Lipids: Recommendations for Using Different Types of Fats and Oils (Omega-3, Omega-6 and Monounsaturated Oils)" That paper also explains the relationship of the different fatty acids more clearly … and it has pictures!]

Food sources of EPA and DHA: Fish and fish oil provide ready-made EPA and DHA. Taken during pregnancy they improve the DHA content of the fetal brain, and during lactation it increases the amount of pre-formed DHA provided to the infant.

The "pre-formed" part is important: it is now recognized that there is considerable variation in the ability of different individuals to efficiently operate the pathways that make alpha-linolenic acid into EPA and then into DHA. Alpha-linolenic acid is the form of omega-3

fat found in plants. Flax, canola and walnut oil are the most generous sources. Many --- perhaps even most ---people can use it to make the DHA as needed. But for many people there is a clear benefit from getting at least some EPA and DHA "ready-made" in fish and fish oil supplements. This appears to be particularly true during pregnancy and lactation.

That means that many people must rely on an outside source of EPA and DHA to assure adequacy for their own needs and for the baby. In essence, this means that for some people, these fats are also "essential" because that term means that a person cannot make enough on their own.

This discovery of impaired ability to make adequate EPA and DHA from linolenic acid is well demonstrated now. For example, it is one of the reasons behind the recommendation of the American Heart Association that people eat fatty fish twice a week or take supplemental fish oil because that is the ready-made source of both EPA and DHA. So, clearly, we need to look closer at the adequacy of the mother's diet and nutritional status in general.

Many health professionals erroneously assume that mother's milk will have all the nutrients needed by the baby regardless of mother's nutrient intake. As noted earlier, it is the same concept as the old "perfect parasite" theory of a generation or two ago that presumed that babies simply took whatever they needed from the mother's body during pregnancy. That view has been disproved and discarded long ago, but the same old idea continues to be erroneously applied to the concept of nutritional adequacy in both pregnancy and lactation.

DHA made from an algae source is also available as a supplement, and it is the kind used in some supplements designed for pregnant women and in some children's gummi DHA supplements. This is the same form used to provide pre-formed DHA in infant formulas. It can be a reasonable source of DHA depending on the dosage or amount of DHA per-gummi. And comparison shopping shows that gummi-type DHA supplements for often children provide very little DHA per gummi and they can be quite costly. **Additionally**, **the algae-based products do NOT contain any EPA … the omega-3 fat between linolenic acid and DHA.**

EPA has many metabolic roles in the body involving inflammation, blood clotting, the immune system and other functions, and a person with an inability to produce DHA will likely have a difficulty making EPA as well. For that reason, fish oil as a supplement for pregnant and nursing women has advantages over the products that only provide DHA. **Fish oil supplements are easily available now that are free of mercury and other substances that would be of concern when eating fish to get these special oils.**

Do breast-fed babies need anything else?

A Look at Micronutrients: Vitamins and Minerals

Maternal diet/stores CAN be a factor in the amount of several vitamins and minerals in mother's milk as well. These include iodine, zinc, selenium, all the B-vitamins and vitamin C, so attention must be paid to the adequacy of her intake. The fat soluble vitamins (A, D, E and K) are now being re-evaluated in this regard as well.

This is a surprise to many health professionals because earlier models of prenatal and infant nutrition were based on assumptions that the fetus was a "perfect parasite" taking everything it needed, even at mother's expense. The same assumption carried over to assumptions about the nutritional content of human milk.

This was all in the absence of being able to confirm things scientifically. However, now that these issues have been able to be evaluated, **it is clear that the presumption of nutritional adequacy provided to the fetus or breastfed infant needs to be replaced with careful attention to a number of nutrients in the mother's diet.**

Micronutrient Issues: Vitamins

Vitamin D

An epidemic of vitamin D inadequacy in people of all ages has been the focus of literally hundreds of recent reports in the scientific literature. For years, vitamin D inadequacy has been assumed to be a non-issue because most of the time, deficiency lacks the only symptom that has traditionally led physicians to even look for it: that is, overt bone deformity in children.

It has long been (erroneously) assumed that everybody easily produces generous amounts of vitamin D from the action of sunlight on skin. Additionally, as vitamin D is found naturally in very few foods, it has been added to milk and a few other foods more recently in the US. However, the **amount** currently added is insufficient to maintain appropriate blood vitamin D levels in most cases. **Vitamin D deficiency is now recognized as very common, very dangerous, very often unevaluated and rarely corrected. The health consequences are very serious, but the entire situation is very easy to fix once the issue is recognized.**

Maternal/child vitamin D deficiency issues deserve a close look here.

[The following is an excerpt on specific vitamin D deficiency issues in lactation from my paper "Aunt Cathy's Guide: My Current Top Five Ways to Improve Your Family's Nutrition."

There is <u>much</u> more on multiple vitamin D issues in that publication, including recommendations for action. A version is also available with many references from reports in the scientific literature.]

Vitamin D Inadequacy in Breastfeeding Alert

Interestingly, mother's milk is an amazingly nutritious food and breastfeeding is certainly encouraged. However, the milk does not contain vitamin D. This is probably because when people were invented nobody lived in Fargo. As an adaptation to live well up here, we need to have a furnace, a coat, really good mittens and vitamin D. It is that simple. It is also a possibility that the milk would provide adequate amounts if the mother herself were not vitamin D deficient. This question is being studied, but in the meantime, for the health of both mother and baby, it is best to assume that it provides too little unless it is actually checked.

