Breastmilk feeding is not the same as breastfeeding
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Some of the differences between “direct” breastfeeding and feeding human milk with a device:

- Milk from the breast sprays the entire oropharynx of the baby. Some milk components kill pathogenic bacteria on contact; other components are sticky, and ‘grab onto’ pathogens, sweeping down the digestive track for elimination. When milk is fed from a device, no such spraying occurs.
- The proportion of fat increases during each feed, from relatively low-fat to higher in fat. This affects the baby’s appetite and desire to keep feeding, and possibly other reasons that the baby has for nursing. About 1/3 of babies stop feeding during a let-down, strongly suggesting they’ve had enough fat for that feed. There is no change in fat proportion when milk is fed from a device. The only other strong trigger of satiation is stomach distension, which takes about 20 minutes, and is one factor in infant obesity.
- Sucking at the breast affects the baby’s oral configuration, spreading the palate and developing the normal shape and function of the face, jaws and mouth. Sucking on a bottle (teat) or swallowing from a cup or spoon uses very different muscles which develop the palate and facial shape differently.
- During direct breastfeeding, the baby’s eyes focus at the approximate distance to the mother’s eyes, fostering normal eye development. Also, mothers usually use and switch positions and how they hold the baby, further changing and enhancing eye development. Lazy eye (one eye doesn’t get much stimulation) is an artifact of bottle-feeding (regardless of what’s in the bottle).
- Sucking at the breast fosters normal airway patency. Sucking on a bottle creates excess inter-oral pressures, with a resultant higher rate of collapsed airways and obstructive sleep apnea in children. (Pacifier sucking creates even higher inter-oral pressures that bottle-feeding.)
- Sucking at the breast fosters normal eye-hand coordination, because the baby uses hands to massage the breast and often the mother’s face and body. In bottle-feeding, the baby’s hands move to the bottle instead of another human being. Later development of reading is influenced by eye-hand development starting in infancy.
- Direct breastfeeding is the ultimate in baby-led feeding, resulting in increased/normal trust and development of autonomy. The mother’s body responds to baby’s cues by releasing milk in response to the baby’s cues, and the baby ends the feed when satiated. When milk is expressed and given by a device, no such signaling of the mother’s body occurs, and the dyad must rely on other cues to develop mutuality.
- New research confirms that the baby’s microbiome is different and more robust/varied with direct breastfeeding than with feeding expressed milk, which affects baby’s immune system.
- Direct breastfeeding provides extensive skin-to-skin contact between mother and baby, which has enormous importance to overall sensory development.
- Direct breastfeeding changes the mother’s behavior and orientation to the baby during sleep, and changes the baby’s orientation to the mother during sleep. Only direct breastfeeding dyads maintain an en-face position during sleep. The mother doesn’t roll away and come back, which is a suffocation risk. The baby orients to the breast, and does not scoot/move all

over or off the sleep surface. There is very frequent touching and a high degree of awareness of each other, even during deep sleep. This ONLY happens during direct breastfeeding.

- Milk varies in composition by time of day. Feeding that milk at a different time of day can disrupt the baby's circadian rhythms.
- Milk protective components vary by the mother's exposure to pathogens, and even her pending illness. Separating the intake of that milk from the time when the mother was exposed compromises the immune properties of the milk and thus reduces the baby's protection from pathogens.
- Most mothers who express and feed their milk to their babies use bottles with teats. Bottles and teats are products which fall within the scope of the *International Code of Marketing of Breastmilk Substitutes.*

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O'Sullivan, E. J., et al. (2019). "Comparing Alternative Breast Milk Feeding Questions to U.S. Breastfeeding Surveillance Questions." Breastfeed Med **14**(5): 347-353.

Background: Most mothers in the United States express their milk, which is then bottle fed to their infants. The National Immunization Survey (NIS), used to report national breastfeeding prevalence, asks about infant breast milk consumption, regardless of whether it is consumed at the mother's breast or from a bottle. The NIS data are often erroneously interpreted, however, to mean prevalence of at-the-breast feeding. We hypothesized that over half of infants classified as breastfed at 3, 6, and 12 months by the NIS questions would also be consuming expressed breast milk. Materials and Methods: A convenience sample of 456 mothers of infants 19-35 months of age recruited through ResearchMatch.org completed an online infant-feeding

questionnaire. The questionnaire included both the NIS questions and more-detailed questions about feeding mode, distinguishing between at-the-breast and bottle. Results: Based on responses of our sample to the NIS questions, it could be interpreted that 74%, 64%, and 39% of mother-infant dyads were at-the-breast feeding at 3, 6, and 12 months, respectively. However, at each time point, most infants consumed at least some breast milk from a bottle. As infants got older, the proportion of breast milk consumed from a bottle increased. Conclusions: In this U.S. sample, the predominant breast milk feeding style involves both at-the-breast and expressed breast milk feeding. Future research and national surveillance should consider including separate measures of maternal breast milk expression and infant consumption of expressed breast milk to enable meaningful exploration of maternal and infant outcomes associated with these asynchronous behaviors.

