<table>
<thead>
<tr>
<th>Slide 1</th>
<th>Welcome to the module Infant Feeding</th>
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<tbody>
<tr>
<td>Slide 2</td>
<td>First we will briefly discuss the nutrient needs of infant.</td>
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<td>Slide 3</td>
<td>The nutrient needs of infants are not well established as these data are usually extrapolated from experimental animal data or based on “natural experiments” where populations naturally develop deficiencies. Also, variability in rates of growth among infants makes it difficult to set exact nutrient requirements. All nutrient needs for infants are stated as Adequate Intakes (AIs) not as Daily Recommended Intakes (or DRIs) as the body of evidence to support them is not strong enough to warrant DRI categorization.</td>
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<td>Slide 4</td>
<td>We will be discussing the lactation recommendations and the benefits of breastfeeding for baby, mothers, and society.</td>
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<td>Slide 5</td>
<td>Human milk is made for human babies and is the norm for infant feeding. Breast milk serves as a complete source of nutrition for infants. The American Academy of Pediatrics recommends breastfeeding for at least the first year of an infant’s life. At the very least, infants should be exclusively breastfed for 4 months but preferably for 6 before solids are introduced. Other organizations, such as the World Health Organization, recommend breastfeeding for even longer—for at least the first 2 years of life. According to the WHO, infants should be breastfed exclusively for 6 months. After 6 months, or when the infant shows signs of readiness, solids may be introduced. Signs of readiness will be detailed in the next module. In conjunction with solids, breastfeeding should continue to at least 2 years of age.</td>
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<td>Slide 6</td>
<td>Breastfeeding has many benefits for the infant. It decreases the incidence and or severity of infectious diseases, bacterial meningitis, bacteremia, diarrhea, respiratory tract infection, necrotizing enterocolitis, otitis media, urinary tract infections and late-onset sepsis in preterm infants.</td>
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<td>Slide 7</td>
<td>Other benefits to the infant include decreased rates of sudden infant death syndrome, types 1 and 2 diabetes, lymphoma, leukemia, Hodgkin’s disease, overweight and obesity, hypercholesterolemia, asthma, eczema, food allergies, and dental problems</td>
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<td>Slide 8</td>
<td>Breastfeeding also has neurodevelopmental benefits. It has been linked to enhanced performance on cognitive development tests. Breastfeeding may also produce an analgesic effect during painful procedures. Another important benefit is that breastfeeding promotes mother-child bonding.</td>
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<td>Slide 9</td>
<td>Breastfeeding offers many benefits for mothers as well as infants. Breastfeeding is related to decreases in postpartum bleeding, reduction in uterine size, decreased menstrual blood loss, earlier return to pre-pregnancy weight, increased spacing between pregnancies, decreased risk of breast and ovarian cancer, and possible decreased risk of postmenopausal hip fracture and osteoporosis.</td>
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<td>Slide 10</td>
<td>Breastfeeding has beneficial economic and environmental aspects as well. Since breastfeeding is associated with fewer childhood illnesses, less money therefore needs to be spent on providing medical treatment. Parents also save a lot of money by not having to purchase formula. If more infants are breastfed, then less formula would need to be manufactured, packaged and shipped which would provide greater environmental savings.</td>
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### Module 3: Infant Feeding

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Although it is usually best for baby to breastfeed, there are some contraindications to breastfeeding. Infants with galactosemia (cannot ingest lactose-containing milk) should not be breastfed. Mothers who want to breastfeed may have concerns about whether they can do so if they are ill. Women who should not breastfeed include:
- Those with herpetic lesions localized to the breast, although women with vaginal herpes should be allowed to breastfeed;
- Those with varicella lesions on the breast should provide expressed milk to their infant until their lesions are crusted over, and the infant should receive varicella immune globulin;
- Those with mothers who have active untreated TB;
- Those with miliary tuberculosis - a form of TB that is characterized by a wide dissemination into the human body and by the tiny size of the lesions (1-5 mm). These women with miliary tuberculosis - a form of TB that is characterized by a wide dissemination into the human body and by the tiny size of the lesions (1-5 mm). These women should not breastfeed until they are no longer contagious, approximately 2 weeks;
- Mothers positive for human T-cell lymphotropic virus type 1 or 2. In women with HIV, the risks of not breastfeeding must be balanced with the risk of HIV acquisition. Women with breast cancer should not delay treatment in order to breastfeed. Depending on the therapy, women receiving antimetabolites or chemotherapeutic agents should not breastfeed. Mothers with fever or other minor illness should be permitted to breastfeed.