Because of the finding of serious vitamin D deficiency in many breast-fed babies, in 2003 the American Academy of Pediatrics recommended that breastfed babies be given "at least 200 iu of vitamin D by two months of age." **In 2008 that recommendation was changed to 400 iu/day for ALL infants and they recommended starting it right away** because many babies were actually born with inadequate stores of vitamin D because their mothers were deficient during pregnancy (in spite of taking prenatal vitamins.)

This recommended change also included formula-fed babies and not just breast-fed babies because the standard formulas provided 400 iu only when about a quart (32 oz) a day is consumed. Newborns usually take only about 20 oz, so formula-fed infants would also fail to obtain 400 iu without supplementation.

This change brings US recommendations in line with those of their Canadian colleagues who have recommended 400 iu for babies, and at least 800 iu for everyone else up there for several years now. Here are some details of the kind of research that led to this change in recommendation:

A recent study in Boston of 380 healthy infants and toddlers who were seen for a routine health visit evaluated the prevalence of vitamin D inadequacy or overt deficiency. Forty four of 365 children,**12%, had levels lower than 20 ng/mL (clearly deficient)** and 146 children **(40%) had inadequate vitamin D status** based on levels below an accepted optimal threshold (≤30 ng/mL.*)

[Prevalence of Vitamin D Deficiency Among Healthy Infants and Toddlers. ***Arch Pediatr Adolesc Med.*** 2008;162(6):505-512.
Neonatal vitamin D status at birth at latitude 32 degrees 72': evidence of deficiency. J Perinatol. 2007 Sep;27(9):568-71.]

The same Boston authors studied the therapeutic amounts of vitamin D supplementation needed to correct the low vitamin D status of the children. They concluded that these two approaches were effective for bringing low vitamin D levels into the range of ≥30 ng/mL* within a 6 week treatment period: Daily 2000 IU vitamin D2 or D3, **or** Weekly 50,000 IU vitamin D2.

[Treatment of Hypovitaminosis D in Infants and Toddlers.
J Clin Endocrinol Metab. 2008 Apr 15.]

*However, note that a report described earlier suggested that the healthiest ranges of serum vitamin D may in fact be above this "optimal threshold" of ≥30 ng/mL, and that it might be in the range of 36-48 ng/mL. [Optimal serum 25- hydroxyvitamin D levels for multiple health outcomes. Adv Exp Med Biol. 2008;624:55-71.]

Many other approaches to therapeutic supplementation are being investigated as well.

There are concerns about inadequacy of vitamin D in breastmilk (or in any infant feeding regimen) in MANY areas beyond its relationship to the pattern of overt bone deformity we call rickets. Most are not visible.

Inadequacy of vitamin D is now known to be an independent risk factor for an ever-widening range of negative health conditions:

"All-Cause Mortality"

Asthma Diabetes (both **Type 1** & **Type 2)**

Cancer of the Breast, Colon, Prostate, Pancreas
and other types, with roles in both prevention and treatment.

Cardiovascular Disease
both heart attack and especially congestive heart failure

Depression and **Dementia**

Developmental Problems

End-Stage Renal Disease

Immune System Compromise

Lupus, Fibromyalgia and **Scleroderma**

Multiple Sclerosis

Osteoarthritis, Osteomalacia and **Osteoporosis**

Pain in Muscle, Nerve and Bone

Pre-eclampsia in Pregnancy

Rheumatoid Arthritis

Sarcopenia (muscle weakness) and **Falls**

Clearly, assuring the mother's vitamin D adequacy is very important to her health as well as the health of her infant, but this is a topic outside the scope of the present article.

"The recommended adequate intakes for vitamin D are inadequate, and, in the absence of exposure to sunlight, a *minimum* of 1000 IU vitamin D is required to maintain a healthy concentration of 25(OH)D in the blood."

Optimal serum 25- hydroxyvitamin D levels for multiple health outcomes. Adv Exp Med Biol. 2008;624:55-71.

Prevalence of Vitamin D Deficiency Among Healthy Infants and Toddlers *Arch Pediatr Adolesc Med.* 2008;162(6):505-512. Treatment of Hypovitaminosis D in Infants and Toddlers. J Clin Endocrinol Metab. 2008 Apr 15.] Prevalence of Vitamin D Deficiency Among Healthy Infants and Toddlers *Arch Pediatr Adolesc Med.* 2008;162(6):505-512. Vitamin D Status: Measurement, Interpretation, and Clinical Application. Ann Epidemiol. 2008 Mar 8. Sunlight, UV-radiation, vitamin D and skin cancer: how much sunlight do we need? Adv Exp Med Biol. 2008;624:1-15. Vitamin D deficiency: a worldwide problem with health consequences. Am J Clin Nutr. 2008 Apr;87(4):1080S-6S. Neonatal vitamin D status at birth at latitude 32 degrees 72': evidence of deficiency. J Perinatol. 2007 Sep;27(9):568-71.Am J Clin Nutr. 2004 Mar;79(3):362-71)]
[See my "Top Five" handout for much more on vitamin D.]

This topic is absolutely mushrooming in the scientific literature and the issue is too big to describe thoroughly. Note that the references cited above were from 2007 and 2008. Below are just a few of the 2008-9 references out there I had in one of my other papers, and the 2010 literature has even more Every day another study pops out! I just don't have time to organize it all in time for this Feb. 2011 paper to get where it has to go.

