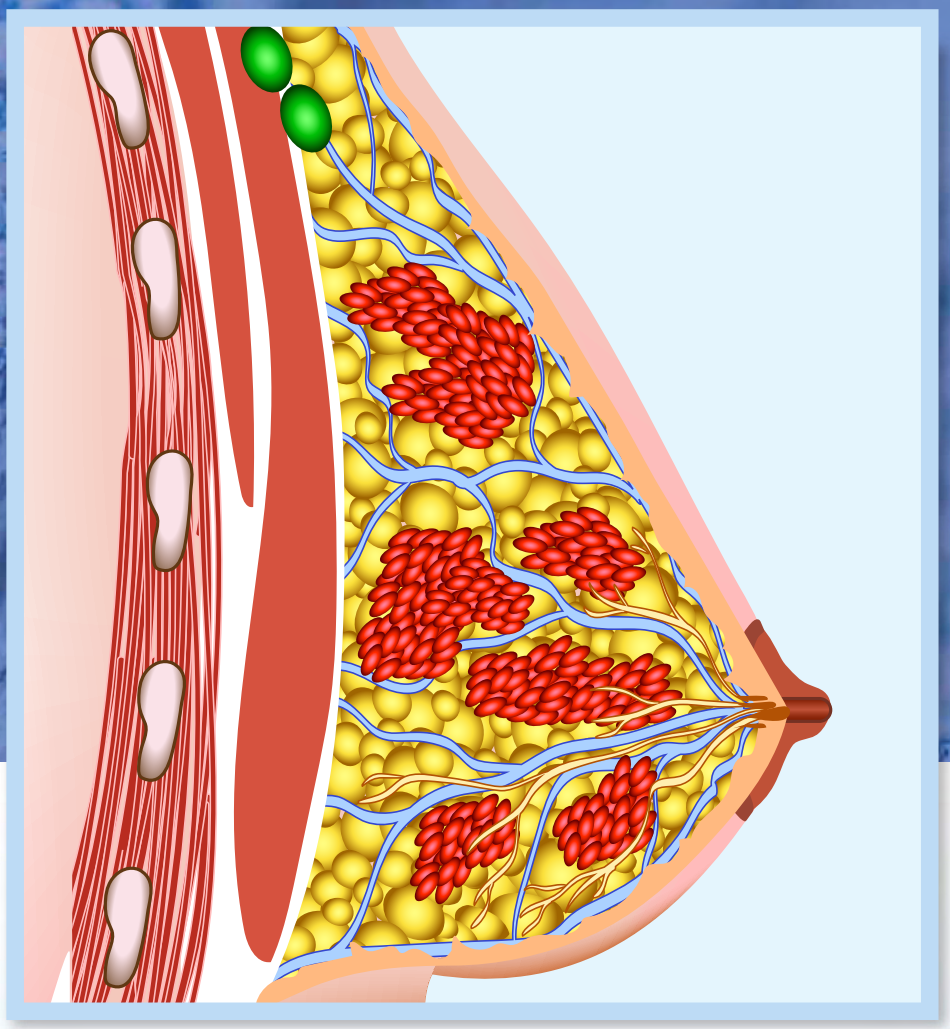
BREASTFEEDING PROTOCOL:

How the Breast Works



BABY-FRIENDLY INITIATIVE STRATEGY ONTARIO

TORONTO Public Health

Provincial Council for Maternal and Child Health
building a brighter future

MICHAEL GARRON HOSPITAL
TORONTO EAST HEALTH NETWORK

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The Breastfeeding Protocols are based on the City of Toronto's Breastfeeding Protocols for Health Care Providers (2013) and are co-owned by the City of Toronto, Toronto Public Health Division (TPH) and the Toronto East Health Network, Baby-Friendly Initiative (BFI) Strategy for Ontario. Revised Protocols are being released as they are completed, and they are available available at https://breastfeedingresourcesontario.ca/resource/breastfeeding-protocols-health-care-providers. All revised Protocols, as well as the complete set of 2013 Protocols, are available at www.toronto.ca/wp-content/uploads/2017/11/9102-tph-breastfeeding-protocols-1-to-21-complete-manual-2013.pdf. For more details on the revision process and terminology, please see the *Introduction to Breastfeeding Protocols for Health Care Providers.*

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Process

The process of revising and updating the Protocol followed a clear methodology based on *Evidence-Informed Decision Making in Public Health* www.nccmt.ca, developed by the National Collaborating Centre for Methods and Tools (NCCMT) and is described in the full Introduction, linked above. Every effort has been made to ensure the highest level of evidence is reflected.

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Use of this Protocol

The BFI Strategy for Ontario and TPH encourage individuals and organizations to use this Protocol to support evidence-informed clinical practice. This Protocol may be copied or printed for the purpose of educating health care practitioners, provided the authors are acknowledged and content is not altered, nor used or reproduced for commercial gains.

Disclaimer

Every breastfeeding dyad and their circumstances must be assessed on an individual basis. In doing so, health care providers must use their own professional judgement along with the evidence in assessing the care and support that the family needs. At times, consultation with another breastfeeding expert or advice from a medical professional (physician, midwife, or nurse practitioner) will be required.

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The Importance of Understanding How the Breast Works

Those who support breastfeeding families greatly benefit from knowledge of breast anatomy and physiology, the components of breast milk, and how supply is established and maintained. This is needed to:

- Ensure health care providers (HCP) have a clear understanding of principles of breast milk production and removal by an infant, or by expression.
- Ensure HPCs have accurate, evidence-based information when teaching clients and assisting them to make an informed decision. This in turn will contribute to higher breastfeeding initiation, duration, and exclusivity rates.
- Educate clients and equip them with a sense of empowerment about their body's ability to nourish their infant with their breast milk and to sustain breastfeeding.
- Increase a mother's confidence and self-efficacy in breastfeeding. This happens when information is provided in a clear and meaningful way, and is both evidence and strength-based.
- Ensure HPCs' understanding of the importance of early milk removal and using cue-based feeding to effectively breastfeed.

Key Messages with Brief Explanations

Key messages with brief explanations are found immediately below, and greater detail is found later in this protocol.

1. Breast anatomy and development (Hale & Hartmann, 2017)

- The breast is made of glandular tissue (mammary gland) which is responsible for milk production (synthesis) and transport of the milk to the nipple. Other components include ligaments and muscles to support the breast (connective tissue), fatty (adipose) tissue, nerves, blood, and lymph.
- The amount of fatty tissue in the breast varies between breasts and among women. The size of the breast is not related to the ability to produce milk.
- The development of the female breast starts in utero, continues in infancy, and during puberty, and reaches maturity during pregnancy and early postpartum.

2. Breast milk transitions

- Colostrum is the first milk produced in the breast from about the second half of pregnancy until about 36-96 hours postpartum. It is thick, yellowish, and is perfect for the newborn infant. Colostrum is produced in small volumes that are enough for a newborn.
- Colostrum has high concentrations of some nutrients (sodium and chloride), protein and immune cells (immunoglobulins) (Lawrence & Lawrence, 2016). The effects of colostrum are diluted if the baby receives other food or drinks like infant formula.
- During pregnancy, some mothers may notice they are producing colostrum through leakage or hand expression, and many do not.
- Colostrum gradually changes into transitional milk around 36-96 hours after delivery (Hale & Hartmann, 2017). It becomes mature milk by about 9-30 days postpartum (Lawrence & Lawrence, 2016).
- Breast milk provides infants with their nutritional needs, protects infants from infection, and promotes healthy growth and development (Andreas et al., 2015; WHO, 2015).