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One of the areas that is very interesting is human immunodeficiency virus (HIV) and breastfeeding. Originally, all mothers who had HIV were recommended to not breastfeed their infants, however we have realized that in some cases there are more health risks associated with unsafe water supply. In the developing world in particular, often times women are now encouraged to breastfeed, because the breastmilk, even if there is a small risk of HIV transmission, it is a better choice than using formula due to sanitation problems. In short, if there is no safe water supply, breastfeed no matter what. On the other hand, women in the US who are infected with human immunodeficiency virus should not breastfeed.
| Slide 13 | Mothers who want to breastfeed may have concerns about whether they can do so if they take medications, or ingest certain substances. It is important to note that medications, caffeine and alcohol can go into breastmilk, so infants who are fed breastmilk will actually get some low levels of these substances. Small amounts have not been documented to have any affect on infant development but higher intakes may cause issues. Most medications are compatible with breastfeeding, so taking medications is usually not a reason to forgo breastfeeding. For those that are not compatible, alternative medication may be used after consulting with a health provider. Any medication including OTC medications and herbs should be discussed with the health care provider. Providers and patients can both use the link provided in order to find current information on medications and breastfeeding. When a breast-feeding woman drinks coffee, her infant receives a small dose of caffeine. Breast-fed infants of women who are heavy coffee drinkers (10 or more cups per day) may develop “caffeine jitters”. Breastfeeding women are advised to limit their consumption of regular coffee to less than 4 cups a day. Alcohol is transferred from a woman’s body to breast milk. The development of the brain and nervous system of infants breast-fed by chronic, heavy drinkers appears to be retarded. There is also concern that alcohol ingestion by breastfeeding women may decrease milk production. Breastfeeding women should avoid alcohol or at least limit it to one drink with a meal per day. The body can metabolize alcohol at a rate of 1/2 oz per hour. Link: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?LACT |
In terms of substances that mothers should avoid while breastfeeding, nicotine and cotinine in cigarettes can pass from the mother into her breastmilk for about 2.5 hours after smoking. Very few women who smoke breastfeed, but those who do run the risk of passing some of the byproducts on to the infant. Smoking may also reduce milk supply. Smoking cessation is recommended for mothers who want to breastfeed. Women who do smoke can reduce the risk to the infant by cutting down on the amount they smoke; never smoking in the house, car or around the infant; breastfeed before smoking. Women ingesting drugs of abuse need counseling and should not breastfeed until they are free of the abused drugs. These drugs, such as marijuana, cocaine and heroine, cause changes in the composition of breastmilk and cause delayed development. There has been major concern lately about the use of insecticides, pesticides and some of the other compounds around homes or in occupational areas where women work, because they can actually pass into human milk. Environmental contaminants, such as lead, DDT, PCBs are transferred into breast milk. Many environmental contaminants may be stored in a woman’s fat or bone tissues. When the fat stores are later broken down for use in breast milk or the calcium in bone is mobilized, the contaminants stored in the fat or bone may enter the breastmilk. The ingestion of fish from contaminated waters has been linked to abnormally high levels of PCBs in breast milk. Infants exposed to PCBs can develop rashes, digestive upsets, and nervous system problems. With environmental toxins, however, it is concluded that the benefits of breastfeeding outweigh the risks to infants from harmful substances in the environment. Infants are much smaller than women, and it takes a smaller dose of caffeine, alcohol, drugs, or environmental toxins.

Next, we will be discussing the physiology of lactation and characteristics of breastmilk.

Secretory cells differentiate in the second half of pregnancy. Prolactin and placental lactogen are involved in this process. At this time, the body is capable of producing small amounts of milk, but the release is prohibited by progesterone. At delivery, progesterone decreases and causes the release of milk. Suckling of the breast causes the release of prolactin and oxytocin, which are the two main hormones of lactation. There is a peptide in human milk that works as a feedback inhibitor that regulates milk production in response to demand.
### Module 3: Infant Feeding

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Delivery removes the placenta, which is the source of the large amounts of progesterone and, thereby, releases milk production from inhibition. Suckling at the breast (stimulation of the nipple) stimulates prolactin secretion by the anterior pituitary. Prolactin provides the primary stimulus for milk production, and prolactin release in turn is linked to the withdrawal of milk from the breast. The demand for milk by the infant is thus naturally part of a positive feedback system that sustains the supply. If there is a demand for milk (meaning if there is stimulation of the breast), then not only is milk withdrawn, but prolactin is also secreted and more milk is produced. If a woman does not nurse her baby after birth, milk production will stop fairly soon. As a baby matures and nurses less frequently, less milk is produced. When a baby is finally weaned, milk production ceases. In addition, during lactation, prolactin exerts a secondary action to inhibit gonadotropin secretion, thus decreasing fertility when a woman is breast-feeding.

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Oxytocin is the other key hormone involved in lactation. It is synthesized in the hypothalamus and stored in the posterior pituitary. Oxytocin is needed for milk let down. It contracts the myoepithelial, or smooth muscle, cells in the breast to push the milk through the ducts.