However, anyone interested in looking further into this issue can easily go to www.pubmed.org and enter the search term vitamin D. The response is overwhelming. You can also limit your search, say, by entering the words vitamin D infant or lactation, or whatever. "Pubmed" stands for "Public Medline." It is a free service provided by the National Library of Medicine at the National Institute of Health in Washington DC)

A Sample of Some of the Many 2007-2009 Vitamin D References in the Scientific Literature

2009

Modern concepts in the diagnosis and treatment ovitamin D deficiency and its clinical consequences. J Environ Pathol Toxicol Oncol. 2009;28(1):1-4. Vitamin D and aging. J Steroid Biochem Mol Biol. 2009 Mar;114(1-2):78-84. Vitamin D and type 2 diabetes Is there a link? Prim Care Diabetes. 2009 Apr 21. Behavioural and physical characteristics associated with vitamin D status in women. Bone. 2009 Jun;44(6):1085-91 Hypovitaminosis D is Associated with Greater Body Mass Index and Disease Activity in Pediatric Systemic Lupus Erythematosus. J Pediatr. 2009 May 14. Association between 25-hydroxyvitamin D levels and cognitive performance in middle-aged and older European men. J Neurol Neurosurg Psychiatry. 2009 Jul;80(7):722-9. Sex-specific association of serum vitamin D levels with physical function in older adults.Osteoporos Int. 2009 May;20(5):751-60. Vitamin D status and muscle function in post-menarchal adolescent girls. J Clin Endocrinol Metab. 2009 Feb;94(2):559-63. 25.

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2008

Prevalence of Vitamin D Deficiency Among Healthy Infants and Toddlers *Arch Pediatr Adolesc Med.* 2008;162 (6):505-512. Treatment of Hypovitaminosis D in Infants and Toddlers. J Clin Endocrinol Metab. 2008 Apr 15. Optimal serum 25- hydroxyvitamin D levels for multiple health outcomes. Adv Exp Med Biol. 2008;624:55-71. Sunlight, UV-radiation, vitamin D and skin cancer: how much sunlight do we need? Adv Exp Med Biol. 2008;624:1-15. Vitamin D deficiency: a worldwide problem with health consequences. Am J Clin Nutr. 2008 Apr;87(4):1080S-6S.] [Diagnosis and treatment of vitamin D deficiency. Expert Opin Pharmacother. 2008 Jan;9(1):107-118. Prevalence of vitamin D deficiency among healthy infants and toddlers. Arch Pediatr Adolesc Med. 2008:162(6):505-512 Hypovitaminosis D among healthy children in the United States. .Arch Pediatr Adolesc Med. 2008:162(6):513-519. ndependent association of low serum 25-hydroxyvitamin D and 1,25-dihydroxyvitamin D levels with all-cause and cardiovascular mortality. Arch Intern Med. 2008:168(12):1340-1349. Vitamin D and cardiovascular disease risk. Curr Opin Clin Nutr Metab Care. 2008 Jan;11(1):7-12. Hypovitaminosis D in obese children and adolescents: relationship with adiposity, insulin sensitivity, ethnicity, and season. Metabolism. 2008 Feb;57(2):183-91. 25- Hydroxyvitamin D and Risk of Myocardial Infarction in Men A Prospective Study *Arch Intern Med.* 2008;168(11): 1174-1180. Diagnosis and treatment of vitamin D deficiency. Expert Opin Pharmacother. 2008 Jan;9(1):107-118. Vitamin D in Health and Disease. Clin J Am Soc Nephrol. 2008 Jun 4. Monthly ambient sunlight, infections and relapse rates in multiple sclerosis. Neuroepidemiology. 2008;31(4):271-9,

2007

Neonatal vitamin D status at birth at latitude 32 degrees 72': evidence of deficiency. J Perinatol. 2007 Sep;27(9):568-71. Dose response to vitamin D supplementation among postmenopausal African American women. Am J Clin Nutr. 2007 Dec;86(6):1657-62. The urgent need to recommend an intake of vitamin D that is effective. Am J Clin Nutr. 2007 Mar;85(3):649-50. Vitamin D and prevention of breast cancer: pooled analysis. J Steroid Biochem Mol Biol. 2007;103(3-5):708-11 Prevalence of Vitamin D Deficiency Among Healthy Infants and Toddlers *Arch Pediatr Adolesc Med.* 2008;162(6):505-512. Neonatal vitamin D status at birth at latitude 32 degrees 72': evidence of deficiency. J Perinatol. 2007 Sep;27(9):568-71. Macro- and micronutrients in patients with congestive heart failure, particularly African-Americans. Vasc Health Risk Manag. 2007;3(5):743-7. Vitamin D supplementation & total mortality: a meta-analysis of randomized controlled trials. Arch Intern Med. 2007 10;167:1730-7

Vitamin K

A new focus on a previously unrecognized inadequacy of vitamin K in many Americans is showing that many people get far too little and that it contributes to serious health problems such as osteoporosis, kidney damage, calcification of the arteries, pre-eclampsia, diabetes and cancer of the liver and colon. This is in addition to the long recognized role of vitamin K as a tool needed when one needs to clot blood.

Until fairly recently (starting in about 2005) the blood-clotting function was the only known role of vitamin K. Another factor recently identified as contributing to inadequacy is our assumption that generous amounts of vitamin K are provided by intestinal bacteria. Because of this, little nutrition advice focused on this nutrient, it was not included in many multivitamin products, and even the MyPyramid.gov website neglected to include it (or vitamin D) in the sample two-week diet for nutritional adequacy evaluation.

However, it appears that we are all actually much more dependent on an outside source (dietary or supplement) than was assumed. Vitamin K status was (and still is) rarely evaluated, so it is still assumed that all is well. Recent research makes it clear that many people are in fact getting far too little of this nutrient, and it is hurting them.

