Comparison of cow-milk, breast milk and formula: nutritional, immunologic and developmental considerations

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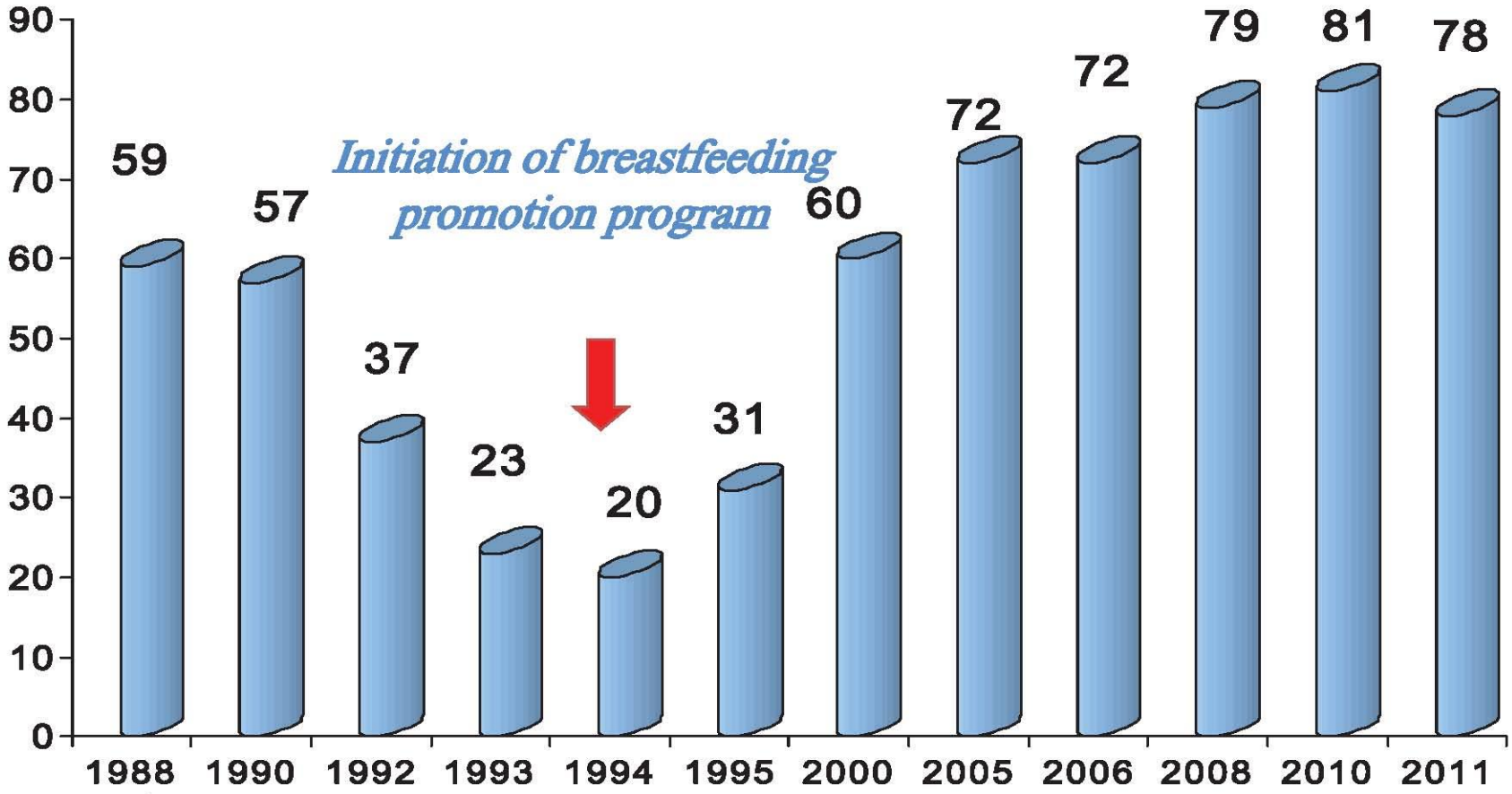
Trends and prevalence of breastfeeding (%)