Karimi, M., et al. (2012). "The effect of educational intervention on decreasing mothers' expressed breast milk bacterial contamination whose infants are admitted to neonatal intensive care unit." J Res Health Sci **13**(1): 43-47.

BACKGROUND: Various reasons accounted for the infection of infants kept at Neonatal Intensive Care Unit (NICU). Expressed breast milk may be regarded as a source of infection in infants. This study investigated the source of bacterial contamination and the impact of educational interventions on the contamination of mothers' expressed breast milk (EBM) level whose infants are hospitalized at NICU. METHODS: Fifteen mothers used to express breast milking their infants admitted at NICU, involved in this study was conducted during October 2011-March 2012. Samples taken from hands, breast, pumps, breast milk, and milk storage containers and therefore 244 samples were prepared by sterile cotton swab and cultured on Blood Agar and EBM. After presenting enough training to mothers, cultures of the same positions were carried out again. Only those samples proved infected that number of their bacterial colonies exceeded 104 cfu / ml or even there was a growth of pathogenic organism. RESULTS: Before intervention 80% of mothers had infected by at least one sample that reduced to 36% after the intervention. Before intervention 25.4% of samples were contaminated; however after intervention, it reduced to 8.2%. The main source of contamination was milk containers and pumps; moreover, Pseudomonas, E-coli, and Klebsiella were among the most common bacteria of samples' contamination. CONCLUSION: The possibility of EBM contamination was relatively high but educational interventions might reduce the risk of prevalence.

Felice, J. P., et al. (2016). "Pumping human milk in the early postpartum period: its impact on long-term practices for feeding at the breast and exclusively feeding human milk in a longitudinal survey cohort." Am J Clin Nutr.

BACKGROUND: Most American mothers who feed human milk (HM) now use pumps to produce some of the HM they feed. Pumping is nationally recommended, but associations between pumping and HM-feeding durations are unknown. OBJECTIVES: We examined whether and how the pumping frequency and types of reasons for pumping between 1.5 and 4.5 mo postpartum are associated with HM-feeding durations. We classified pumping reasons as nonelective [e.g., because of a difficulty feeding at the breast (FAB)] or elective (e.g., to produce HM to mix with solids). We hypothesized that women who pumped more frequently or nonelectively would have shorter HM-feeding durations. DESIGN: We used data from 1116 mothers in a longitudinal cohort who fed and pumped HM 1.5-4.5 mo postpartum. We used chi2and Cox proportional hazards regression models to examine the survival of any HM feeding,

exclusive HM feeding, and FAB. RESULTS: Compared with mothers who pumped for elective reasons, mothers who reported one nonelective reason had greater hazards of stopping feeding any HM (HR: 1.12; 95% CI: 1.05, 1.21) or exclusive HM (HR: 1.14; 95% CI: 1.09, 1.20) and of stopping FAB (HR: 2.07; 95% CI: 1.77, 2.42). Mothers who pumped most frequently had the highest mean hazards of stopping feeding any HM (HR: 1.82; 95% CI: 1.68, 1.93) and feeding exclusive HM (HR: 1.21; 95% CI: 1.14, 1.26). Hazards of stopping FAB varied across the year. Compared with the least-frequent pumpers, the most-frequent pumpers had a 2.6-fold higher hazard of stopping FAB at 3 mo postpartum and a 1.7-fold higher hazard at 6 mo postpartum. CONCLUSIONS: Nonelective pumping reasons and higher pumping frequency were associated with shorter HM-feeding durations. Mothers who report that they use a breast pump for reasons related to either employment or FAB difficulty and their infants may be more vulnerable to risks associated with a shorter HM-feeding duration.

Azad, M. B., et al. (2013). "Gut microbiota of healthy Canadian infants: profiles by mode of delivery and infant diet at 4 months." Canadian Medical Association Journal.

Background: The gut microbiota is essential to human health throughout life, yet the acquisition and development of this microbial community during infancy remains poorly understood. Meanwhile, there is increasing concern over rising rates of cesarean delivery and insufficient exclusive breastfeeding of infants in developed countries. In this article, we characterize the gut microbiota of healthy Canadian infants and describe the influence of cesarean delivery and formula feeding. Methods: We included a subset of 24 term infants from the Canadian Healthy Infant Longitudinal Development (CHILD) birth cohort. Mode of delivery was obtained from medical records, and mothers were asked to report on infant diet and medication use. Fecal samples were collected at 4 months of age, and we characterized the microbiota composition using high-throughput DNA sequencing. Results: We observed high variability in the profiles of fecal microbiota among the infants. The profiles were generally dominated by Actinobacteria (mainly the genus Bifidobacterium) and Firmicutes (with diverse representation from numerous genera). Compared with breastfed infants, formula-fed infants had increased richness of species, with overrepresentation of Clostridium difficile. Escherichia-Shigella and Bacteroides species were underrepresented in infants born by cesarean delivery. Infants born by elective cesarean delivery had particularly low bacterial richness and diversity. Interpretation: These findings advance our understanding of the gut microbiota in healthy infants. They also provide new evidence for the effects of delivery mode and infant diet as determinants of this essential microbial community in early life.