3. Breast milk production

- Hormones prepare the mammary gland during pregnancy by multiplying the ducts, alveoli, and other structures in preparation for lactation (Macias & Hinck, 2012). This contributes to an increase in breast size and breasts may feel fuller (Hale & Hartmann, 2017).
- Effective and frequent removal of milk, by an infant or if needed by expression, will build and maintain milk production (Lawrence & Lawrence, 2016; Pollard, 2011).

4. Components of breast milk

- The components of breast milk are always changing to meet the growing and developing needs of the infant and child. This is one reason why breast milk is very complex (Hassiotou et al., 2013; Williams et al., 2017).
- Breast milk components are different among women and yet are tailored for each mother and her infant (Hassiotou et al., 2013).
- Many components vary according to the mother's circadian rhythm and peak at different times of the day (Pundir et al., 2017).
- The fat and cell content in mature milk varies between feedings, throughout each feeding, between breasts, time of day, and among women. Fat content tends to increase during feedings as breast fullness decreases (Hassiotou et al., 2013).

- Breast milk supports the development of the infant gut by nourishing helpful bacteria. These helpful bacteria are first introduced at birth, mostly with a vaginal birth and when no antibiotics are used (Witkowska-Zimmy & Kaminska-El-Hassan, 2017). Although mode of birth and antibiotic use influence the microbiome, mothers have the ability to directly positively influence the microbiome through breastfeeding. The microbiome is the community of microorganisms in the gut such as bacteria, fungi, and viruses.

- As the infant feeds at the breast, contact with the mother's skin further helps in the maturation of the infant gut microbiome. Breastfeeding helps build the immunity of the infant and child for the duration of the breastfeeding experience (Pannaraj et al., 2017). Also, maternal and infant infections both stimulate a quick immune response in breast milk (Hassiotou et al., 2013).
- Feeding expressed breast milk is healthier than feeding infant formula. Direct breastfeeding is healthier than feeding expressed breast milk as it best develops a healthy infant gut. A study suggests that breastfeeding is important for the development of the infant gut with potential lifelong importance to gut health (Yu et al., 2015). For more information on direct breastfeeding compared to breast milk feeding, see *Informed Decision Making* Protocol.

5. Factors affecting milk production

- Early, frequent and effective milk removal has the biggest impact on milk production.
- There is strong evidence supporting the importance of immediate and uninterrupted skin-to-skin contact and initiation of breastfeeding, especially within the first hour of delivery (Moore et al., 2016; WHO, 2017).
- If an infant is not feeding at the breast or is not effectively transferring milk at the breast, expressing milk regularly is required. This should start as soon as possible, such as within the first hour after birth, to stimulate and/or maintain milk production (Geddes et al., 2016; Hassiotou et al., 2013; Lawrence & Lawrence, 2016; Pollard, 2011).
- Hand expression is an effective way to remove milk, can help build supply, and is probably more effective than a pump in the first 24 hours. All mothers could benefit from learning how to hand express.
- Expressing breast milk using a pump should not be implied as a routine part of breastfeeding, yet sometimes it is needed. Interventions such as relaxation, massage, warming the breasts, hand expression, and lower cost pumps may be as effective, or more effective, than large electric pumps. Using massage with expression (hand or pump) can yield higher output, and combining hand expression with pumping may also increase output. Strong evidence suggests the most suitable method for milk expression may depend on the time since birth, purpose of expression, and the individual mother and infant (Becker et al., 2016). A combination of approaches should be tailored to each mother.

6. Maternal nutrition

- Evidence suggests that a direct relationship between either maternal diet or fluid intake on breast milk composition has not been adequately studied (Bravi et al., 2016; Keikha et al., 2017; Ndikom et al., 2014). Canada's Food Guide recommendations for breastfeeding mothers remain relevant and should continue to be followed.

The following is a more detailed explanation of the above key messages.

1. Breast Anatomy and Development

The female breast is primarily made of glandular and fat (adipose) tissue (Figure 1). The amount of fat tissue in the breast varies among women and between breasts, making the size of the breast an invalid indicator of its ability to produce milk (Hale & Hartmann, 2017). There is a high supply of blood in the breast which drains from the mammary and axillary veins. There are also a large number of nerves supplying the breast. Breast surgery or trauma may affect nerve sensations to the breast (Pollard, 2011). More research is required to determine the relationship between mammary blood flow and milk production (Geddes et al., 2016).

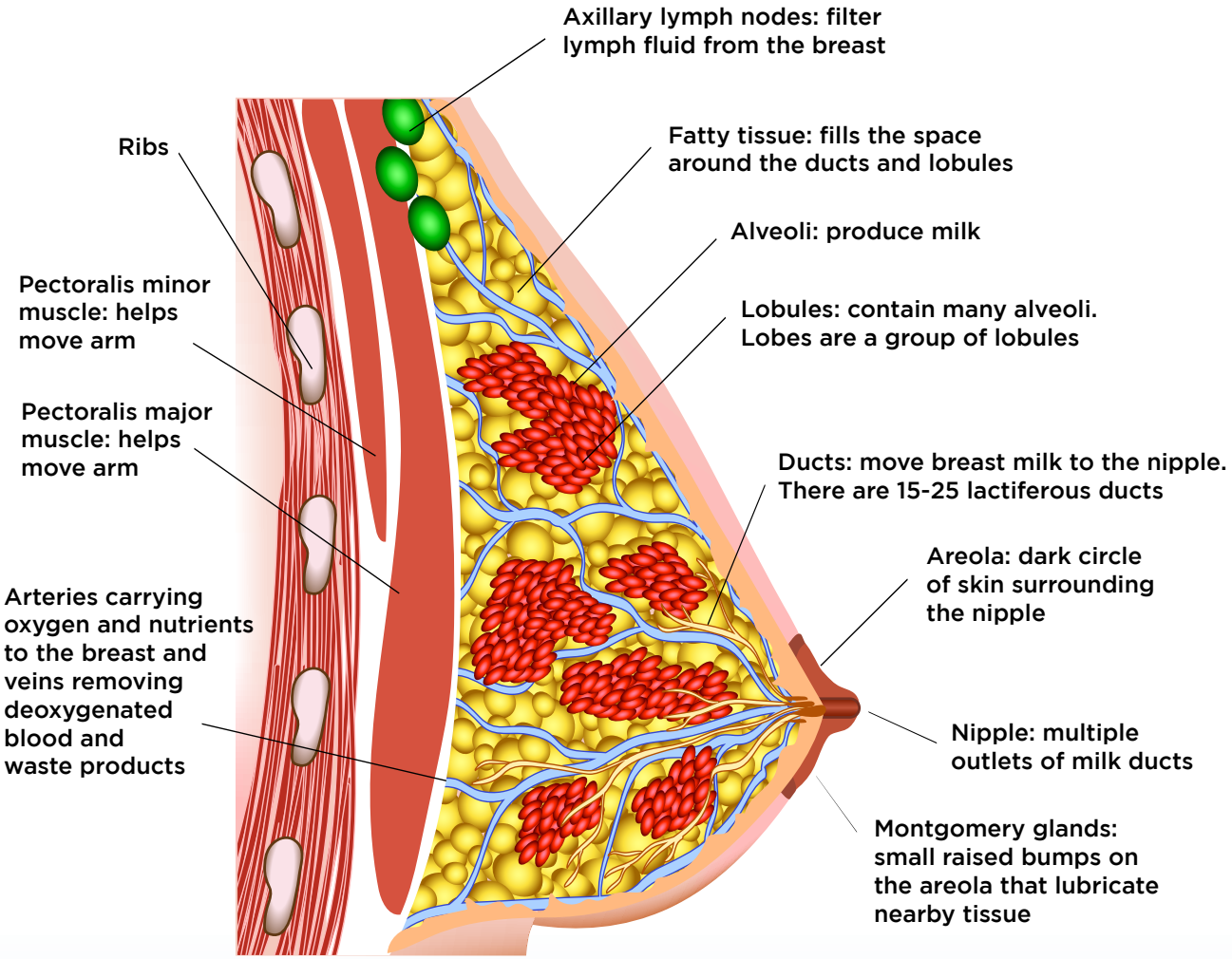


Figure 1: Breast Anatomy

Mammogenesis is the development of the mammary gland beginning in the embryo and extending beyond the initiation of lactation.