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Human milk contains both nutrients required by the newborn infant for energy and metabolism and non-nutritional components that promote infant health, growth and development. Nutrients in breastmilk include metabolic fuel, such as fat, protein and carbohydrates, free water, and raw material necessary for tissue growth and development, such as long-chain fatty acids, essential amino acids, vitamins, minerals and trace elements. Breastmilk also contains non-nutritional components. These are antimicrobial factors, digestive enzymes, hormones, growth factors and growth modulators.
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During lactation, women can generally consume their usual diet. The vitamin and mineral content of human milk stays relatively consistent across lactating women despite wide variations in their diets. Water soluble vitamins are more likely to be reduced in human milk secondary to low intake by mom, but long-term poor dietary intake can reduce the concentrations of most vitamins and minerals in human milk. The concentrations of iron, zinc and copper decrease throughout lactation. The concentrations of copper and zinc, despite their decrease throughout lactation, appear adequate to meet the infant’s nutritional needs until approximately 6 months of age. The concentration of iron may also not meet the infants needs beyond 6 months of breastfeeding, and at this time, an iron supplement, in the form of iron-containing complementary feedings, is indicated to prevent subsequent iron-deficiency anemia. Although infants rarely show signs of deficiency even when Mom’s diet is poor, vitamins A, D, B12 and folate are exceptions. Vitamin B12 is available from animal foods only: meat, fish, poultry, cheese, milk, eggs; vitamin B12 fortified soy milk. Breastfed infants of strict vegan mothers are at risk of B12 deficiency. Increased rates of breast-feeding in the US have had the unintended side effect of increased vitamin D deficiency (rickets) in infants. Breast milk contains a very low amount of vitamin D, so infants receiving human milk need to get it from exposure of their skin to sunlight or from supplements. The American Academy of Pediatrics recommends supplementing all breastfed infants with 400 IU of vitamin D. Infants who develop vitamin D deficiency fail to get enough sunlight exposure due to winters in cold climates or from being fully clothed or covered with sunscreen to protect their skin from the sun. Modest exposure to sunshine (about 30 minutes a week with diapers only) is

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Human milk contains a variety of non-nutrient compounds that are beneficial to infants. Hormones, growth factors, anti-inflammatory and immunoprotective agents, cytokines and digestive enzymes make human milk the ideal first food for infants. These non-nutrient factors compensate for the neonate’s immature digestive and barrier functions and modulate the transition from intrauterine to extrauterine life. These components may be of particular importance for young infants, as the digestive system and host defense are still immature and susceptible to infection.
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Human milk is naturally sweet and contains lactose as the primary source of carbohydrate. The predominant protein is whey, but other proteins such as casein and immunoglobulins are also found in breastmilk. The fatty acid content of human milk varies by Mom’s dietary intake. Short chain fatty acids are derived from carbohydrate intake, and are relatively consistent across women. On the other hand, the long-chain fatty acids reflect Mom’s total dietary intake and can therefore vary widely between women.

**Slide 23**

40% of the energy in breastmilk is provided by lactose, which is the primary carbohydrate in human milk. 80 to 85% of carbohydrate in

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Whey and casein are the main protein fractions that make up human milk. Whey is the predominant protein making up 60% and casein makes up 40%. This is compared with cow’s milk which is 18% whey and 82% casein. Casein combines with minerals like calcium, phosphorus and magnesium to form micelles. The formation of micelles from casein and minerals increases the absorption of the minerals, but not the casein. The casein proteins have low solubility in stomach acid; they form curds. Casein is hard to digest since it becomes hard in the presence of acid. Because cow’s milk has a higher casein content, it is less easily digested by infants than human milk. The whey proteins are more easily digested and promotes more rapid gastric emptying than casein. The 4 major proteins that make up whey are lactoferrin, secretory immunoglobulin A and albumin. The primary whey protein is alpha-lactalbumin. In cow’s milk, the major whey protein is beta-lactoglobulin, which is the particular protein associated with allergy to cow’s milk. Lactoferrin and secretory IgA make up 30% of all milk protein. These two proteins are thought to protect against infant gastrointestinal and respiratory tract infections. Lactoferrin proteins transport and promote the absorption of iron. They are also bacteriostatic agents to a range of organisms, meaning they inhibit the growth of certain bacteria.
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The whey protein secretory immunoglobulin A is the principal immunoglobulin of human milk. The specificity of human milk secretory immunoglobulin A antibodies reflects the mother’s exposure to various antigens and is independent of the specificity profile of bloodborne IgA. In the entero-mammary immune system, the mother produces secretory immunoglobulin A antibodies when exposed to foreign antigens found in the maternal plasma. These antibodies are elaborated at mucosal surfaces and in her milk. By ingesting the milk that contains specific secretory immunoglobulin A antibody, the infant receives specific passive immunity against bacteria that the mother was exposed to and the germs from maternal stores that the infant was also exposed to. The antibodies are not destroyed by the hydrochloric acid in the infant’s stomach. The system is active against a variety of antigens in infants. The secretory immunoglobulin A in human milk protects against germs found in humans; the secretory immunoglobulin A in cow’s milk protect against germs found in the cow.

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The lipid system in human milk is structured to facilitate fat digestion and absorption. Half of the energy content of breastmilk is provided by fat, although the milk only consists of approximately 4% fat. The fat is mostly fatty acids in the form of short-chain and long-chain triglycerides; 98% of the fat is in the form of fatty acids. The other 2% is in the form of phospholipids and cholesterol. Fatty acids are responsible for transferring fat soluble vitamins A, D, E, and K and prostaglandins. Prostaglandins are a type of lipid compound that is enzymatically derived from fatty acids. Technically they are hormones.
Fatty acids are the building blocks of fats and are important for energy metabolism and cell growth. The fatty acid content of human milk will vary according to the mother’s dietary intake. Short chain fatty acids are derived from carbohydrate intake (they are produced when dietary fiber is fermented in the colon), and are relatively consistent across women. On the other hand, the long-chain fatty acids reflect the mother’s total dietary intake and can therefore vary widely between women. The long-chain fatty acids are derived from omega-3 & 6 fatty acids in the maternal diet. Oleic acid and palmitic acid are the most abundant fatty acids and they help to increase the digestibility of milk. Also high proportions of linoleic acid, linolenic acid and long-chain polyunsaturated fatty acids, such as arachidonic acid (ARA) and docosahexaenoic acid (DHA). These long chain polyunsaturated fatty acids are constituents of brain and neural tissue and are needed in early life for mental and visual development. The concentration of fat in human milk increases as lactation progresses in order to support rapid infant growth and development.