Concerns about "toxicity" of vitamin K based on the observation that it dissolves in oil have also been shown to be incorrect. In fact, vitamin K is so non-toxic that there is not an upper end of safety identified for its intake. No-one has ever demonstrated an overdose. One reason it is not toxic is that it operatesna s a simple co-factor … a tool that must be present for certain things to move forward. It does not MAKE you clot your blood … it LET'S you clot your blood if your body is telling you to do it.

[Aside: People on the anti-coagulation drug **Coumadin** need to have a very consistent amount because the drug works by interfering with vitamin K. Inadequacy is dangerous for them too, however because it increases the volatility of coagulation. It also puts them at risk for osteoporosis, cardiovascular disease and cancers like everyone else. No one benefits from a vitamin deficiency situation. The Coumadin issue is a specific drug/nutrient interaction … not a general nutrition issue. **For people NOT on this drug, vitamin K is not scary … although inadequacy of vitamin K IS scary.**

Please see my paper "New Roles for Vitamin K" for all the details and references, and another paper I have available for health professionals specifically on the Coumadin issue and the new research that should significantly change how we manage it.]

Some of the new issues being identified have significant implications for pregnancy and lactation. Women who have insufficient vitamin K are at risk of hemorrhage at delivery and have an increased risk of pre-eclampsia. Their infants are at risk of intrauterine hemmorhagic events.

Consider that in America it is common to give infants a vitamin K shot at birth, to reduce the risk of hemorrhage in newborns who received inadequate vitamin K in utero. That means that overt consequential deficiency in the newborn was a common enough occurrence to make vitamin K administration at birth become a standard practice.

I think that means that we should look more closely at maternal vitamin K status (and everyone's for that matter.) For one thing, the vitamin K shot at birth does not protect against hemorrhagic events in either mom or fetus. Studies of newborns have demonstrated that some

children are born with evidence of earlier hemorrhagic events that can contribute to developmental delays.

Additionally, not all babies actually receive the vitamin K shot because of home delivery options, parents' right of refusal, etc. Teleologically, it would seem to be an inefficient plan to design people in such a way that infants all around the world would be born vitamin deficient and at great risk unless someone is on hand with a syringe full of vitamin K. This is an issue requiring attention from both the obstetric and pediatric medical experts working together.

In the meantime, mother's milk can easily be low in vitamin K if mother is low. And many mothers have been shown to be low. If the baby received the vitamin K shot, the low vitamin K status of her milk will not be an issue any more for the baby (Although it will still be a problem for mother.)

But any breastfed baby to whom that shot was not administered really needs to have vitamin K reliably provided. And again … at the moment it is not standardly in many vitamin supplement products. Additionally, it would be a good idea to provide that extra vitamin K to a formula-fed infant as well if the shot was not given … the amount provided in the formula does not provide a generous enough amount to compensate for a combination of low stores at birth and no vitamin K shot.

Vitamins B12 and B6

The B vitamins play many critical roles in metabolism and inadequacy can compromise the growth and development of the baby. In America, serious deficiency of B vitamins is presumed to be extremely rare, but it is now recognized that some of them need a much closer look. Most health professionals are aware that alcohol abuse frequently results in dangerous deficiency of thiamin and folic acid, and of course, perinatal alcohol abuse is even more problematic. But there are other specific concerns about vitamins B12 and B6 that deserve some special attention during both pregnancy and breastfeeding.

As described earlier, for <u>some</u> nutrients (e.g. calcium and protein,) a relatively deficient mother will still provide a good amount to the fetus/baby even at her own body's expense. However, **all of the water soluble vitamins (B vitamins and vitamin C) will fail to be provided optimally to the baby if mother is deficient … maternal needs for these nutrients must be met before she "shares."**

Vitamin B12

Recently, for example, it was found that **babies of mothers who had an inadequate intake of vitamin B12 have deficiency levels even if the mother's labs show her own vitamin B12 level to still be in the normal range.** Deficiency is extremely injurious to the nervous system of both mother and baby. The following are three circumstances that put people at special risk.

1. Because vitamin B12 is found naturally only in animal products, **vegans are well known to be at great risk** unless they take a vitamin supplement containing vitamin B12. There are MANY reports in the scientific literature about this problem and the damage to the infants when it occurs during pregnancy or lactation. But simply assuring that the vegan mother has been taking a supplement **regularly** for quite some time is all one needs to do.

   But if she has not been taking one, or has only begun to take vitamin B12 during pregnancy, for example, her vitamin B12 status could easily still be too low for the fetus/baby to receive the needed amount for optimal development. As vitamin B12 is extremely non-toxic, ideally in this situation a physician or other provider should consider giving her a therapeutic level to correct a suspected deficiency right away.

2. One of the less-well-recognized **emerging risk factors for vitamin B12 deficiency is among people who have GERD (gastro-esophageal reflux disease) and use PPI (proton pump inhibitor) medications that prevent gastric acid production.** Natural sources of vitamin B12 require the presence of gastric acid before it can be absorbed. [This is different from the role of Intrinsic Factor in vitamin B12 absorption.]