Lactogenesis is the onset of milk secretion.

Table 1: Development of the Female Human Breast (Hale & Hartmann, 2017, p. 20)

Stage of Development	Characteristics of Development
Prepubertal	• Basic ductal system is developed. • Symmetrical growth.
Puberty	• Increased cell growth with each menstrual cycle. • Growth of the ductal system. • Asymmetrical growth.
Pregnancy	
Rapid Mammogenesis • First half of pregnancy.	• Rapid growth and branching of ducts and lobules. • Increase in epithelial cells.
Lactogenesis I • Second half of pregnancy.	• First stage of milk production. • Epithelial cells change into milk producing cells (lactocytes). • Production of colostrum begins around 16 week's gestation. • Increased density of the mammary gland.
Term	
Lactogenesis I • Continues from delivery to 36-96 hours after delivery.	• Epithelial cells change into milk producing cells (lactocytes). • Colostrum is produced in small but suitable quantities to meet the newborn's needs.
Lactogenesis II • Occurs 36-96 hours postpartum.	• The onset of increased milk production after the infant is born. • Closure of space between epithelial cells. • With infant suckling, stimulation, and milk removal, breasts feel fuller with increased growth and development of the alveoli and ducts and an increase in volume of breast milk produced.
Lactogenesis III • From about 9 days postpartum to involution.	• Also known as galactopoesis. • Maintenance stage of lactation.
Involution	
Post-lactation involution (return to pre-pregnant state)	• Begins with weaning from breastfeeding. • Gradual removal of milk-producing cells in the mammary gland occurs when weaning begins. • Cell death begins to occur within 2 days of involution. Milk changes to a secretion similar to colostrum. • The mammary gland returns to a pre-pregnancy state. • The breast returns to being influenced by hormonal changes of the menstrual cycle.
Postmenopausal involution	• Glandular tissue wastes away. • Increase in fat tissue. • Tissue is less elastic-like.

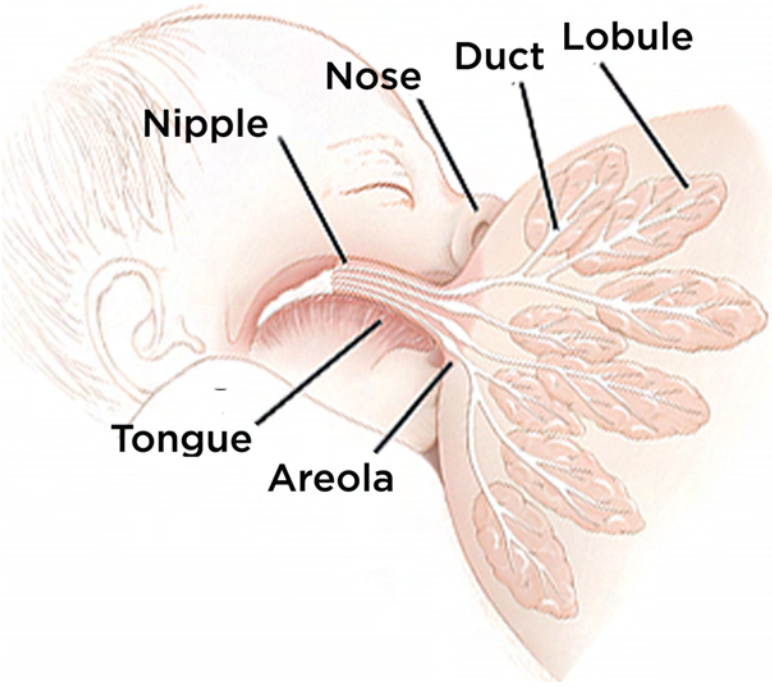


Figure 2: Lactating breast after letdown. Letdown (also called milk ejection) is when the milk is released from the alveoli. During letdown the ducts become shorter and wider, and return to normal several minutes after sucking stops (Gardner et al., 2015). www.mountnittany.org/articles/healthsheets/313

Table 2: Breast Anatomy and Function

Structure of the breast	Function	Importance to breastfeeding
Mammary Gland Milk-producing gland inside the breast.	• Mammogenesis (breast development) begins in the embryo, with rapid growth in pregnancy, and continues during lactation (Hale and Hartmann, 2017). • Hormones involved in mammogenesis: – During adolescence, the primary hormone is estrogen. – During pregnancy, a number of hormones prepare the mammary gland by multiplying the ducts, alveoli, and other structures (see Hormones and *Lactation*, Table 4 below).	• Almost all sizes of breasts can produce enough milk. Breast size varies among women because of the amount of fat tissue, not the ability to produce milk. Breast size does not determine milk storage capacity (Hale & Hartmann, 2017; Lawrence & Lawrence, 2016; Pollard, 2011). • During pregnancy, an increase in breast size begins at about 6 weeks gestation. The size increase is due to structural changes inside the breast. • Postpartum, the structural changes support an increase in milk production and a further increase in size (Hale & Hartmann, 2017; Macias & Hinck, 2012). • Not all breasts follow the same growth pattern.
Alveoli Clusters of glandular tissue in the breast where breast milk is produced and stored.	• Alveoli are surrounded by myoepithelial cells that contract when an infant sucks or when milk is expressed. The contraction of the cells is known as letdown or Milk Ejection Reflex (MER). During letdown, the alveoli secrete breast milk into the ducts and the ducts widen. • Mothers may spontaneously have a letdown from other stimulation like hearing their infant cry, think about her infant, or hear another infant cry. • Milk storage happens in the alveoli (not in the ducts) and milk moves out of storage with a letdown (Macias & Hinck, 2012).	• Letdown may occur multiple times and at various intervals during the infant feeding session (Gardner et al., 2015). • During a letdown parents can see a change in the sucking behavior. During a letdown the infant's mouth opens, there's a short pause, and then mostly closes.

Table continued....