Source: MoH data

%	2005	2007	2010	2011
Exclusive breastfeeding for 6 months	48.4	52.2	62	59
Breastfeeding for one year and over	38	39	43	37

Saribekyan K. Stunting reduction workshop. Yerevan. May 7010.2013

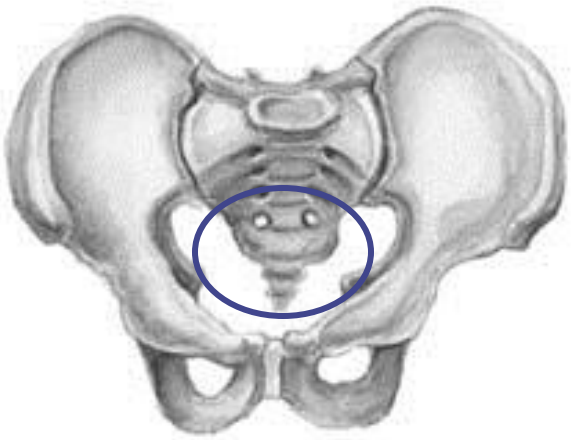
Breast milk composition and human evolution

- Human and cows milk has evolved over millennia for the specific needs of each species
- In humans biped gate and brain size determined composition of human milk
  - Humans walked upright ~ 2 million years ago
  - Brain size increased to accommodate more intelligent behaviors and language in humans
  - Biped gate altered the structure of female pelvis from being round to wider width then length…

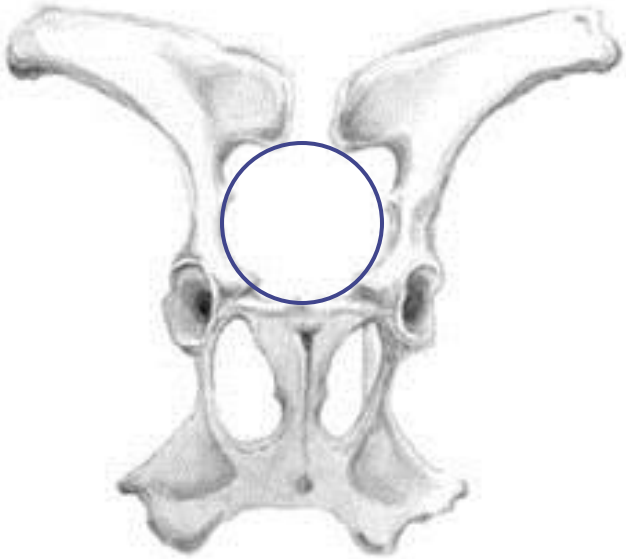
Newton ER. *Clin Obstetric*. 2004;47:632-42

Human and Cow Pelvis

Human female pelvis



Cow pelvis



Evolutionary solution was to deliver the fetus at decreased levels of maturity

Human breast milk is adapted to needs of an immature newborn

- Humans have adapted their breast milk to make up for the immaturity of the newborn by secreting bioactive components

Duck-billed platypus

- Cow milk lacks these factors because there was no evolutionary pressure on the cow to develop them

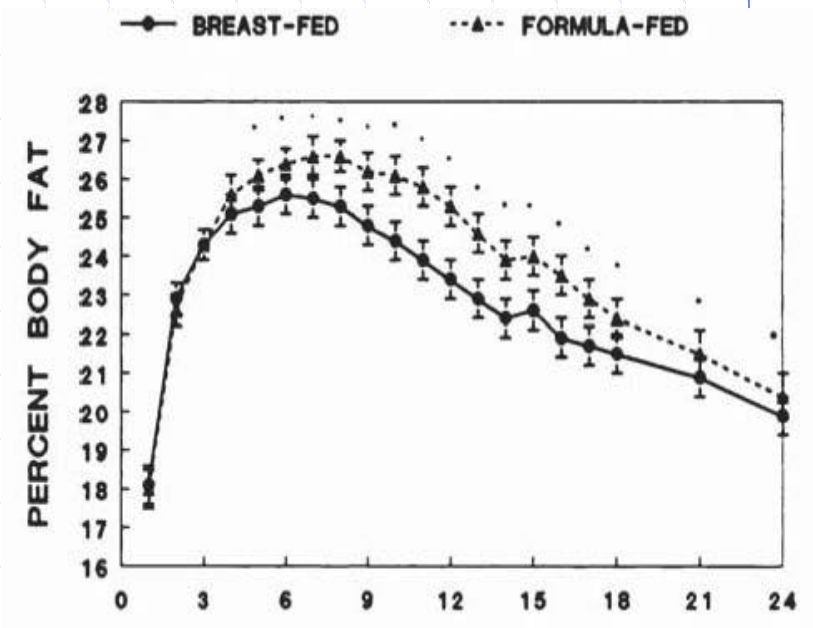
Newton ER. *Clin Obstetric*. 2004;47:632-42