Hassiotou, F., et al. (2012). "Breastmilk is a novel source of stem cells with multilineage differentiation potential." Stem Cells **30**(10): 2164-2174.

The mammary gland undergoes significant remodeling during pregnancy and lactation, which is fuelled by controlled mammary stem cell (MaSC) proliferation. The scarcity of human lactating breast tissue specimens and the low numbers and quiescent state of MaSCs in the resting breast have hindered understanding of both normal MaSC dynamics and the molecular determinants that drive their aberrant self-renewal in breast cancer. Here, we demonstrate that human breastmilk contains stem cells (hBSCs) with multilineage properties. Breastmilk cells from different donors displayed variable expression of pluripotency genes normally found in human embryonic stem cells (hESCs). These genes included the transcription factors (TFs) OCT4, SOX2, NANOG, known to constitute the core self-renewal circuitry of hESCs. When

cultured in the presence of mouse embryonic feeder fibroblasts, a population of hBSCs exhibited an encapsulated ESC-like colony morphology and phenotype and could be passaged in secondary and tertiary clonogenic cultures. While self-renewal TFs were found silenced in the normal resting epithelium, they were dramatically upregulated in breastmilk cells cultured in 3D spheroid conditions. Furthermore, hBSCs differentiated in vitro into cell lineages from all three germ layers. These findings provide evidence that breastmilk represents a novel and noninvasive source of patient-specific stem cells with multilineage potential and establish a method for expansion of these cells in culture. They also highlight the potential of these cells to be used as novel models to understand adult stem cell plasticity and breast cancer, with potential use in bioengineering and tissue regeneration.

Li, R., et al. (2010). "Do Infants Fed From Bottles Lack Self-regulation of Milk Intake Compared With Directly Breastfed Infants?" Pediatrics: peds.2009-2549.

Objective: How breastfeeding reduces the risk of childhood obesity is unclear, and 1 hypothesis pertains to the ability of breastfed infants to self-regulate. We studied whether infants' self-regulation of milk intake is affected by feeding mode (bottle versus breast) and the type of milk in the bottle (formula versus expressed breast milk). Patients and Methods: Participants in the 2005-2007 Infant Feeding Practices Study II received monthly questionnaires during their infant's first year, and compete data were available for 1250 infants. We tested the impact of feeding mode and type of milk during early infancy on self-regulation during late infancy. Results: Although only 27% of infants fed exclusively at the breast in early infancy emptied the bottle or cup in late infancy, 54% of infants who were fed both at the breast and by bottle did so, and 68% of those who were fed only by bottle did so. Multivariate regression analysis indicated that infants who were bottle-fed more intensively early in life were [~]71% or 2 times more likely to empty the bottle or cup later in life than those who were bottle-fed less intensively ([1/3]-[2/3] or [2/3] of milk feeds given by bottle versus < [1/3] of milk feeds). When feeding formula and expressed milk were considered separately, similar dose-response relationships were observed. Conclusions: Infants who are bottle-fed in early infancy are more likely to empty the bottle or cup in late infancy than those who are fed directly at the breast. Bottle-feeding, regardless of the type of milk, is distinct from feeding at the breast in its effect on infants' self-regulation of milk intake.

Li, R., et al. (2012). "Risk of Bottle-feeding for Rapid Weight Gain During the First Year of Life." Arch Pediatr Adolesc Med **166**(5): 431-436.

OBJECTIVE: To better understand the mechanisms behind breastfeeding and childhood obesity, we assessed the association of weight gain with the mode of milk delivery aside from the type of milk given to infants. DESIGN: A longitudinal study of infants followed up from birth to age 1 year. Multilevel analyses were conducted to estimate infant weight gain by type of milk and feeding mode. SETTING: Pregnant women were recruited from a consumer mail panel throughout the United States between May 2005 and June 2007. PARTICIPANTS: One thousand eight hundred ninety nine infants with at least 3 weight measurements reported during the first year. Main Exposures Six mutually exclusive feeding categories and proportions of milk feedings given as breastmilk or by bottle. MAIN OUTCOME MEASURES: Weight measurements reported on 3-, 5-, 7-, and 12-month surveys. RESULTS: Compared with infants fed at the breast, infants fed only by bottle gained 71 or 89 g more per month when fed nonhuman milk only ($P < .001$) or human milk only ($P = .02$), respectively. Weight gain was

negatively associated with proportion of breastmilk feedings, but it was positively associated with proportion of bottle-feedings among those who received mostly breastmilk. Among infants fed only breastmilk, monthly weight gain increased from 729 g when few feedings were by bottle to 780 g when most feedings were by bottle. CONCLUSIONS: Infant weight gain might be associated not only with type of milk consumed but also with mode of milk delivery. Regardless of milk type in the bottle, bottle-feeding might be distinct from feeding at the breast in its effect on infants' weight gain.