This slide compares human milk to cow’s milk and gives an idea of the differences in the nutrient that infants get when they have cow’s milk based formula versus human milk. Human milk is different than cow’s milk. Human milk is made for human infants, it is perfect for their nutritional needs; cow’s milk is not. In human milk the predominant protein is whey -making up 60% while casein makes up 40%. This is compared with cow milk which is 18% whey and 82% casein. The primary whey protein in human milk is alpha-lactalbumin. In cow’s milk, the major whey protein is beta-lactoglobulin. Beta-lactoglobulin is the particular protein associated with allergy to cow milk. Cow’s milk also has less sIgA than human milk. In addition, remember that the sIgA in human milk protects against germs found in humans; the sIgA in cow’s milk protect against germs found in the cow.
The first fluid secreted during lactation is colostrum or “early milk” also known as “gold milk”. It is yellow in color due to the high carotenoid content. Colostrum is lower in fat and sugar than mature milk, but richer in proteins, especially immunoglobulins. Colostrum is important in protecting the infant’s health because it helps to mediate immune response and may aid in preventing jaundice. Colostrum is high in immunoglobulin A, which coats the Gastrointestinal tract, and it is also high in Immunoglobulin G and Immunoglobulin M. Because colostrum is not very energy rich and is produced in limited amounts (40 milliliters on the first day, 400 mL at 3 days), a breast-fed baby relies primarily on its own fat and glycogen supplies for energy until the secretion of mature milk begins. Thus a normal breast-fed baby may lose up to 10 percent of its birth weight while waiting for the mature milk to come in. Transitional breastmilk is lower in protein and higher in fat and Carbohydrate than mature human milk. Compared to colostrum, it is also higher in calories and water soluble and fat soluble vitamins. After 2-3 weeks postpartum, mature milk is formed. The volume of milk also increases. By 3 weeks after birth, a breast-fed baby is drinking a little over a liter of milk per day, which provides the infant with about 700 kcal of energy. Water makes up approximately 90% of mature milk. Dissolved in the water are fats, carbohydrates, proteins, enzymes, vitamins and minerals. Most of the energy comes from the fat content of the milk. Lactose also provides some energy, but it also has benefits such as providing glucose and galactose and stimulating the growth of normal intestinal bacteria. Mature milk continues to change over the course of the first year.

The composition of mature milk changes over the course of the feeding (fore milk and hind milk). Foremilk is the milk produced during the first 2 to 5 minutes of a feeding. Fore milk is more watery and higher in protein and Carbohydrate. It is also lower in fat, with shorter chain fatty acids present in high amounts. Hind milk is the milk produced as the feed progresses, after about 4 minutes. Hind milk is creamier and higher in fat, abundant in long chain fatty acids. The fat content provides satiety. For infants having trouble growing, some physicians recommend feeding them the hind milk first using a breast pump. This picture shows two samples of human breast milk. The sample on the left is foremilk, the watery milk coming from a full breast. The sample on the right is hind milk, the creamy milk coming from a nearly empty breast.
### Module 3: Infant Feeding

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Even if an infant is born preterm, the mother can still breastfeed. Preterm milk is higher in protein and electrolytes than full-term milk. Additional nutrients are often added to human milk fed to preterm infants, as their needs for some nutrients are higher. Milk from mothers of preterm infants, especially during the first weeks after delivery, contains higher amounts of energy and higher concentrations of fat, protein, sodium, and chloride but slightly lower concentrations of lactose, calcium, and phosphorus compared with milk from mothers of term infants. The higher fat content accounts for the higher energy density of preterm milk. The higher protein content of preterm milk expressed during the first 2 to 3 weeks of lactation may be sufficient to match the fetal growth requirement for nitrogen when consumed at large amounts (180 to 200 mL/kg per day). However, by the end of the first month of lactation, the protein content of preterm milk is inadequate to meet the needs of most preterm infants. Long-term use of unsupplemented human milk in preterm infants can cause hyponatremia at 4-5 weeks of age and at 8-12 months of age, osteopenia at 4-5 months, and zinc deficiency at 2-6 months. To correct the nutritional inadequacies of human milk for preterm infants, human milk fortifiers are available that provide additional protein, minerals, and vitamins. Preterm milk will eventually mature into term milk.

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Next we will discuss breastmilk production and storage.