Comparison of nutritional and immune modulating factors in breast milk, cow milk and formula

Growth differences between breastfed and formula fed infants

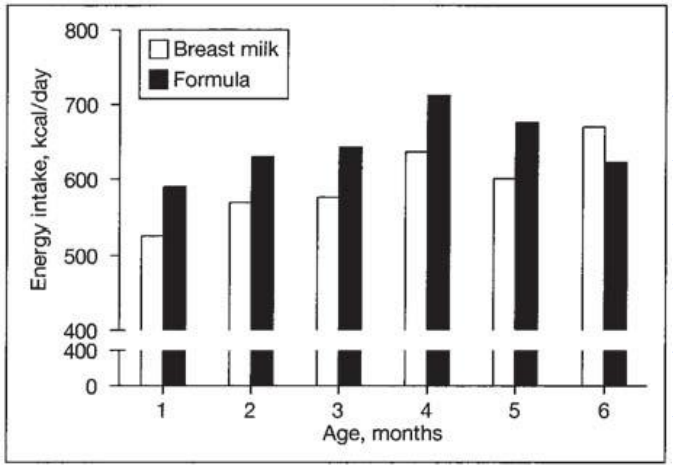
- Formula fed infants have significantly more body btw 3-18 mo

- Possible causes
  1. Growth factors in breast milk
  2. Different endocrine responses to feeding
  3. Control of food intake (self-regulation)
  4. Nutrient composition of food-same in formula, different in breast milk



Dewey KG et al. Am J Clin Nutr. 1993;57:140-145

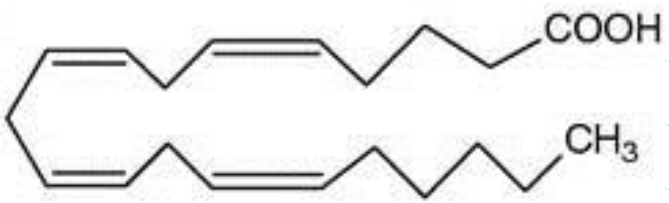
Energy



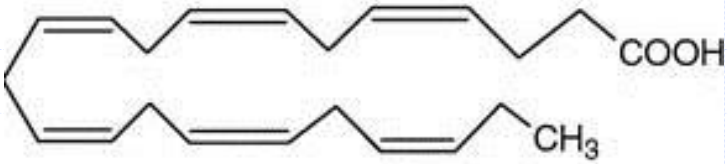
- Equal energy density in breast milk and formula ~670 kcal/l
- Breast fed infant consume less energy
  - Not all CHO and proteins in breast milk are digestible
  - Breast fed infant take less volume (800 vs 1000 ml per day at 3 mo)
  - Breast fed infants can better regulate intake
- Energy requirement of infants might have overestimated the "true" requirements by 10-30%

Lonnerdal B. Nestle Nutr Workshop Ser Pediatr Program. 2008;62:189-203

Lipids



Arachidonic Acid [AA]