Structure of the breast	Function	Importance to breastfeeding
Ducts Tubular structures that direct breast-milk flow from the alveoli out through the nipple. Duct branches intertwine through-out the breast and eventually go from the alveoli to the nipple. Ducts are surrounded by fatty and glandular tissue (Macias & Hinck, 2012).	• The ducts increase in diameter when letdown occurs and transport breast milk from the alveoli to the nipple. • As a response to an infant suckling, ducts will shorten, widen, and increase in pressure due to the release of breast milk from the alveoli (see Figure 2 above). • When breast milk stops being removed, the duct size returns to its resting diameter within 2 minutes due to a backward flow of breast milk (Gardner et al., 2015).	• Ducts transport milk and do not store milk. • There are 15-25 lactiferous ducts that go into the nipple (Lawrence & Lawrence, 2016). At the nipple tip there are an average of 5-9 duct openings (Hale & Hartmann, 2017). • Ducts are small, superficial and compressible. This makes massage and breast compressions effective for milk removal (Hale & Hartmann, 2017).
Nipple Raised area at the centre of the areola (dark area around the nipple) where the milk ducts exit the breast.	• Nipples are flexible and able to stretch and mould to conform to an infant's mouth. • The nerve endings are highly sensitive to stimu-lation. By stimulating the nipple, it triggers the release of oxytocin and causes the letdown to occur (Lawrence & Lawrence, 2016; Pollard, 2011).	• Breast milk ducts merge at the nipple and allow breast milk to exit the breast. • The size and shape of the nipple may influence the infant's ability to achieve a deep latch. • There are multiple duct openings at the nipple (Pollard, 2011).
Areola A dark area around the nipple. Among women, it varies in size and colour and sometimes on one side of the body compared to the other. Like the nipple, the areola is sensitive to touch and stimulation (Pollard, 2011).	• Increases in size and darkens in colour as a response to hormones during pregnancy and lactation. • Helpful bacteria found on the areola are transferred to the infant gut during breastfeeding (Pannaraj et al., 2017).	• Change in size and colour are thought to assist the infant in locating the nipple during latching. • Good bacteria that may be present on the mother provide a boost to the infant's immunity, especially during the first 6 months of life (Pannaraj et al., 2017).

Table continued....

Structure of the breast	Function	Importance to breastfeeding
Montgomery's tubercles Also called Montgomery glands. These are sebaceous glands on the areola.	• Release a protective, oily secretion that lubricates the areola and nipple during pregnancy and lactation (Lawrence & Lawrence, 2016; Pollard, 2011).	• The secretion protects the areola and nipple area and provides a helpful scent for infants to latch. • It is normal for a small amount of milk to be secreted from these openings. Many mothers will never notice this (Pollard, 2011).

2. Breast Milk Transitions

Breast milk comes in different forms that transition from one to the other in a continuum. They are known as colostrum, transitional breast milk, and mature breast milk. The main components are highlighted in Table 3 below.

Table 3: Forms of Breast Milk

Form	Composition	Importance to breastfeeding
Colostrum	• Thick, yellowish fluid. • Rich in proteins (due to a large number of immunoglobulins), fat soluble vitamins, and some minerals. • Less fat and lactose (a type of sugar) than mature breast milk (Andreas et al., 2015). • Higher concentration of immune cells than mature milk (Andreas et al., 2015).	• Primary function is protection against disease while also providing nutrition (Hassiotou et al., 2013): – Is all the infant needs initially. Effects of colostrum are diluted if the infant receives other foods or drinks. – Large number of immune cells helps protect the newborn infant from infection. These cells may also protect the mammary gland against infection (Hassiotou et al., 2013). – Newborns have immature kidneys and are only able to deal with small volumes (Pollard, 2011). – Helps to clear meconium (laxative effect) which has a high concentration of bile and reduces risk of jaundice (Lawrence & Lawrence, 2016). – Small volumes help to coordinate infant's suck-swallow-breathe pattern in the first few days. – Contains essential nutrients such as cholesterol for nerve myelination, and enzymes that aid with digestion. It also contains antibodies and antioxidants (Lawrence & Lawrence, 2016).

Form	Composition	Importance to breastfeeding
		• First milk produced during around 16 weeks gestation and in early postpartum. • In the first 3 days postpartum, the volume per feeding ranges from 2 to 20 ml, depending on the frequency of feeds (Lawrence & Lawrence, 2016).
Transitional milk	• Breast milk produced during lactogenesis II. The amount of milk gradually increases. • The concentration of fat, lactose and amount of calories gradually increases (Pollard, 2011). • The concentration of immunoglobulins gradually decreases. Breastmilk continues to contain a high number of immunoglobulins.	• Breast milk may have a yellowish tinge. • Produced from about 3-9 days or 2 weeks postpartum (Lawrence & Lawrence, 2016) though number of stated days vary within high-quality references. • There is not a moment of clear-cut changes to the breast milk but rather change is part of a continuum of events (Wambach & Riordan, 2016).
Mature milk	• Milk transitions to mature milk about 9-30 days after birth. • At the beginning of a feeding, there is a higher concentration of protein, lactose, and water. • The components are always changing to meet the infant's needs: – Protein decreases from month 2 to month 7 (Andreas et al., 2015). – Lactose (carbohydrate) increases from months 4 to 7. – Fat changes within a feed and tends to increase as breast fullness decreases. It also changes depending on climate (Andreas et al., 2015).	• The higher concentration of protein, lactose and water at the beginning of the feed may give the milk a bluish tinge. • As the feeding progresses, the milk typically becomes whiter as the fat content increases. Breast milk provides all the water an infant needs even in hot climates. • Human milk is species specific and perfectly balanced to meet an infant's changing needs. • The protective effect of human milk continues to be important as long as breastfeeding continues.

3. Breast Milk Production

- Hormones are triggered when the nipple and areola are stimulated by infant hand movements and suckling.
- Hormones are released into the mother's bloodstream, sending messages to the brain via the hypothalamic-pituitary-adrenal (HPA) axis.
- The messages, as well as other maternal and infant behaviours, trigger breast milk production and the letdown or breast milk ejection reflex (Pollard, 2011).
- Effective and frequent removal of milk, by an infant or by expression, will build and maintain milk production (Lawrence & Lawrence, 2016; Pollard, 2011). The recommendation is at least 8 feedings in a 24 hour time period.

Table 4: Hormones and Lactation (Hale & Hartmann, 2017)

Lactation cycle	Related hormones and their functions	Importance to breastfeeding
Mammogenesis – development of the mammary gland starting early pregnancy, resulting in multiple alveoli and structures to support lactation.	**Progesterone and estrogen** are female hormones responsible for the increased size and sensitivity of the mammary gland during pregnancy.	• These changes are signs that the breasts are preparing to make breast milk.
Lactogenesis – The initiation of milk production beginning from pregnancy and ending when the breast returns to its pre-pregnancy state after the infant fully weans. There are 3 stages.		
Lactogenesis I – colostrum phase • Controlled by the **endocrine** system (hormonal). • Begins middle to late-pregnancy and ends 36-96 hours postpartum.	**Prolactin** is a maternal hormone needed for milk production and the maintenance of lactation. • It is synthesized, stored, and released from the anterior pituitary gland. • It stimulates the development of the mammary gland. • Although prolactin is present during pregnancy, it is inhibited by progesterone and estrogen. • Prolactin is also inhibited by prolactin-inhibiting factor (PIF). See details next page.	• Begins in pregnancy and is driven by hormones. • Colostrum is produced in mid to late pregnancy (from around 16 week's gestation) and in amounts needed by an infant in early postpartum. • Some mothers may leak colostrum during pregnancy and others may not (Pollard, 2011).

Table continued....