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Lactation is an extension of the mother’s direct physiological investment in her offspring after birth. Depending on the mother’s circumstances, anywhere from 15% to 50% of her total energy budget goes into producing milk. A mother’s ability to produce adequate amounts of milk depends on the efficient mobilization of fat stores. The energy needed for milk production can be met in a number of ways: increasing food consumption, mobilization of stored fat reserves, reduction of expenditures on physical activity.
Among women in the developed world, milk production has proven very robust and difficult to disrupt. A number of factors affect breastmilk volume, but the main determinants of breastmilk volume are feeding frequency and duration. Beginning in the first 24 hours after birth, for the first 2 weeks, an infant will feed about 8-12 times or more every 24 hours, usually for 10-15 minutes per breast. Over time, the feedings will decrease to 8-10 per day. The sucking and swallowing abilities are not fully developed in most preterm infants, and are not as strong in smaller infants as in larger infants. Full term and larger infants often feed better than preterm and smaller infants. Greater suckling strength results in better feeding which results in larger volumes of breastmilk. These infants can feed longer which creates greater stimulation for breastmilk production. Nicotine decreases prolactin and oxytocin production, and therefore decreases milk production and let down. In addition, babies breastfed by smokers are more likely to have symptoms of colic as compared to babies breastfed by non-smokers. As mentioned, nicotine and cotinine in cigarettes can pass from the mother into her breastmilk for about 2-3 hrs after smoking. Still, it is preferable for smoking mothers to feed their infants breastmilk rather than formula; they should either breastfeed before smoking or wait about 3 hours after smoking before they breastfeed. Alcohol may also inhibit oxytocin and therefore prevent milk let down and make feeding more difficult.
Contraceptive that are not “low dose” pills may decrease milk volume if estrogen levels are high. Women should discuss use of contraceptives and the effect on milk production with health care providers. In studies where women took supplemental proteins, vitamins, and minerals with their normal diet, breastmilk volume did not appear to be affected. However, in severely malnourished women, supplemental foods do seem to affect volume and protein content. Only when caloric intake approaches starvation level is milk production significantly curtailed. Across a broad range of caloric intakes above this minimum, however, milk production is maintained at a level matched to demand. When maternal energy intake is low, maternal metabolism is reduced in order to maintain milk production. When maternal energy intake recovers, in this case as a result of the supplementation program, the mother’s metabolism is restored while milk production remains unchanged. Dehydration may reduce breastmilk volume. It is important to encourage mothers to drink plenty of fluids while they are feeding, although overhydration can also decrease milk production.

Breastmilk can be stored in glass, hard plastic bottles, plastic freezer bags or milk storage bags. The best practice is to cool the human milk right away, although it can be stored at room temperature for up to 8-10 hours. If not used within this time period, it can be stored in a refrigerator for up to 3 days. If human milk is transported via cooler, it can be kept on ice for up to 24 hours prior to refrigeration. Fresh milk that is frozen in the separate freezer compartment of a self-defrosting refrigerator is good for 3-6 months. Fresh milk can also be stored for up to one year in a deep freezer. If milk has been stored in a refrigerator for 48 hours or less, it can later be stored in a freezer. Rule of thumb: If you plan to use the breastmilk within 3 days, don’t freeze it. If you are planning to freeze it, do it within 24-28 hours of expressing it.
There are a number of acceptable ways to thaw breast milk. Human milk should be thawed in the refrigerator for 8-20 hours prior to feeding. If needed, it can be thawed under cool or lukewarm running tap water or in a basin of warm water. Human milk should not be left out at room temperature more than 4-8 hours nor should it be microwaved. Thawing in a microwave is not recommended because it reduces the concentration of IgA and decreases lysozyme activity. Microwaving also produces hot spots in the milk. Freezing and heat treatment of human milk alter such labile factors as cellular elements, immunoglobulin (Ig)A, IgM, lactoferrin, lysozme. However, freezing generally preserves these factors better than heat treatment. Thawed human milk should be stored in a refrigerator and used within 24 hours. Once thawed, the milk should never be refrozen. When breastmilk is stored it often separates into layers in which the cream will rise to the top. Once thawed, the bottle should be shaken before the milk is fed to the infant.