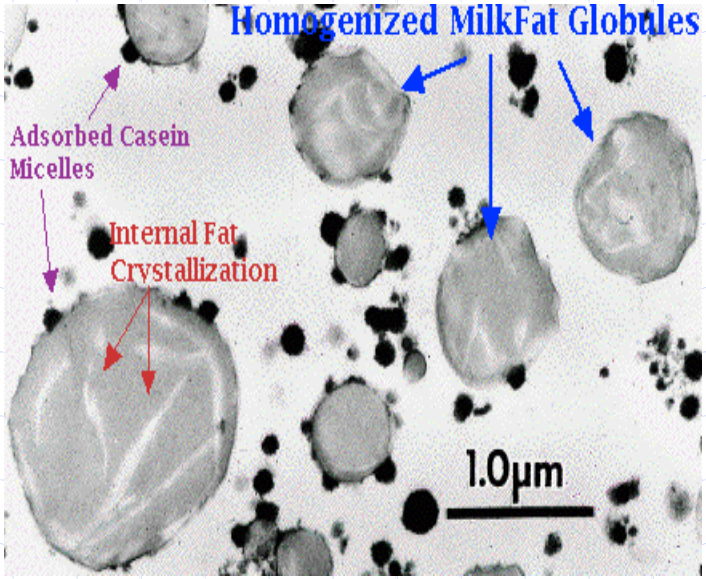
Docosahexaenoic acid [DHA]

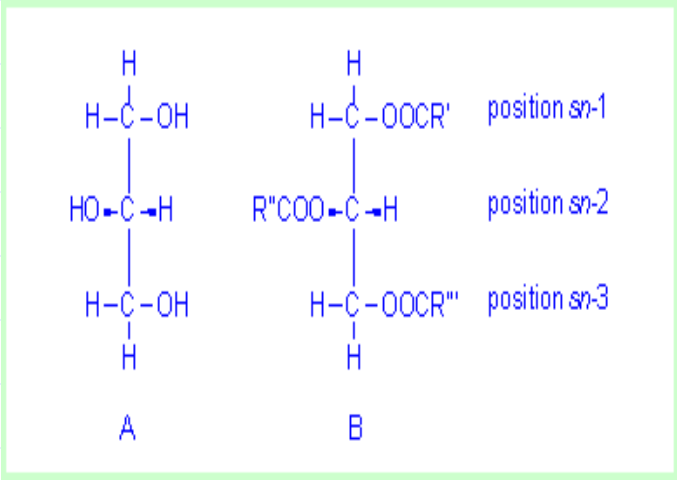
- Composition
  - Breast-milk
    - Colostrum—low
    - Early milk—3.5-4.0%
    - Mature milk—3.5-4.5%
  - Formula—3.5%
- Differences btw breast milk and cow milk
  - Cow milk lacks long-chain polyunsaturated fatty acids (AA, DHA) because calf can synthesize them
  - AA and DHA are essential for humans and found in greatest proportion in early breast milk
  - AA and DHA improve vision and brain development—problem solving at 10 mo of age
- AA and DHA are added to formula

Newton ER. *Clin Obstetric*. 2004;47:632-42

Lipid function-Milk Globule

- Non-polar core made of fatty acids on a triacylglycerol
- Fatty acids are arranged in specific order to allow easy digestion by lipases
- Bovine milk globule destroyed by milk pasteurization
- Results in prolonged digestion of formula (4 hrs) relative to breast milk (2 hrs)





Goff D.*University of Guelph, Canada*. http://www.foodsci.uoguelph.ca/dairyedu/chem.html#lipids3

Lactose in breast, bovine milk and formula

- Predominant carbohydrate in milk
  - 6.8 g/dL in human milk
  - 4.9 g/dL in bovine milk
- Structure: glucose +galactose
- Functions in humans
  - Major energy for brain--level of lactose correlates with brain size across species
  - Galactose is used to make galactolipids, especially cerebrosides needed for CNS development

Newton ER. *Clin Obstetric*. 2004;47:632-42

Differences in protein composition

Quantity of protein in milk	
Milk type	g/L
Colostrum	20-30
Early Breast milk	9-11
6 months Breast milk	8-10
Formula	12-14