Lactation cycle	Related hormones and their functions	Importance to breastfeeding
Lactogenesis II • Controlled by the **endocrine** system (hormonal). • Begins with an increase of breast milk production 36-96 hours after childbir th (Hale & Hartmann, 2017, p. 92).	• **Progesterone and estrogen** levels suddenly fall after the placenta is delivered and: – Trigger lactogenesis II. – Cause the closure of junctions between the alveolar cells. – Increase the growth and development of the alveoli and ducts. • The onset of lactogenesis II may be influenced by a number of factors. For more information, see **Table 6** below and ***Initiation of Breastfeeding*** Protocol.	• The amount of milk produced is mostly influenced by the stimulation and release of maternal hormones. • Milk volume increases rapidly, especially in the first month.
	Prolactin • Increased levels are stimulated by the sudden drop in progesterone and estrogen levels after the placenta is delivered. • No longer inhibited by protein-inhibitor factor, it stimulates the alveoli to produce and secrete milk. • Prolactin receptors are located on the milk-producing cells and allow prolactin to bind to them. This triggers the regulation of milk production. • Currently, there are no reference values for normal prolactin levels in breastfeeding women, limiting interpretation of blood values in women with breastfeeding difficulties (Stuebe et al., 2015). • Research suggests that the normal range for prolactin levels may vary, depending on the frequency of breast-feeding. Measurement is of minimal value.	• Skin-to-skin contact within the first hour of birth promotes the release of prolactin and oxytocin needed for lactogenesis II (Moore et al., 2016; Pollard, 2011). • Skin-to-skin contact continues to benefit breastfeeding for the first months following birth (Moore et al., 2016). • Breasts are fuller with the increased volume of milk. Mothers may refer to this stage as “milk coming in” (Hale & Hartmann, 2017; Lawrence & Lawrence, 2016; Nommsen-Rivers et al., 2010) though this is more appropriately referred to as “milk volume increasing”. • The amount of prolactin is related to the amount of nipple stimulation during early states of lactation after the first 4 days postpartum (Lawrence & Lawrence, 2016). • Frequent and exclusive breast-feeding in the first few weeks postpartum may affect prolactin levels and increase breast milk production (Stuebe et al., 2015).

Table continued....

Lactation cycle	Related hormones and their functions	Importance to breastfeeding
Lactogenesis II (Contined)	• Prolactin is dependent on estrogen, progesterone, glucocorticoids, insulin, thyroid hormone, parathyroid hormone, and oxytocin (Lawrence & Lawrence, 2016). • Prolactin levels follow a circadian rhythm and peak at night (Maningat et al., 2009).	• It's important that at least some breastfeeding occurs overnight when prolactin levels are higher.
	Prolactin-inhibiting factor (PIF) or Feedback inhibitor of lactation (FIL) • A substance secreted by cells (lactocytes) in the breast. • It regulates milk production in the breasts using a negative feedback response: – As the alveoli become full with breast milk, the PIF builds up and prevents more milk production. – Full breasts prevent the uptake of prolactin. – When the breast milk is removed and the breasts are softer, then the amount of PIF is reduced and milk production begins again (Pollard, 2011).	• Milk production increases at a much faster rate when the breasts are less full. (Gardner et al., 2015). • Mothers need to feed their infants according to infant cues and not wait until their breasts feel full.
	Oxytocin • A maternal hormone which causes letdown. It sends messages to cells in the alveoli and causes the breast milk to be released into the ducts (Lawrence & Lawrence, 2016; Nommsen-Rivers et al., 2010). • Is secreted by the posterior pituitary gland in response to infant sucking and infant hand massage. • Dilates the ducts during a letdown.	• Oxytocin is released not only by nipple stimulation, but also by the mother touching, hearing, seeing, smelling, or thinking about her infant (Lawrence & Lawrence, 2016). • Oxytocin is released during labor, breastfeeding, and skin-to-skin contact (e.g., in response to touch, stroking, warm temperature, etc.). • It promotes feelings of calm, wellbeing, and anti-stress in both mother and infant (Uvnäs-Moberg et al., 2015).

Table continued....

Lactation cycle	Related hormones and their functions	Importance to breastfeeding
Lactogenesis II (Contined)	• Sends messages to the uterus to contract. This is why some women have cramps while breastfeeding in the early postpartum period (afterbirth pains). These cramps are normal and prevent maternal haemorrhaging and promote uterine involution (shrinking) after birth (Uvnäs-Moberg et al., 2015). • Oxytocin has a calming effect on the mother and decreases her cortisol levels. • Oxytocin permeates the area of the brain associated with bonding and mothering. • Some studies on synthetic oxytocin used to induce labour show a possible negative effect on breast-feeding initiation and duration (more studies are needed) (Garcia-Fortea et al., 2014; Uvnäs-Moberg et al., 2015).	• More than one letdown occurs during a single breastfeeding (average 2-3 times) each lasting from 45 seconds to 3.5 minutes (Gardner et al., 2015; Pollard, 2011). • A letdown is often noticed by looking at how often the infant sucks and swallows. At first the infant sucks rapidly. After a letdown an infant has a slower suck pattern, with wider jaw opening, and short pauses to swallow. • Some mothers may feel the initial letdown in the breasts as a "tingling" feeling, but not subsequent ones (Gardner et al., 2015). Other mothers may not feel a letdown, but still have a normal letdown response.
	Other maternal hormones also have important roles in lactation. Some of them are below.	
	Glucocorticoids: • Contribute to the development of the mammary gland, production of fat, protein and lactose in milk, and transportation of water across cell membranes. • Regulate the body's responses to stress and functions as an immune booster (Pollard, 2011; Pundir et al., 2017). • Glucocorticoids follow a circadian rhythm and peak in the early morning (Pundir et al., 2017). • Suppress insulin action (Nommsen-Rivers, 2016).	• Required for milk production, letdown, and breastfeeding maintenance (Pundir et al., 2017). • There is inconsistent evidence to suggest that a high level of maternal cortisol produced during stress decreases milk supply or negatively affects the release of oxytocin (Hale & Hartmann, 2017; Pundir et al., 2017).

Table continued....

Lactation cycle	Related hormones and their functions	Importance to breastfeeding
Lactogenesis II (Contined)	**Thyroid-stimulating hormone (TSH):** • Helps with breast growth and establishing lactation. • Helps the breast respond to growth hormone and prolactin (Pollard, 2011). • Levels are higher at about 2 to 8 weeks postpartum in breastfeeding women and then decrease. • Currently, there are no reference values for thyroid hormone levels for breast-feeding women, making it difficult to measure optimal levels in women experienc-ing breastfeeding difficulties (Stuebe et al., 2015).	• Thyroid hormone functions differently in breastfeeding women than non-breastfeeding women. • It may be important to measure thyroid levels in mothers with low supply.
	Insulin: • Helps with mammary gland development in pregnancy, milk production, and maintenance of milk supply. • Critically related to mammary gland growth during lactation; therefore, is directly related to milk production (Nommsen-Rivers, 2016)	• Women who do not have optimal levels of insulin have an increased risk for delayed onset of lactogenesis, poor milk supply, and difficulty in breastfeeding maintenance (Nommsen-Rivers, 2016). This is especially true in women who are obese.
	Growth Hormone: • Plays a role in milk production along with insulin. • Regulates the mammary gland for breastfeeding maintenance (Nommsen-Rivers, 2016; Pollard, 2011). • Prolactin and oxytocin remain especially important, among other hormones.	

Table continued....

Lactation cycle	Related hormones and their functions	Importance to breastfeeding
Lactogenesis III (galactopoesis) • Controlled by an autocrine system which means milk production is regulated by supply and demand (Pollard, 2011).	• Prolactin and oxytocin remain especially important, among other hormones.	• Considered the maintenance phase of milk production. Begins around 1 month after delivery, with milk volumes stabilizing at about 750-800ml/24 hours (Hale & Hartmann, 2017). See Figure 4 and YouTube video below for more information.