Although not an equivalent to breastmilk, infants are also fed infant formula. The composition of human milk provides a basis for the composition of infant formulas, but these formulas do not duplicate the composition of human milk for several reasons. First, human milk contains a number of components, such as hormones, growth factors, antibodies, enzymes and live cells, that are difficult, if not impossible, to add to infant formula. Second, infant formula are made from cow milk and other ingredients, which often provide nutrients that are dissimilar in chemical form and composition to corresponding nutrients in human milk. Third, infant formulas are heat-treated to have long shelf lives, generally at least 1 year. Also, the bioavailability of some nutrients in infant formula may be lower than that of the nutrients in human milk.
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<th>Slide 39</th>
<th>Most infant formulas are largely based on cow’s milk, which differs in a number of ways from human milk. The cow’s milk used in formulas has been processed to make the nutrient content similar to human milk. In cow’s milk the predominant protein is casein. Since the primary protein in human milk is whey rather than casein, some milk-based formulas have been altered to contain more whey, although the dominant protein may vary among infant formula brands. The protein in infant formula is still different from breast milk because of the different amino acids and protein composition. In addition, infant formula is lower in fat and higher in carbohydrate, protein, and minerals than breast milk. The formulas have been made more digestible using homogenization and heating. Also, Standard infant formula has 20 Kcals/oz.</th>
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<td>Slide 40</td>
<td>Soy formula can be used by infants that are allergic or intolerant of cows milk or those from vegan families. These formulas contain soy protein isolate made from soybean solids, vegetable oils as the fat source, Carbohydrate (usually sucrose and/or corn syrup solids), and vitamins and minerals. Soy-based formulas are usually fortified with the essential amino acid methionine. Methionine is added to improve the protein profile and because it is found in low quantities in soy beans. Both cow’s milk based formulas and soy based formulas are typically fortified with iron.</td>
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<td>Slide 41</td>
<td>Specialty formulas are available. Hypoallergenic formulas have been developed for infants with allergies or intolerance to cow’s milk infant formulas or those with a family history of allergies. In these formulas, the allergy-causing protein has been modified. Hypoallergenic formula is usually soy-based and has reduced lactose levels. Elemental formulas use hydrolyzed proteins and medium or long-chain fatty acids. These are not widely used due to cost and low acceptance by infants, but are occasionally needed in infants with multiple food allergies or other metabolic conditions. Amino acid-based formulas have been specifically designed for infants who have extreme protein hypersensitivity—when symptoms persist even when extensively hydrolyzed protein formulas are used. These formulas are more costly than cow’s milk protein- and soy protein-based formulas.</td>
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Follow-up formulas are meant to simulate natural changes in human milk that occur over time. They are higher in protein and lower in fat, which is what we see with human milk after 4-6 months postpartum. These formulas also known as toddler formulas. They are nutritionally adequate but offer no clear advantage over standard infant formulas during the first year of life. The iron fortification and balance of nutrients they contain may be an advantage for toddlers receiving inadequate amounts in their solid feedings. Some individuals make home-made formulas from goats milk or evaporated milk and often use corn syrup as the CHO course. These formulas are not nutritionally complete, increase risk of food allergies and can lead to metabolic acidosis, failure to thrive, kwashiorkor and/or marasmus. Some of these formulas are too high in protein and cause the baby’s kidneys to work overtime.

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Probiotics and prebiotics are now added to a variety of formulas. They are added in order to stimulate the microflora of the gut so that the bacterial content is more beneficial, with the goal to achieve the same affect that you get with human milk. Breastfeeding is important in development of the intestinal microflora. The oligosaccharides in breastmilk are believed to serve as growth factors for intestinal microflora (the good bacteria in the gut) by providing non-protein nitrogen that help feed these good bacteria. There have been a few studies that have looked at the effects of these formulas and they have found that when you add pre- and probiotics to infant formulae it reduced diarrhea, produced softer stools, it may reduce allergies and it may reduce the infections in infants. But again, the data have never proved that these are as effective as human milk. ARA and DHA are now added to about 95% of formulas. These are added for brain and retina development.
Infant formulas are available in 3 forms: powder, concentrate, and ready-to-feed. All infant formulas must be manufactured in adherence to good manufacturing practices, and all production facilities are inspected at least annually by the US Food and Drug Administration (FDA). There are a number of issues to consider when preparing formula for infant consumption. For example, use proper hand-washing techniques whenever preparing or feeding infant formula. Once opened, cans of ready-to-feed and concentrated liquid product can generally be stored covered (with plastic overcap or aluminum foil) in the refrigerator for no longer than 48 hours. Powder formula should be stored in a cool dry place, not in the refrigerator. Prepared formula should not be left out of the refrigerator. If more than one bottle is prepared at a time, those bottles for later use should be refrigerated immediately. All bottles should be used within 24 hours. Once the feeding has begun, the contents should be fed within an hour or discarded. Disposable bottles may be preferable for some parents who do not have the time or resources to continually sanitize bottles for future use. Infants 3 months and younger are more likely to contract illnesses from micro-organisms in bottles and nipples that are improperly cleaned, cleaned in contaminated water, or filled with contaminated water. For infants less than 3 months, glass or hard plastic bottles and bottle parts (nipple, caps, rings) should first be thoroughly cleaned using soap, hot water, and bottle and nipple brushes, and then either be sterilized in boiling water or washed in a properly functioning dishwasher machine. If disposable plastic bottle liners are used, the bag should be discarded after one use and the nipples, rings, and caps sterilized. After 3 months, bottles should be thoroughly washed using soap and hot water and bottle and nipple brushes or cleaned in
| Slide 45 | Infant formula preparation should be discussed with all parents who chose to bottle feed. Common issues that occur with formula preparation include directly feeding concentrated formula or diluting ready to feed (because the cans look so similar). Both can lead to severe medical consequences. Not diluting concentrate can result in increased renal solute load, high intake of protein/energy, obesity, hypematremia, dehydration, acidosis and brain damage. Overdiluting formula can result in failure to thrive, water intoxication, hyponatremia, irritability, coma, death. Powder formula may be the best alternative as it minimizes the risk of these practices. |
| Slide 46 | We will now discuss important issues in feeding preterm and full term infants and the differences between the two. |
| Slide 47 | Infants born more than 3 weeks before the mother’s due date are considered preterm. About 10% of all pregnancies in the US are preterm. Preterm infants have needs different than those of term infants, and the best way to meet these needs is through breastfeeding. Human milk is important for infant health, and even more so for preterm infants. Preterm infants are at greater risk of morbidity and mortality and feeding them breastmilk during the first 6 months of life decreases both infant and childhood morbidity and mortality. Breastfeeding decreases the incidence and/or severity of infectious disease and late-onset sepsis in preterm infants. In addition, it is important that preterm infants receive the colostrum, because preterm colostrum is higher in many anti-infective factors as compared to term colostrum. The risk of necrotizing enterocolitis is lower in infants who receive colostrum/breastmilk. |
Even if an infant is born preterm, the mother should still breastfeed. Preterm milk is higher in protein and electrolytes than full term milk. Additional nutrients are often added to human milk fed to preterm infants, as their needs for some nutrients are higher. The milk from mothers of preterm infants, especially during the first weeks after delivery, contains higher amounts of energy and higher concentrations of fat, protein, sodium, and chloride but slightly lower concentrations of lactose, calcium, and phosphorus compared with milk from mothers of term infants. The higher fat content accounts for the higher energy density of preterm milk. Mothers of preterm infants should be encouraged to provide their milk for feeding their infants. Even mothers who are planning to feed infant formula upon discharge from the hospital should be encouraged to express their milk for a few days or weeks after delivery. This milk can be used to establish enteral feeding during the early critical weeks of life. If infants require nutrition support, human milk from the preterm infant’s mother is the preferred choice for enteral feeding. Human milk is well tolerated by preterm infants and has been reported to promote the earlier achievement of full enteral feeding compared with infant formula.