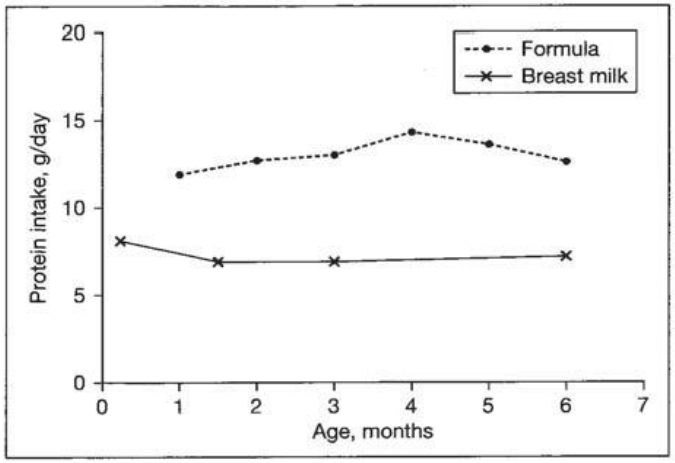
Milk type	Whey(%)	Casein (%)
Cow	20	80
Early Breast	80	20
6 months	50	50
Formula	40	60

Differences in amino acids (**cow milk**)

More sulfa-containing amino acids

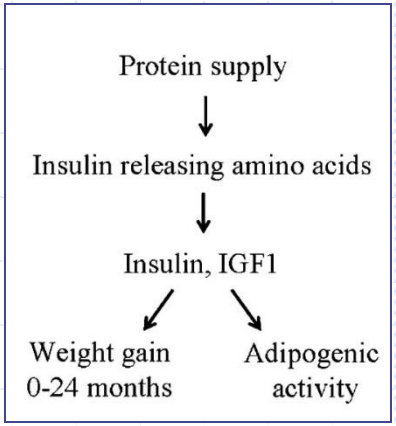
Taurine—absent (added to formula)