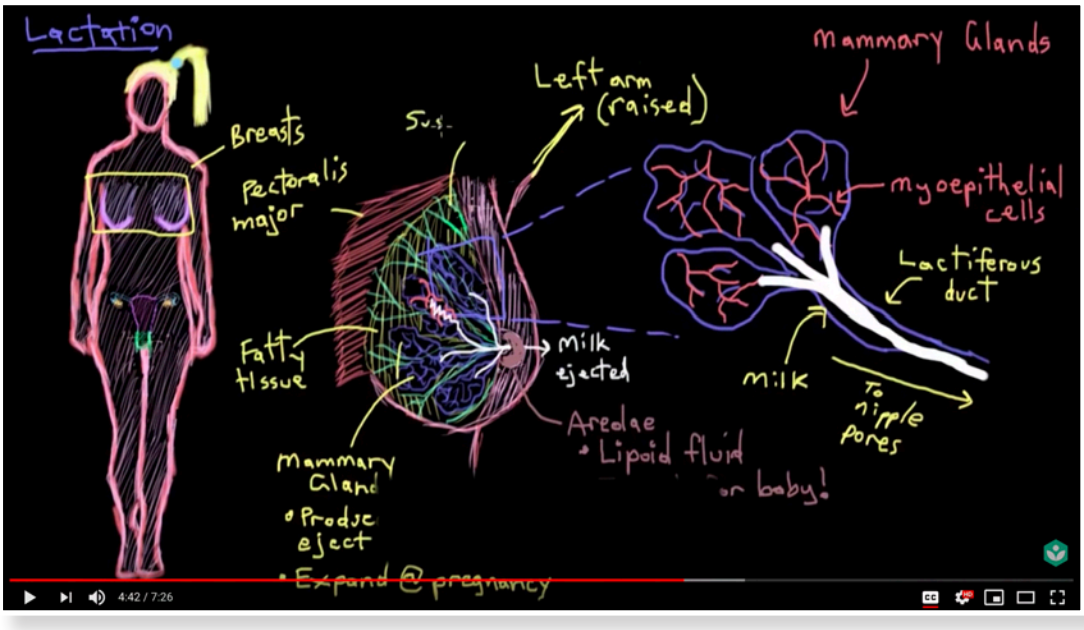


Figure 4: Breast Anatomy and Lactation (Khan Academy Medicine, 2014) To further understand breast anatomy and how milk is produced, watch the following video: https://www.youtube.com/watch?v=o6dx4uZCxBI

4. Components of Breast Milk

Until six months, breast milk fully satisfies the nutritional needs of infants. It contains proteins, fats, carbohydrates, and other biologically active components such as vitamins and minerals. Breast milk also has immunological, biochemical, and cellular components. The components of breast milk have the potential to significantly alter newborn immunity and susceptibility to infection (Andreas et al., 2015). See Figure 5 below called Cells in Human Milk.

Breast milk is generally dynamic, not constant, so it is always changing. It depends on many factors such as stage of lactation, parity, gestational age, time of day, and time into the feeding (Sosa-Castillo et al, 2017). Research is currently being done to further understand the relationship of all breast milk components to infant growth and development (Williams et al., 2017).

Table 5: Breast Milk Composition

Component	Function	Importance to breastfeeding
Water	• Water is the largest component of breast milk. • About 80% of mature breast milk is made up of water. Water contributes to the temperature-regulating mechanism of the newborn because 25% of heat loss is from evaporation of water from the lungs and skin (Lawrence & Lawrence, 2016).	• Breastfed infants do not need supplemental water, even in hot weather. • It is important to keep a newborn warm to prevent water and heat loss. Skin-to-skin, mother with infant, is a biologically normal environment for an infant. For more on skin-to-skin see ***Initiation of Breastfeeding*** Protocol.
Fats (lipids)	• Fats are the second largest component and are the largest source of energy in breast milk i.e., 40-55% of total energy (calories) (Andreas et al., 2015). • Required for infant growth and development. • Lawrence & Lawrence (2016) state fats in human milk allow maximum absorption of fatty acids, provide essential fatty acids and polyunsaturated fatty acids, and provide cholesterol. These all contribute to growth of the infant and the infant's brain.	• There is an association between fat cells and protection from infections (Andreas et al., 2015). • The percentage of fat content in breast milk continues to increase throughout the feed as the breast softens and can peak at 30 minutes after the end of the feed (Hassiotou et al., 2013). This may be significant in satisfying the infant during frequent cluster feedings. More research is required. • A strong study showed fat content was higher with breast massage during pumping. There was no difference in the energy content of milk expressed by hand, manual pump, or electric pump (Becker et al., 2016).
Immune factors	• Immunoglobulins (protein cells), provide antimicrobial and immunological factors to protect against infection (Hassiotou et al., 2013). • Colostrum has a high concentration of immune cells. • Immune cells make up a small amount (less than 2%) of cells in mature milk of a healthy mother (Hassiotou et al., 2013A). Breast milk provides active and passive immunity to the infant because it has a rich source of immunoglobulins, lactoferrin, lysozymes, cytokines, and other immunological factors.	• Many studies show breast milk protects infants from respiratory and gastrointestinal infections, such as necrotizing enterocolitis, gastroenteritis, severe respiratory illness, otitis media, and urinary tract infections (Pannaraj et al., 2017). • Recent studies show the association of beneficial bacteria in breast milk to the development of the infant gut (Pannaraj et al., 2017). • Breastfeeding has been shown to decrease the risk of some childhood cancers (Amitay & Keinan-Boker, 2015; Lawrence & Lawrence, 2016). See ***Informed Decision Making Protocol***.

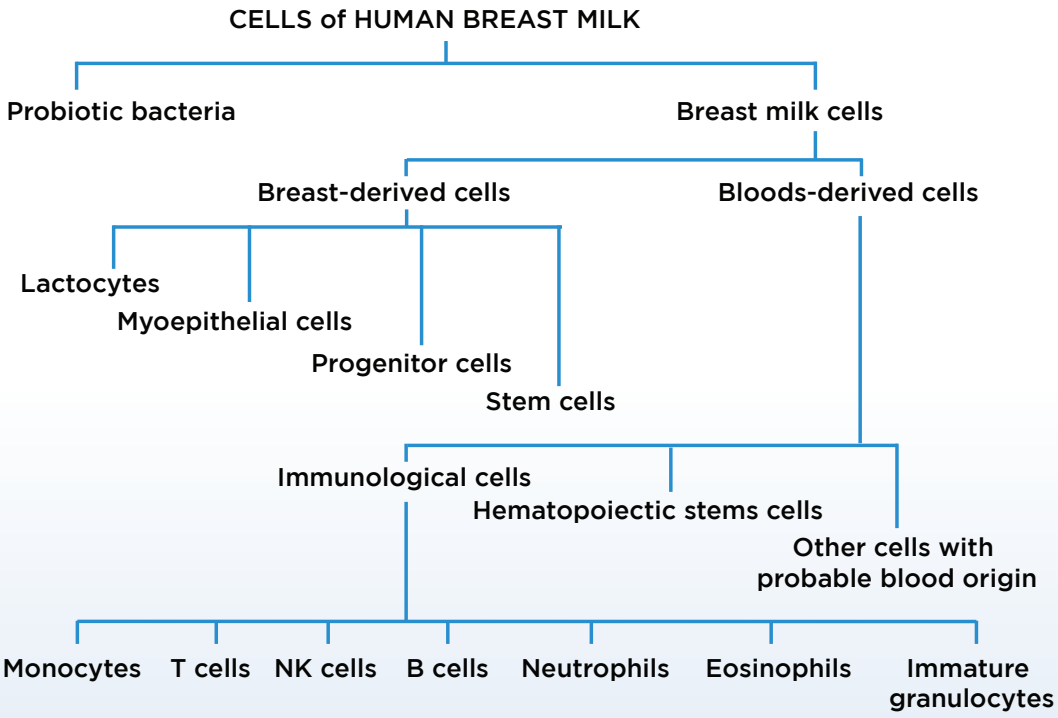
Table continued....