   People who use these medications cannot absorb vitamin B12 from natural sources, but they can easily get around this problem by taking a supplement that contains vitamin B12 … just like vegans but for a different reason. In this case it is because the crystalline B12 in supplements does not require the presence of acid in order to become absorbable. But also just like vegans, **if she has been taking the medication for a long time and has only recently begun to take supplemental vitamin B12, there may be a degree of deficiency sufficient to warrant giving a therapeutic amount.**

3. It is becoming increasingly common for women of childbearing age to have undergone **bariatric surgery (gastric bypass for weight loss)** prior to becoming pregnant. Long-term vitamin and mineral status in the women is rarely evaluated, but when it IS, there are several nutrients commonly found to be seriously inadequate even with the use of prescribed supplements.

   Some of these, like copper deficiency (generally extremely rare in the general public and therefore not monitored) are showing up as causes of serious neurologic damage. The potential damage to a fetus or breast-fed infant is huge. Additionally, months/years after the actual surgery many woman stop taking their prescribed supplements for a variety of reasons. This is even more common among people with less ability to afford them. Long term follow-up is rarely undertaken for anything besides weight status and effect on cholesterol or diabetes. By the time micronutrient inadequacies are recognized it is because they are severe enough to be visible … and that is often past the point where prevention of injury is an option.

   An additional important observation is that a study evaluating the nutritional status of people considering bariatric surgery found that **the majority had significant inadequacy of a number of nutrients even before having the surgery**. This may be because of a likely history of trying various restrictive or unbalanced diets to lose weight. But it is also

a reflection of the fact that many people whose appearance suggests that they are very "well-fed" are actually not "well-nourished" at all in terms of vitamins and minerals. In fact, intake of several vitamins and minerals is recognized in large national studies to be unsatisfactory in a large number of Americans.

[Please see my "Carnitine Explanations" paper for more information about another important problem issue that may be present in some people undergoing bariatric surgery.]

Deficiency of vitamin B12 is just one of several problems that are of great concern in the special pregnancy/lactation context. This mother may have <u>several</u> severe nutritional problems that are very likely to have gone unrecognized. Unfortunately, the simple multivitamin that solved vitamin B12 problems for vegans and PPI users is unlikely to be an adequate intervention here. What should be done about it is outside the scope of this paper, but vitamin B12 <u>shots</u> would likely be a needed. Heightening the awareness of healthcare professionals about the existence of the problem is a good place to start.

[Please see my "Vitamin B12" handout for more information about problem issues with this nutrient.]

Vitamin B6

Adequacy of **vitamin B6** in exclusively breast-fed infants has been found to rely often on gestationally accumulated stores. **For some infants, human milk alone without supplemental foods may be insufficient to meet vitamin B6 needs after 6 months of age** (*Pediatr Gastroenterol Nutr* 1996 23(1):38-44.) Earlier introduction of meats or the use of a multivitamin drop will correct this situation. Most infant vitamin drops contain vitamin B6 and they often contain iron, but they do not contain zinc. **Meats are the richest sources** of **vitamin B6 and well-absorbed iron and zinc … the three nutrients that have been observed to "drop out" of breastmilk after 6 months.**

This argues for reversing our most recent traditional pattern of introduction of solids by introducing meats by about age 6 months instead of introducing it after 10 months or later. This problem can also be addressed by using a crushable-type multivitamin with minerals instead of an infant vitamin drop; it contains <u>all three</u> of the micronutrients (zinc, iron and vitamin B6) that decrease so precipitously in mother's milk after 6 months. It can be crushed and added to baby food.

<u>Micronutrient Issues: Minerals</u>

Iron

The **iron** in human milk is very well absorbed – the best of them all, with estimates between 25% and 50% absorption. Compare this with the next best source of iron (meats, at about 20%) and with the much less absorbable form in plants and pills (which are only about

0.25-2% absorbed.) But although iron in human milk is well absorbed, but there is not a great deal of it.

Most term babies are presumed to have enough iron stored up so they do not "run out" until about 4 months of age. Since this is the age at which many babies begin to have the developmental skills to eat from a spoon, providing foods that are good iron sources plus the iron in mother's milk may be adequate.

On the other hand, one might argue for providing an additional source of iron (e.g. an iron drop) to avoid emptying baby's iron reserves before he/she actually "runs out." Premature babies often have poorer iron stores because the iron (like zinc, calcium and other minerals) is stored in the baby's body primarily in the third trimester of pregnancy. They simply get out of line too soon.

The iron "cost" of growth is high, and inadequacy of iron stores can have serious consequences. Anemia is associated with decreased ability to learn and to pay attention that can remain a problem for months after the anemia itself is corrected by treatment. Additionally, the "presumed iron stores" of the average term baby are just that … "presumed" … not "assessed." **Historically this approach has not always served us well**.

Iron-deficiency anemia has also been found to be associated with increased likelihood of being identified as having mild or moderate developmental delay in school. This is likely because iron has many important rolls in all of the cells of the body, including such tasks as oxygen transport, energy production, protection against environmental toxins, and function of brain neurotransmitters. For example, some iron-related brain-development functions in utero are on such a strict time-table that inadequacy of iron during that period can cause irreparable impairment.

As was the case with calcium, good iron status also decreases the absorption of lead from the environment, a known agent of severe injury to brain, bone and kidneys, and a contributor to hypertension. Iron deficiency results in an attempt to increase absorption of iron in the intestine, and the process accidentally increases the absorption of lead as well.

Reliance on hemoglobin to screen for poor iron status is risky without also having information about the adequacy of the person's iron intake. This is because hemoglobin levels can actually remain normal until iron stores are depleted. A low hemoglobin is a sign of trouble, but a normal one tells very little about the status of iron stores. Measures of iron stores (like a "ferritin" level) are rarely used at present in evaluating babies who appear to be healthy. But asking specific questions about regular iron supplement use and/or meat consumption tells us a lot about the likelihood of there being an unrecognized compromised iron status in a particular woman or infant.