Formula fed babies get more protein than breast fed

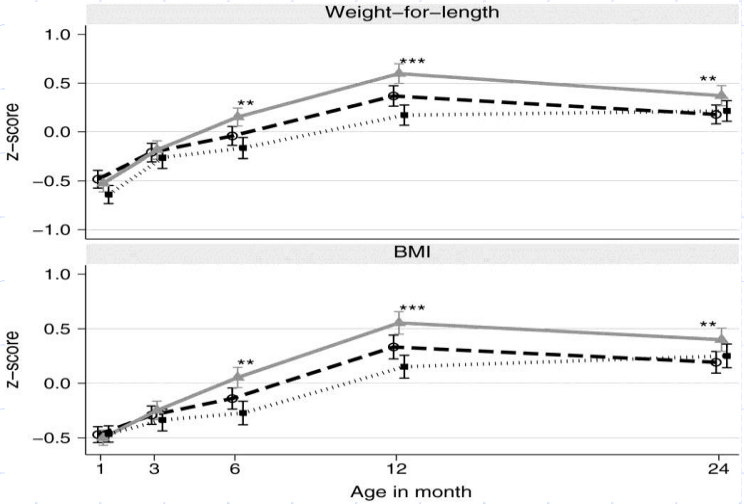


Lonnerdal B. Nestle Nutr Workshop Ser Pediatr Program. 2008;62:189-203

Protein intake hypothesis



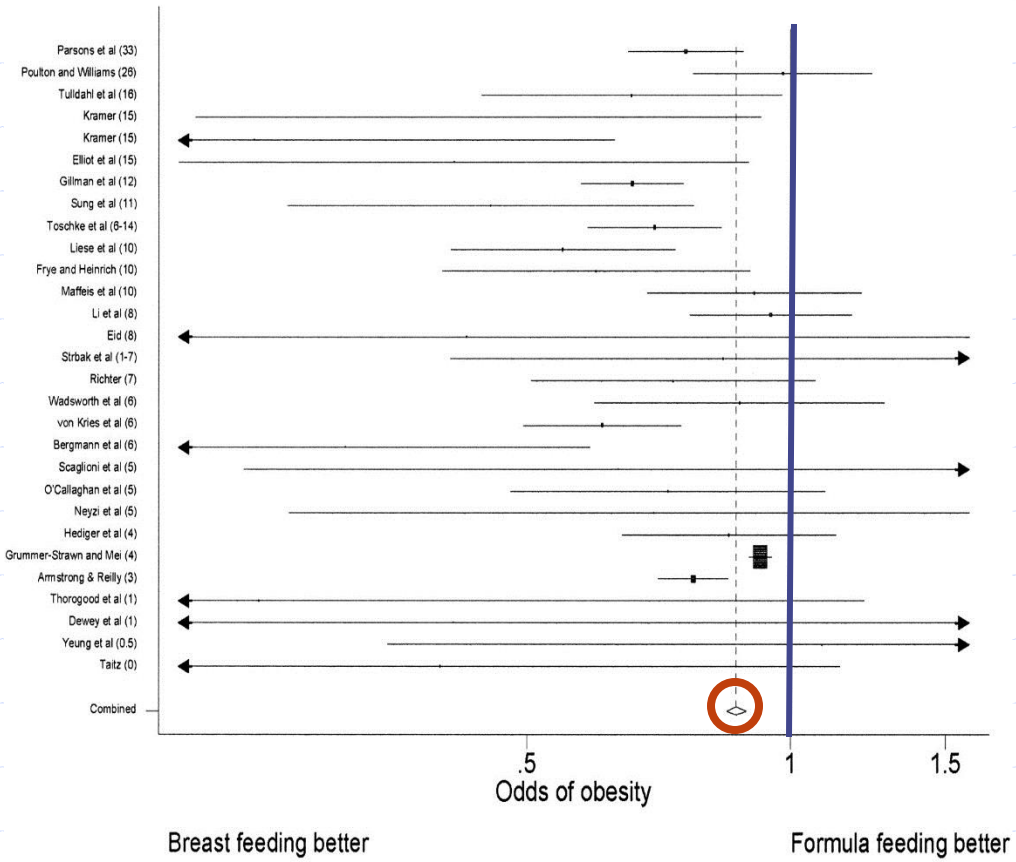
- Formula fed infants get 70% more protein than breast-fed
- Excess protein causes increased circulation of insulin releasing amino acids resulting in increased production of insulin, IGF-1 and programming for heavier infant and children later in life
- RCT of lower protein vs higher protein formula showed that at 2 yrs of age, infants on lower protein formula have lower BMI



Taylor R, *et al*. Curr Opin Clin Nutr Metab Care. 2005; Lucas A *et al*. Paediatr Scand. 1981
Koletzko B, von Kries R, Closa R, et al. Am J Clin Nutr 2009;89:1836–1845.

Odds of obesity of breast vs formula feeding, OR=0.87, 95%CI (0.85,0.89)

- Adjustment for confounding
  - Low SES
  - Maternal BMI
  - Smoking
- Reduced effect to 7%



Owen, C. G. et al. Pediatr 2005;115:1367-1377; Kramer M. Am J Clin Nutr.2007;86:1717-21

Breastfeeding and short term and long term offspring benefits?

Breast milk, the immune system and the gut

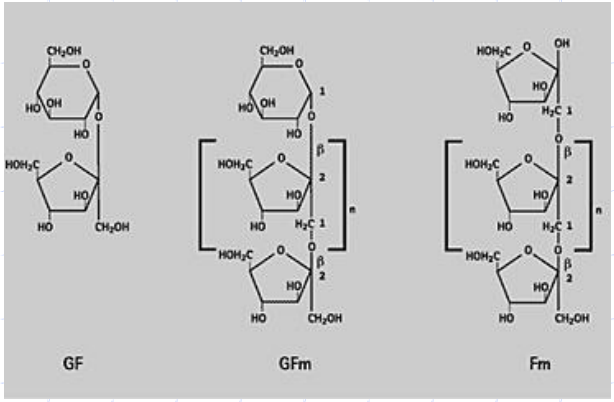
Newborn's Immune System—The "Guard Dog"

Trained

Untrained

Guard dog	Immune system
Recognizing master	Recognizing self
Recognizing friend	Tolerance (allergens)
Biting thief	Killing pathogens