Component	Function	Importance to breastfeeding
	• Immune cells increase in response to infections in all infants including the older infant, toddler and/or mother (Hassiotou et al., 2013A). • Breast milk has an abundance of bioactive factors to support and enhance the immune system of the newborn (Moossavi et al., 2018). • Breast milk is thought to contain epithelial cells, stem cells, and is a continuous source of beneficial (probiotic) bacteria, including Lactobacillis and Bifidobacterium (see Figure 5 on Cells of Human Milk). These components are referred to as milk microbiota (Moossavi et al., 2018). • There is a relationship among maternal cells, bacteria, and nutrients in breast milk (Williams et al., 2017; Witkowska-Zimmy & Kaminska-El-Hassan, 2017).	• A study suggests that breastfed infants of mothers with asthma had significantly less risk of infant wheezing, regardless of maternal age, education, smoking, and other factors (Azad et al., 2017). • Breast milk may protect the infant from chronic illnesses such as diabetes, obesity and inflammatory bowel disease (Pannaraj et al., 2017). • The concentration of immune cells is also thought to protect the mammary gland from infection. • Recent studies show an association between stem cells found in breast milk with infant and breast health. (Witkowska-Zimmy & Kaminska-El-Hassan, 2017). • The relationship between nutrients and other cells in breast milk may help maintain breast health (Williams et al., 2017). • Immune cells remain important for the whole time an infant is breastfed. Changes continue throughout lactation to meet infant needs and protect mother and infant from infections (Andreas et al., 2015).
Vitamins and minerals	• Essential for healthy growth and development. • Have key roles in various cells. • Help develop immune function (Andreas et al., 2015).	• Beneficial for developing, maturing, and repairing the infant gut (Andreas et al., 2015). • Iron absorption from human milk is 49% of available iron, whereas infants absorb 10% of iron in cow's milk, and 4% of iron-fortified formulas (Lawrence & Lawrence, 2016). • Calcium absorption from human milk is 67% however, infants absorb 25% of calcium in cow's milk (Wambach & Riordan, 2016).

Table continued....

Component	Function	Importance to breastfeeding
		• Currently the Canadian Pediatric Society recommends vitamin D supplementation of breastfed infants. Vitamin D is important to infants and is available in varying quantities in breast milk. In the future and after more studies, the recommendation may be to supplement pregnant and lactating mothers at risk of low intake of vitamin D (Lawrence & Lawrence, 2016).
Enzymes and hormones	• Enzymes are important such as lysozyme (bacteriocidal and anti-inflammatory action), lipases (fat digestion), amylase (starch digestion), and leptin (appetite regulation) and others (Lawrence & Lawrence, 2016). • Hormones like human growth factor play key roles that are not fully understood (Wambach & Riordan, 2016).	• It is known that enzymes and hormones work best when not mixed with other substances. • Enzymes like leptin that regulate appetite and satiety may be protective against risk for overweight in breastfed infants (Wambach & Riordan, 2016).

This illustration provides a few more details of cells in breast milk including stem cells.



Direct breastfeeding versus breast milk feeding.

Immune and other benefits of breast milk are affected by HOW an infant is fed. Direct breastfeeding is better for an infant than providing expressed breast milk (EBM) especially exclusive EBM feeding.

- Skin-to-skin contact soon after delivery helps to line the infant gut of all infants, also known as seeding the gut. Breastfeeding further fuels the infant microbiome (Pannaraj et al., 2017).
- About 40% of bacteria found in the infant gut in the first month of life are from the mother's skin and milk (Pannaraj et al., 2017).
- Recent studies show direct breastfeeding to be more protective against childhood asthma, compared to breast milk feeding or formula feeding (Azad, et al., 2017; Klopp et al., 2017).
- Maternal and infant infections both stimulate a quick immune response in breast milk composition in a direct breastfeeding relationship (Hassiotou et al., 2013).
- Breast milk cells are live during breastfeeding, suggesting benefits far beyond what is currently known (Hassiotou et al., 2013b).

See more about the differences between direct breastfeeding and exclusive breast milk feeding in the ***Informed Decision Making*** Protocol.

5. Factors Affecting Milk Production

Table 6: Factors Affecting Milk Production

Factor	Effect	Importance to breastfeeding
Early and uninterrupted skin-to-skin contact	• Skin-to-skin immediately after birth facilitates infant self-regulation and self-attachment (Windstrom, 2011) [low quality study]. • Immediate and undisturbed postpartum skin-to-skin improves the infant's natural ability to suck and improves breastfeeding success (Dani, 2015) [low quality study]. • Breastfeeding duration increases by an average of 64 days when skin-to-skin is started less than 24 hours after birth (Moore, 2012). • Immediate skin-to-skin contact was consistently found to support the early initiation of breastfeeding regardless of mode of delivery (Lau, 2017).	• Early skin-to-skin contact and early initiation of breastfeeding within the first hour after delivery may increase the likelihood of any or exclusive breastfeeding up to 1-4 months of life (Moore et al., 2016; WHO, 2017). • Showing mothers how to breastfeed immediately postpartum makes them more likely to continue breastfeeding. Support offered pre- or postnatally by trained professionals, peer supporters, or a combination of both, is effective (McFadden et al., 2017). See ***Initiation of Breastfeeding*** Protocol.
Milk removal	• The amount of breast milk produced depends on how often and how effectively milk is removed from the breast. • Drained (softened) breasts produce milk at rates higher than fuller breasts (Hassiotou et al., 2013). • Effective and frequent removal of milk with milk ejection reflex will result in increased milk production (Gardner et al., 2015). • Frequency and timing of milk ejection varies between and within feedings (Gardner et al., 2015).	• Feeding in short intervals allows the breast to produce (or maintain) milk at a higher rate, suggesting an increase in milk supply. It is important to drain or soften breasts frequently to increase milk supply. • Frequent feeding or expressing milk 30 minutes after breastfeeding may increase milk production (Hassiotou et al., 2013). • The addition of food or fluids other than breast milk in the first 6 months, unless medically indicated, may affect milk supply. See ***Medical Indications of Supplementation*** Protocol (TPH, 2013).

Table continued....

Factor	Effect	Importance to breastfeeding
Effective infant suck for milk removal	• Effective breastfeeding requires the infant to have effective coordination of a suck, swallow, breathe pattern (Geddes et al., 2016). See ***Effective Suck and Ineffective Suck*** Protocol (TPH, 2013).	• If infant is unable to effectively transfer or remove milk within 6 hours of delivery, then expression by hand or pump at appropriate subsequent intervals is required to initiate lactation (Geddes et al., 2016; Hassiotou et al., 2013). The Breastfeeding Committee for Canada (2017) recommends starting within 1 hour.
Placenta encapsulation/ pills (placentophagy)	• Research is needed to determine the effect of encapsulated placental pills on human milk production.	• There are no studies examining the effects or safety of placentophagy in humans, despite claims that nutrients and hormones consumed from the placenta may increase (or decrease) milk production (Marraccini & Gorman, 2015).
Maternal intravenous fluids	• The Academy of Breastfeeding Medicine Protocol on Engorgement (2016) quotes a pilot study by Kujawa-Myles et al. (2015) stating, "Large amounts of intravenous fluids given during labor appear to be associated with an earlier and more prolonged maternal perception of breast fullness and tenderness as well as increased levels of breast edema extending beyond day 9 postpartum" (p. 160). • A high-quality study by Noel-Weiss et al. (2011) indicates that an infant experiencing "further weight loss after the first 72 hours is not likely connected to maternal fluids and should not be dismissed as a fluid correction".	• Breast edema caused by maternal IV fluids and its relationship to milk production is not known. • A pilot study by Kujawa-Myles et al. (2015) suggests inappropriate interventions to reduce swelling, such as expressing, may affect the initiation of breastfeeding. Further studies are required to examine the effect of IV fluids on postpartum breast swelling.
Delayed lactogenesis II	• The onset of increased milk volume after the first 72 hours (Hale & Hartmann, 2017).	• Mothers who are at risk of delayed lactogenesis II should be provided with early and appropriate lactation support until milk is effectively produced and mother and infant are doing well (Nommsen-Rivers et al., 2010). • Mothers should be made aware of their risk for delayed lactogenesis II during pregnancy and/or early postpartum.