There is some concern that providing additional iron to a breast-fed baby may decrease the effectiveness of one of the substances in human milk that helps to control bacterial growth. Lactoferrin in human milk binds iron that E. coli bacteria in the gastro-intestinal tract need in order to reproduce. Giving additional iron would make more free iron available to the bacteria as well as to the baby.

It is not clear that this is a big problem, however, since there are many other bacteria-fighting substances in human milk that are not affected by the presence of iron. Also, the fact that most formula-fed infants thrive while regularly receiving generous dietary iron that is not bound to lactoferrin suggests that is not a major problem. After all, these babies receive none of the many other protective substances in breast milk either.

Complicating the picture is the finding that the iron in infant cereal that has traditionally been used to provide iron in baby's diet may not be as well absorbed as had been believed. Its ability to provide useable iron to the infant has been questioned, but so far no one has questioned whether iron provided in the form of fortified cereal increases the risk of E coli infection in breast-fed (or any) infants.

Two feeding practices can sometimes have an effect on the absorption of iron in infants:

1) Iron supplements given with a (non-human) milk or formula feeding are likely to be less well absorbed compared with supplements fed with an acidic food or meat. Meat contains "Meat Protein Factor" which enhances absorption of inorganic iron from other foods fed with the meat.

2) Although in some cultures it is common to feed **tea** to infants, the tannins in it greatly reduce inorganic iron absorption in both infants and adults. This does not appear to be a problem for organic iron forms such as are found in breastmilk and meats, so feeding tea to breastfed infants does not induce iron deficiency anemia the way it can in those not breastfed.

   Interestingly, in some world situations the traditional feeding of tea to infants has actually been of great benefit in terms of child survival for the simple reason that the water fed to baby has been boiled and germs have been destroyed. Together, protective elements in mother's milk and boiling any water fed to baby are a terrific combination where bacteria and parasites make the water unsafe.

   However, there is a risk of iron (and zinc) deficiency in a non-breastfed infant who is regularly given tea, and people in many cultures do commonly give it. One way to solve this potential problem (besides encouraging breastfeeding) would be to advise them to **introduce meats earlier**, because the generous iron and zinc content is in a form that is unaffected by the presence of tannins, plus the effects of Meat Protein Factor can help avoid the problem.

Zinc

Iron often described as the micronutrient most likely to be deficient in Americans. However, it is useful to remember that **iron status is also the only non-electrolyte nutrient we evaluate** in many settings. Status of many other nutrients may be suboptimal, but **one that is particularly likely to be "iffy" in an individual with iron deficiency is zinc.**

This is because in nature iron and zinc tend to be distributed similarly in foods and they are also similarly affected by substances that impair or increase intestinal absorption. A person who is iron deficient may also be zinc deficient, although we rarely evaluate it and therefore do not recognize it. And if that person is iron deficient in spite of taking iron supplements and eating iron-fortified foods (which are usually NOT also fortified with zinc,) the odds are even greater that zinc adequacy may be compromised. The exception would be a person has relative iron deficiency because of excessive blood loss.

This is not to make a case for checking zinc levels in people's blood … the point is that **we can regard iron inadequacy as a marker/screening-tool for suspicion of unrecognized inadequacy of zinc in particular, and many other nutrients as well.** In general, people do not consume a diet that gives them a terrific amount of all the nutrients needed except for just the only one we check. Think of that low iron measure as the "canary in the coal mine" that tips you off to an otherwise invisible threat in time to do something about it.

Why is zinc such an issue here?

Zinc is a co-factor in over two hundred metabolic pathways in the body, including making DNA (the genetic center of every cell and hugely important for growth), making T-cells, and metabolizing alcohol and other potentially dangerous substances. Inadequacy is known to impair growth and the function of the immune system. However, zinc has been found to need some attention in breast-fed infants. The same mineral storage patterns are seen for both iron and zinc, with the third trimester being the major period of mineral accretion in the fetus. For this reason, preterm infants are also especially likely to have poor zinc stores.

For term infants, the combination of a well-nourished mother who provided normal fetal zinc stores and then provides human milk should meet growth needs until about age six months. After that time, zinc and iron may be inadequate as described earlier. Of course, a history of <u>poor</u> zinc nutrition of the mother complicates the picture further. Some studies have found that zinc supplementation of exclusively breastfed infants in these circumstances improves growth or other parameters of zinc adequacy [e.g. *Lancet* 2000 Jun 10;355(9220.)]

Supplementing a mother to maintain adequate zinc status does not correct this problem because the **zinc content of the milk begins to drop regardless of her zinc status**. As described earlier, a change in recommended "starter food" patterns has been suggested that includes an earlier introduction of meats (the most abundant source of bioavailable forms of both iron and zinc, and also a generous source of vitamin B6) in breast-fed infants [*Acta Paediatr* 1998;87(6); *J Mammary Gland Biol Neoplasia* 1999;4(3)].

Again, note that infant vitamin drops do <u>not</u> provide zinc (or any minerals except iron and sometimes fluoride) and they contain no folic acid. So if earlier introduction of meats is undesirable, the best way to assure adequacy of zinc, iron and vitamin B6 would be to give a crushed chewable children's multivitamin with minerals.