Differences in gut ecology between breastfed and formula fed infants

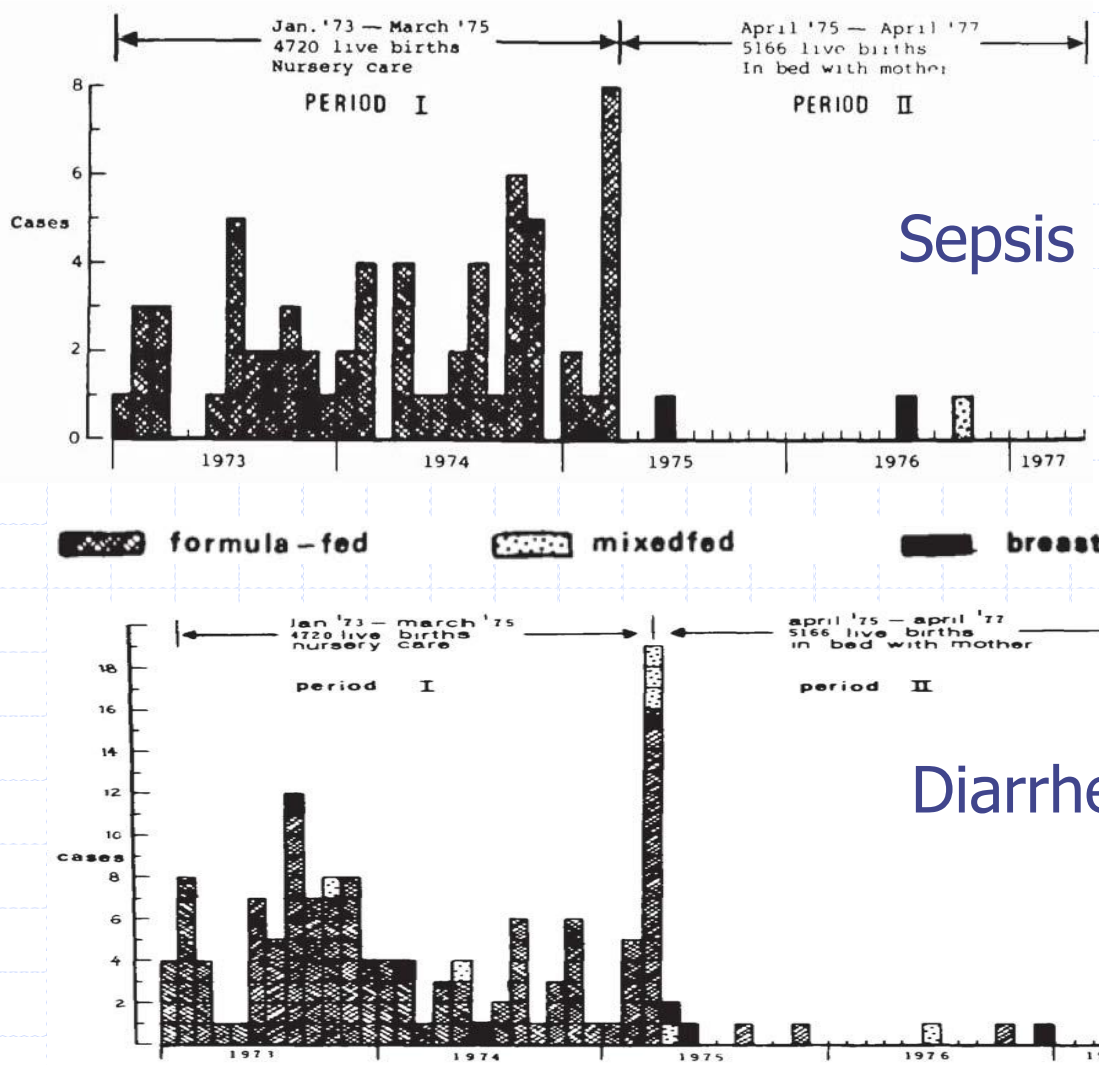


- During vaginal birth newborns GI tract is contaminated with maternal GI flora that has commensal bacteria (Bifidobacterium)
- These bacteria "train" the immune system to tolerate allergens (pollen, etc)
- Breast milk promotes the growth of bifidobacterium by providing prebiotic substrate for fermentation—fructo and galactooligosaccharides
- Intestine of newborn born vaginally and breastfed has more bifidobacterium and lactobacillus then formula fed infant