This table compares 100 milliliters, or 3.3 ounces, of preterm formula to term formula. Typically preterm formulas contain 24 calories per ounce compared to 20 calories per ounce found in standard formulas. Protein, fat, calcium and phosphorous contents are also higher in preterm formulas.
Module 3: Infant Feeding

### Slide 50

One of the issues to keep in mind with preterm infants, whether they are breastfed or bottle-fed, is that they often have difficulty feeding effectively. Feeding requires that the infant be able to suck, swallow and breathe at the same time. Suckling and swallowing abilities are not fully developed in infants until about 34 weeks or later in gestation. Premature infants born before 34 weeks often do not have the neurological capability to coordinate sucking, swallowing and breathing and therefore non-nipple feedings (enteral or parenteral) may be needed. Respiratory therapy, which is often required in preterm infants, interferes with oral feeding and so TPN is often utilized initially. It is also important to know that the nutrient needs that we talk about are based on full term infants, but if an infant is born preterm, their needs are going to vary by the gestational age at which they were born and then as they grow we need to talk about corrected age so that we know where the infant is developmentally. Developmental delays are common among preterm infants, especially those born before 33 weeks gestation, which may also complicate feeding.

### Slide 51

Preterm infants may need vitamin and mineral supplementation. The infant’s pediatrician should be consulted before giving vitamin or mineral supplements. Infants consuming less than 16 ounces standard formula or equivalent amounts of human milk per day should receive one vitamin dose and infants consuming 16 to 32 ounces of breastmilk or formula should receive one half of a standard vitamin dose because they are not receiving adequate formula or milk in order to provide all their vitamins. Iron supplementation should be done by 2 months of age and should be given in doses of 2-4 mg/kg body weight/d based on their age (dose increases with age).
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<td>Vitamin D is needed, either through formula or vitamin supplements for all breastfed infants. For formula-fed infants: 32 oz (one liter) standard formula or 21 oz of NeoSure or other preterm formula will provide adequate amounts. Vitamin D intakes greater than the recommended levels do not necessarily improve bone mineralization in preterm infants, so high doses are not required. Calcium and phosphorous are added to formulas and what we find is that extra calcium and phosphorous in the preterm formulas actually improve catch-up growth. You might want to consider a commercial follow-up formula for infants if they have any risks of osteopenia either if they were LBW or if they have other medical conditions. It is important to make sure that we do not give preterm infants too much vitamin A because they can get excessive intakes.</td>
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<td>The needs of normal birth weight infants differ from those of low birth weight infants. Infants are considered low birth weight if they are 5.5 lbs or less. Multivitamins are recommended for all breastfed infants that are low birth weight, whether they are preterm or term infants. We need to give special consideration to vitamins D, K and folic acid, as well as calcium, phosphorous and iron. Ongoing vitamin D supplementation of 400 IU is needed for all breastfed infants. In fact the new recommendations indicate that it is probably needed for most LBW infants. Standard infant formulas will meet the needs of infants when they are consuming ≥ 32 oz/day.</td>
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### Module 3: Infant Feeding

**Slide 54**

In assessing the nutrient needs of all infants (full term, preterm, normal weight, and LBW) we look at growth. We are particularly interested in making sure that any preterm infant who have lost weight will gain weight and that growth is sustained in all infants. Height, weight and head circumference are important, but most important is looking at the weight-for-length curves. We want them to find a track and follow it; so if they are at the 45th percentile by a few months of age, we like to see them follow that. If they are at the 80th percentile, we like to see them follow that. What we don’t want to see is infants who start out well, but then their growth deteriorates over time. Weight gains of 10-15 g/day after 6 months of age are ideal. We are looking for steady sustained growth. There are specific issues that need to be addressed when assessing preterm infants. Less preterm or larger LBW infants will generally catch-up within the first 1-2 years of age with their other peers. Smaller and more preterm infants may take between 3-5 yrs to catch up to their full-gestational peers.