Table continued....

Factor	Effect	Importance to breastfeeding
	• Factors which are potentially associated with delayed lactogenesis II in term infants include: – Mothers with Type 1 diabetes, obesity (BMI>30), retained placental products, caesarean birth, previous breast surgery or breast radiation treatment, hormonal imbalance, underdeveloped breasts, polycystic ovarian syndrome, anesthesia, medications, traumatic delivery, breast edema, and/or inadequate stimulation or colostrum/milk not being removed (Hart & Hartmann, 2017, p. 105). For more information see ***Initiation of Breastfeeding*** Protocol).	• Delayed lactogenesis II can contribute to the risk of newborn weight loss, early supplementation, and early weaning of breastfeeding (Nommsen-Rivers et al., 2010).
Other factors to be aware of	• Sufficient glandular tissue of the breast. • Intact innervation of the breast. • Adequate prolactin and receptor sites. • Oxytocin release. • Retained placental fragments. • Sheehan's syndrome. • Some medications, some herbs.	• For further information consult quality resources such as Lawrence & Lawrence (2016) found in the reference list.

6. Maternal Nutrition

a. Maternal diet and effect on breast milk composition.

- Most of the evidence currently used in clinical practice shows an indirect association of maternal nutrition on breast milk composition.
- There is weak evidence associating maternal diet to the nutritional content in breast milk. Further studies are required (Keikha et al., 2017).
- There are a limited number of studies linking DHA (from fish consumption) and vitamin C intake to breast milk composition (Bravi et al., 2016).

b. Risk of allergies.

- There is an inconsistent link between maternal diet and allergies in their children (Netting et al., 2013). An *Australian Consensus Statement on Infant Feeding Guidelines to Prevent Food Allergies* recommends that dietary restrictions are not normally indicated (Netting et al., 2017).
- Families with a history of severe allergies are to consult with a medical professional.

c. Extra maternal oral fluid intake to increase milk production.

- A Cochrane review found the effect of additional fluids to increase milk supply for breastfeeding mothers remains unknown. There is not enough evidence to support an increased fluid intake beyond a breastfeeding mother's physiological need (Ndikom et al., 2014).
- There is no evidence linking type of a mother's dietary fluid intake (milk, water, fruit juice, non-alcoholic beverages) to increased milk supply (Bravi et al., 2016; Sosa-Castillo et al., 2017; Keikha et al., 2017; Ndikom et al., 2014).
- Therefore, the current Canada Food Guide recommendation for breastfeeding mothers to drink to thirst is relevant and should be followed.

d. Colostrum.

- Some cultures discard the first milk. Although it is important to acknowledge that colostrum is breast milk and is valuable for infants, it is important to acknowledge and consider cultural practices. Respectfully encourage feeding the first milk as something that is done in your organization and describe the risks of alternatives. Ensure mothers understand the importance of early and frequent milk removal to stimulate and sustain milk production.

e. Daily vitamin D supplement.

- The Canadian Paediatric Society (Godel, 2007) recommends that:
  - Exclusively breastfed, healthy, term infants receive 400IU of vitamin D per day. Premature infants receive 200IU -400IU.
  - Infants in northern communities (north of 55° latitude, which is about the level of Edmonton) or who have other risk factors (such as dark skin) should get 800 IU per day in low sunlight months between October and April.
  - Overweight and obese infants may need more.
- There is evidence suggesting increasing maternal vitamin D supplementation may meet infant's need (Hollis et al., 2015; Lerch, 2007); however, it is neither common practice nor currently recommended by the Canadian Paediatric Society.
- Mothers who are concerned about their vitamin D intake should consult with a medical professional.

f. Daily calories.

- Breastfeeding mothers have a somewhat higher energy need compared to pre-pregnancy needs. Generally, breastfeeding women need about 350-400 more calories per day than pre-pregnancy needs and are encouraged to eat a balanced diet according to the Canada's Food Guide (Health Canada, 2018).
- Mothers do not need a perfect diet to produce excellent quality milk. Mothers who are vegetarian or follow other dietary regimes are encouraged to breastfeed.

g. Maternal diet influences taste of breast milk and subsequent acceptance of a variety of foods.

Key Resources

Best Start at Health Nexus

Breastfeeding and infant feeding resources.
www.beststart.org

BFI Strategy for Ontario and Toronto Public Health

Breastfeeding Protocols for Health Care Providers.
http://breastfeedingresourcesontario.ca/resource/breastfeeding-protocols-health-care-providers
This includes a link to Toronto Public Health Protocols (2013)

Breastfeeding Resources Ontario

Quality evidence-informed resources that support the Baby-Friendly Initiative such as videos, written resources, and links in one centralized source.
www.breastfeedingresourcesontario.ca

Canada's Food Guide

Link to Eating Well with Canada's Food Guide: A Resource for Educators and Communicators: https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/fn-an/alt_formats/hpfb-dgpsa/pdf/pubs/res-educat-eng.pdf

Canadian Pediatric Society

Link to vitamin D recommendations:
www.caringforkids.cps.ca/handouts/vitamin_d

Khan Academy

Various white board breastfeeding videos.
www.khanacademy.org/

La Leche League

- La Leche League Canada. Find breastfeeding information sheets, and find a group.
  www.lllc.ca
- La Leche League International. Find breastfeeding information.
  www.llli.org

Registered Nurses Association of Ontario

- Breastfeeding Best Practice Guidelines for Nurses (2018): https://rnao.ca/bpg/guidelines/initiation-exclusivity-and-continuation-breastfeeding-newborns-infants-and-young-child and
- Mother/Infant Self-Reflection Guide for Nurses and Clinical Case Studies (2006)
  http://rnao.ca/bpg/guidelines/resources/breastfeeding-educational-resources-motherinfant-selfreflection-guide-nurse

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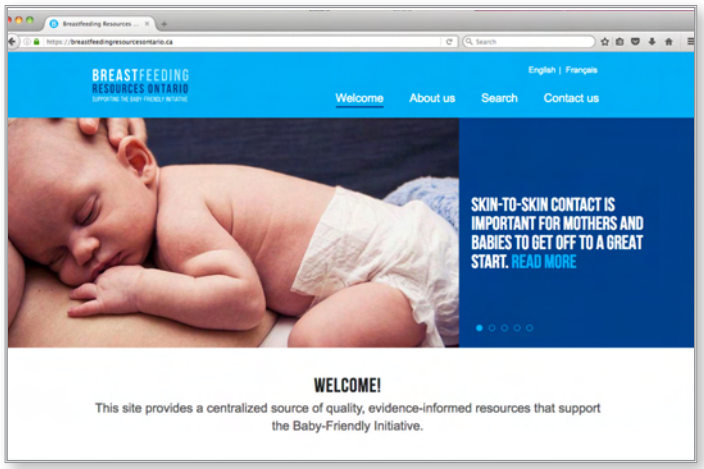

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