Nutrient levels will not exceed safe ranges with this dosage, and this approach also provides baby with the 400 iu of vitamin D recommended for all infants by the American

Academy of Pediatrics and the Canadian health groups as well. If texture is an issue, the pill can be crushed to a fine powder using a small mortar and pestle. These are sold in kitchen stores and discount stores (often for $10 or less) because they are used to crush fresh spices. The powder can be mixed into any baby food.

More information about the zinc content and foods, zinc absorption and some special zinc-related issues in fetal alcohol syndrome, are included in my handouts: "Nutrition Support of Iron Deficiency" and "Thinking about Prenatal Nutrition and Fetal Alcohol Syndrome (FAS.)"

Iodine

Another nutrient problem that has recently been found to need more attention is IODINE DEFICIENCY. In many parts of the world (including parts of the US) iodine deficiency is common, and the traditional international approach to solving it has been to add iodine to salt. However, it appears that the amount obtained from iodized salt is actually not sufficient during pregnancy, and that even in areas that have been thought to have corrected iodine deficiency many women obtain too little.

Iodine Deficiency Disease (IDD) is the number one cause of preventable mental retardation in the world. The resurgence of the problem of iodine deficiency in the US has great importance in pregnancy and lactation in particular because of the devastating effects on the intellectual development of the child. Iodine deficiency can also result in deafness, and a serious lack of energy in anyone affected because it impairs the function of the thyroid gland. **The World Health Organization is now increasing the recommendation for iodine intake by 25%, especially in pregnancy.**

Here is an excerpt from a presentation by UNICEF Deputy Executive Director Kul Gautam:

"… IDD is the single greatest cause of preventable mental retardation. Severe deficiencies cause cretinism, stillbirth and miscarriage. But even mild deficiency can significantly affect the learning ability of populations. Scientific evidence shows alarming effects of IDD. Even a moderate deficiency, especially in pregnant women and infants, lowers their intelligence by 10 to 15 IQ points, with incalculable damage to social and economic development of nations and communities. Today over 1 billion people in the world suffer from iodine deficiency, and 38 million babies born every year are not protected from brain damage due to IDD…"

UNICEF Deputy Executive Director Kul Gautam
This quotation comes from the website http://www.saltinstitute.org/Issues-in-focus/Food-salt-health/Iodized-salt-other-additives. It has much more information about the problems of (and solutions for) IDD.

[For more detail on the most recent research on this topic in the scientific literature, please see my handout "New Attention to an Old Problem: Iodine Deficiency in Pregnancy and Lactation"

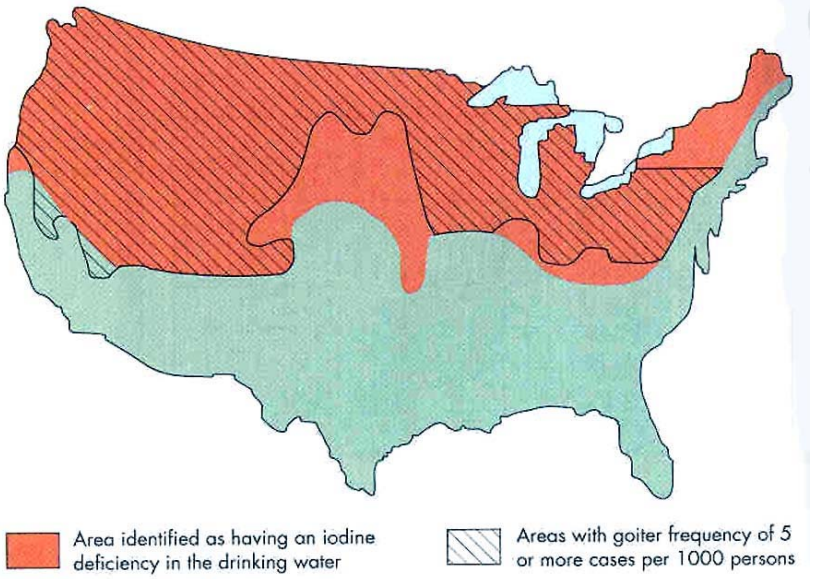
The area of the United States that used to be designated the "goiter belt" because of low iodine in the soil is shown on the map on the next page. The actual iodine content of foods depends on where they were grown, and some protection has likely been provided to the low-iodine regions by the fact that at least some produce may have been grown in an iodine-sufficient region.

This is a new issue to keep in mind as we promote **growing one's own food and buying from local producers** instead of transporting produce from far away. Local food production is terrific for many reasons, but if one lives in an iodine-poor region, it is important to assure iodine sufficiency via a demonstrably adequate intake from some form of iodine supplement.

Map showing spatial correlation between the former "Goiter Belt*" in the northern U.S. and areas where the iodine content of drinking water is naturally low.

www.uwsp.edu/gEo/faculty/ozsvath/images/goiter_belt.htm

[*Goiter is an abnormal enlargement of the thyroid gland, often due to iodine deficiency.]



Back home in America, many people under age 50 who live in iodine-poor regions of the country are quite unaware that they should select "iodized salt." The public health hoopla that accompanied the iodizing of salt in the early 1950s (yes, I remember it … I was THERE!) somehow faded away and the issue went off the radar. **Many people of child-bearing age today have no knowledge that this was once a widespread deficiency disease in the US of critical**

importance to everyone's health and especially dangerous to the development of infants and children … and they don't know it has come back

Even when one intends to buy the iodized salt, the packaging is often very similar and they are side-by-side on the shelf at the store. Most specialty salts that are popular now, like sea salt or exotic salts, are also not iodized. So generally, one should choose iodized salt if one uses salt at home, and people who use little salt should be sure to find an iodine supplement, especially if they live in the northern half of the country.