**Slide 55**

Whenever we see growth faltering, one of the things we need to look at is whether there is a feeding issue, such as being fed too much or not enough. Sometimes we will see infants who grow too rapidly and sometimes we will see infants who do not seem to catch up with their peers. So it is important to see the nutrient content of their dietary intake, how skilled the care provider is in feeding the infant based on their needs, as well as seeing what the parental attitudes are. For infants who have had cardiac surgery or are LBW, parents spend so much time in early childhood wanting to feed and feed their child that they may continue to overfeed them even once they have caught up with their peers. These children can sometimes be at risk for excessive weight gain.

**Slide 56**

Lastly we will discuss Gastroesophageal reflux.
A common issue in infants is gastroesophageal reflux or GER, when the gastric contents do not stay in the stomach and they reflux into the esophagus. It is particularly common in lower birth weight infants but we also see it in full term infants as well. Pathological reflux or reflux that continues long-term is associated with poor growth, esophagitis, irritability, intractable crying, feeding aversion, and respiratory symptoms. The literature is full of case studies of children who had GER as infant and still did not eat well at the age of 6. These individuals exhibited failure-to-thrive for years, and they associated food with pain. So, GER can have some very long-term consequences for the infants if it is not dealt with early on. Screening low birth weight infants for GER should be mandatory, but again, any older child who has a lot of spit up, aspiration, or pain on feeding should be assessed for GER. Data also show that breastfed infants are less likely to show symptoms of GER, so this is another reason that mothers should be encouraged to breastfeed.
| Slide 58 | The following are symptoms or indicators of GER: Spitting up more than 3 times a day, spitting up more than a tablespoon at a time, crying a lot during or after feedings, appearing to be hungry but then when food is brought to the infant they take a couple swallows and refuse it, and spells of arching their back which is what babies often do to try to relieve the pain of reflux. Often these babies will cry a lot. The parents may think that they have colic and mistake the symptoms of colic for the symptoms of GER. It is important to remember that the crying is just one piece. So, if they have persistent crying with excessive spit up with some of the other symptoms, then it needs to be assessed whether it truly is colic or GER. |
| Slide 59 | Working with the infant’s health care provider is recommended. There are medical formulas that have been developed for this condition. There are medications for GER in infants which should only be administered under medical supervision—over the counter mediations should not be given to infants. In some cases, the medications will take care of the GER but in some severe cases surgical management will be needed. The surgery tightens the esophageal sphincter so that the stomach acid and contents cannot enter the esophagus. |
| Slide 60 | Positioning is often the first thing that will be tried with infants who have GER. This is beneficial because of the effects of gravity and changes in lower esophageal sphincter pressure. Position the infant at no less than a 45 degree angle during feeding rather than feeding the infant while they are lying down. Upright positioning during awake times and making sure that the stomach is not compressed will help, so front carrier pouches often work well for infants, or the slings if you can keep the baby upright in the sling. Supports in infant car seats so that the babies is not “slouching over” from side-to-side or forward can help to keep the abdominal compression from happening. Positioning them on a foam wedge during sleep to maintain a 30 degree angle can often help because again it can help keep the reflux from occurring. Also timing feedings so that infants get smaller and more frequent feedings seems to help. |
| Slide 61 | Now it is time to test your knowledge |
| Slide 62 | Question 1: The benefits of breastfeeding include which of the following? A. Decreases risk of some health conditions for mom and baby B. Bonding C. Analgesic effect on infants D. Decreased cost E. All of the above  
Answer: E. All of the above |
| --- | --- |
| Slide 63 | Question 2: What are the functions of prolactin and oxytocin in lactation? A. Prolactin stimulates milk production, Oxytocin needed for milk let down B. Oxytocin stimulates milk production, Prolactin needed for milk let down C. Neither A nor B  
Answer: A. Prolactin stimulates milk production, Oxytocin needed for milk let down |
| Slide 64 | Question 3: Breastmilk changes over time to meet the nutritional needs of infant. A. True B. False  
Answer: A. True. Breastmilk changes in composition to meet the needs of the growing infant. |
| Slide 65 | Question 4: Which of the following do not affect milk production? A. Smoking B. Frequency of feedings C. Vitamin and mineral supplements D. Overhydration  
Answer: C. Vitamin and mineral supplements do not affect the amount of milk produced. |
| Slide 66 | Question 5: In addition to higher concentration of energy and fat, preterm breastmilk is higher in which of the following? A. Lactose B. Electrolytes C. Phosphorous D. Calcium E. All of the above  
Answer: B. Preterm breastmilk is higher in electrolytes such as sodium and chloride. |
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<th>Quiz results</th>
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<td>Slide 69</td>
<td>This completes the module Infant Feeding, presented by the Minnesota Department of Health WIC Program</td>
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