Felice, J. P., et al. (2017). ""Breastfeeding" but not at the breast: Mothers' descriptions of providing pumped human milk to their infants via other containers and caregivers." Matern Child Nutr **13**(3).

As pumping has become more prevalent among American women, pumped human milk (HM) is on the rise in their infants' diets in place of some or all feeding at the breast. We aimed to fill a gap in knowledge about mothers' motivations, practices and perceptions related to pumping, and about mothers' and other caregivers' motivations, practices, and perceptions related to feeding pumped HM. Results related to providing pumped HM are reported here, and results related to pumping are reported elsewhere. We conducted in-depth, semi-structured interviews among a diverse sample of mothers whose infants were fed pumped HM (n = 20), following each up to 1 year postpartum. Data were analyzed using thematic analysis with Atlas.ti. Nearly all mothers felt bottles were necessary to meet infant HM-feeding goals. Nearly all pumped HM was fed by other caregivers because mothers typically preferred and prioritized feeding at the breast for convenience and maintaining their milk supply. Infants were bottle-fed HM for several reasons that changed over time, such as mother's absence, latch difficulty, or desire to share the burden and bonding of feeding. Feeding practices differed between feeds from bottles versus at the breast; some infants were bottle-fed on schedules but fed at the breast on demand. Mothers' methods for storing, transporting, and preparing HM varied substantially and included practices associated with loss of nutrients and microbial contamination. Mothers' reasons for bottle-feeding HM may affect how much their infants are bottle-fed. Consumption of pumped HM may not provide the same benefits to infants as feeding at the breast. These findings highlight important avenues for future research into the relationships between bottle-feeding HM and infant health, growth, and developmental outcomes.

Azad, M. B., et al. (2018). "Infant Feeding and Weight Gain: Separating Breast Milk From Breastfeeding and Formula From Food." Pediatrics.

OBJECTIVES: Studies addressing breastfeeding and obesity rarely document the method of breast milk feeding, type of supplementation, or feeding in hospital. We investigated these practices in the CHILD birth cohort. METHODS: Feeding was reported by mothers and documented from hospital records. Weight and BMI z scores (BMIzs) were measured at 12 months. Analyses controlled for maternal BMI and other confounders .RESULTS: Among 2553 mother-infant dyads, 97% initiated breastfeeding, and the median breastfeeding duration was 11.0 months. Most infants (74%) received solids before 6 months. Among “exclusively breastfed” infants, 55% received some expressed breast milk, and 27% briefly received formula in hospital. Compared with exclusive direct breastfeeding at 3 months, all other feeding styles were associated with higher BMIzs: adjusted β: +.12 (95% confidence interval [CI]: .01 to .23) for some expressed milk, +.28 (95% CI: .16 to .39) for partial breastfeeding, and +.45 (95% CI: .30 to .59) for exclusive formula feeding. Brief formula supplementation in hospital did not alter

these associations so long as exclusive breastfeeding was established and sustained for at least 3 months. Formula supplementation by 6 months was associated with higher BMIzs (adjusted β: +.25; 95% CI: .13 to .38), whereas supplementation with solid foods was not. Results were similar for weight gain velocity. CONCLUSIONS: Breastfeeding is inversely associated with weight gain velocity and BMI. These associations are dose dependent, partially diminished when breast milk is fed from a bottle, and substantially weakened by formula supplementation after the neonatal period.

Moossavi, S. and M. B. Azad (2019). "Origins of human milk microbiota: new evidence and arising questions." Gut Microbes: 1-10.

Human milk contains a diverse community of bacteria. The growing appreciation of commensal microbes and increasing availability of high-throughput technology has set the stage for a theory-driven approach to the study of milk microbiota, and translation of this knowledge to improve maternal and child health. We recently profiled the milk microbiota of healthy Canadian mothers and applied theory-driven causal modeling, finding that mode of breast milk feeding (nursing directly at the breast vs. pumping and feeding breast milk from a bottle) was significantly associated with milk microbiota composition. This observation could reflect an increased exposure to pumps and/or a decreased exposure to the infant mouth. Either way, it provides evidence for the retrograde mechanism of milk inoculation. Here, we discuss the implications of this research and related controversies, and raise new questions about the origins and function of milk bacteria.