Additionally, we frequently are advised to cut back on salt for other health reasons, which can further limit iodine intake. Recently some national health recommendations pushed for an even lower daily sodium intake than before … instead of 3000 mg/day they recommended 1500 mg. I am not arguing against this recommendation … just pointing out the need to make sure that people who follow this health advice are not accidentally injured by iodine deficiency.

Remember that the choice of salt as the way to supplement dietary iodine was made well before ideas of sodium restriction were common for health reasons. Other factors have made an inadequate intake much more likely today. For example, in the 1950s people made most meals from scratch, so iodized salt would be added whenever salt was used in cooking. Now most of our sodium intake comes in the form of processed foods, which are high in salt but the salt is not iodized. Here is an excerpt from a website on this topic:

"…In the United States, from the outset, salt producers cooperated with public health authorities and made both iodized and plain salt available to consumers at the same price. **Even so, the Salt Institute estimates that only about 70% of the table salt sold in the United States is iodized.**

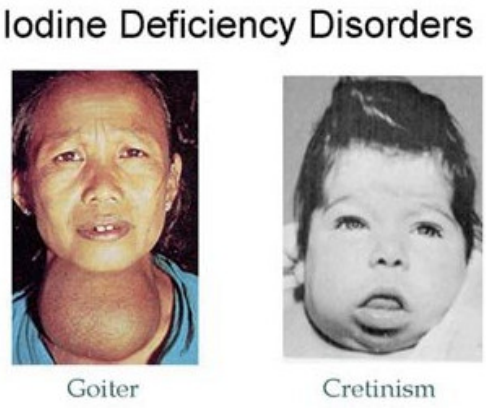
Salt used in processed foods is not iodized. Given that people are cooking less at home and buying either restaurant or processed foods, **iodine intakes in the U.S. have declined from about 250 µg/day to 157 micrograms/day. Public health authorities recommend 150 µg or more** and the need is particularly acute for expectant mothers. Daily Iodine intakes of 1,000 - 1,100 µg are safe for adults and children over 4 years of age…"

http://www.saltinstitute.org/Uses-benefits/Salt-in-Food/Essential-nutrient/Iodized-salt

Also, because it has long been assumed that the iodine deficiency problem was "solved" **in the US by the iodizing program, at present many vitamin pills contain no iodine at all, including many prenatal vitamins.** So, this is one more nutrient that a person should check for when they select a multivitamin.

The WIC Program recently added use of a prenatal vitamin without iodine as a nutrition risk factor for women enrolling in the program. That means that some low income women of childbearing age may soon begin to have this addressed.

At least an awareness of the problem is developing. However, **MOST women are NOT on the WIC Program so this problem is unlikely to be readily recognized. There is great potential for harm.**



There has been a resurgence of goiter development (a marker of iodine deficiency) in America as well as around the world, and thought to be a problem. Additionally, data it is often missed because it is no longer shows that average iodine intakes have decreased markedly in the US. It is also reported that on average iodine intake is sufficient here [Iodine status of the U.S. population, National Health and Nutrition Examination Survey 2003-2004. Thyroid. **2008** Nov;18(11):1207-14.]

However, when one stratifies the data it becomes clear that a great many women here (and around the world) do NOT have a sufficient iodine intake even when men generally do. The risk to fetal and maternal health is substantial, and easy to fix once the problem is recognized.

Major Point: The problem of iodine deficiency needs to be put back on our radar; this is a very newly recognized and extremely important health problem that needs attention.

Please see my paper "Aunt Cathy's Guide to Nutrition:
New Attention to an Old Problem:
Iodine Deficiency in Pregnancy and Lactation 2011"
for detail on this topic, including an annotated bibliography.

Some newer references are included here since this topic may be quite new to many readers and I don't want them to think I am making this stuff up! ☺

Iodine deficiency in infancy - a risk for cognitive development. Dtsch Med Wochenschr. 2010 Aug;135 (31-32):1551-6.Parameters of thyroid function throughout and after pregnancy in an iodine-deficient population. Thyroid. 2010 Sep;20(9):995-1001. Some subgroups of reproductive age women in the United States may be at risk for iodine deficiency. J Nutr. 2010 Aug;140(8):1489-94. Iodine intake and maternal thyroid function during pregnancy. Epidemiology. 2010 Jan;21(1):62-9.Georgian Med News. 2010 Jan; (178):65-8.Iodine deficiency in the prenatal period may form learning ability deficiency in the postnatal period. Epidemiology of iodine deficiency: Salt iodisation and iodine status. Best Pract Res Clin Endocrinol Metab. 2010 Feb;24(1):1-11. Iodine deficiency in pregnancy, infancy and childhood and its consequences for brain development. 2010 Feb;24(1):29-38.Iodine deficiency in pregnancy and the effects of maternal iodine supplementation on the offspring: a review. Am J Clin Nutr. 2009 Feb;89(2):668S-72S.

Fluoride

Fluoride is low in human milk and whether the mother's fluoride intake affects the amount in milk is still subject to some debate. The recommendations for using fluoridated water, fluoride drops, fluoride toothpaste and topical fluoride treatments have changed many, many times over the years that I have been involved in pediatric nutrition. They are being changed again this year regarding the recommended amount of fluoride to add to low-fluoride-containing water supplies.

The American Dental Association has a current list of very specific recommendations on all aspects of the topic of fluoride as it relates to dental issues. It is available at this website:

http://www.ada.org/public/topics/fluoride/infantsformula.asp