Penders J. Pediatrics. 2006;118(2):511-21; Fallani et al., 2010

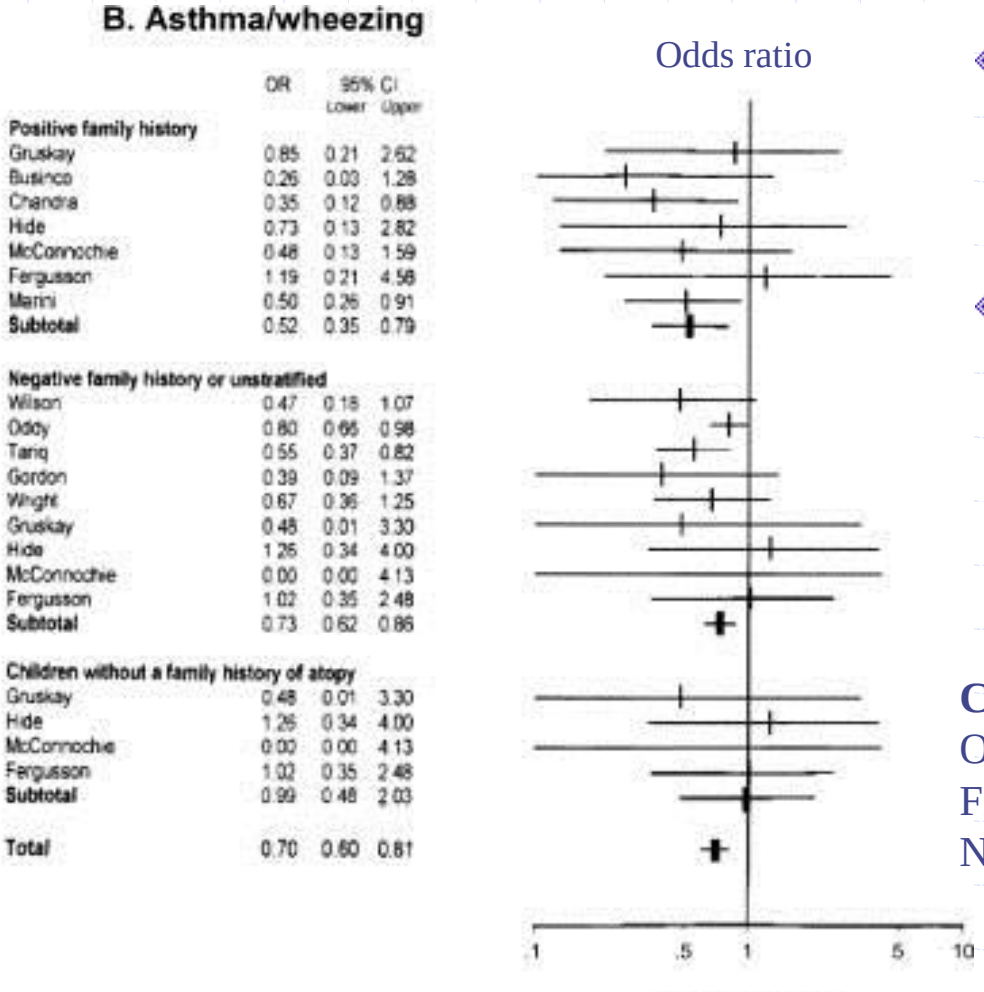
Breastfeeding prevents death from sepsis and diarrhea in newborns

- Nursery in Phillippines
- Period 1—41% exclusively breast fed
- Period 2—85% exclusively breast fed



J Trop Pediatr. 1982;28:287-93

Breastfeeding and asthma risk



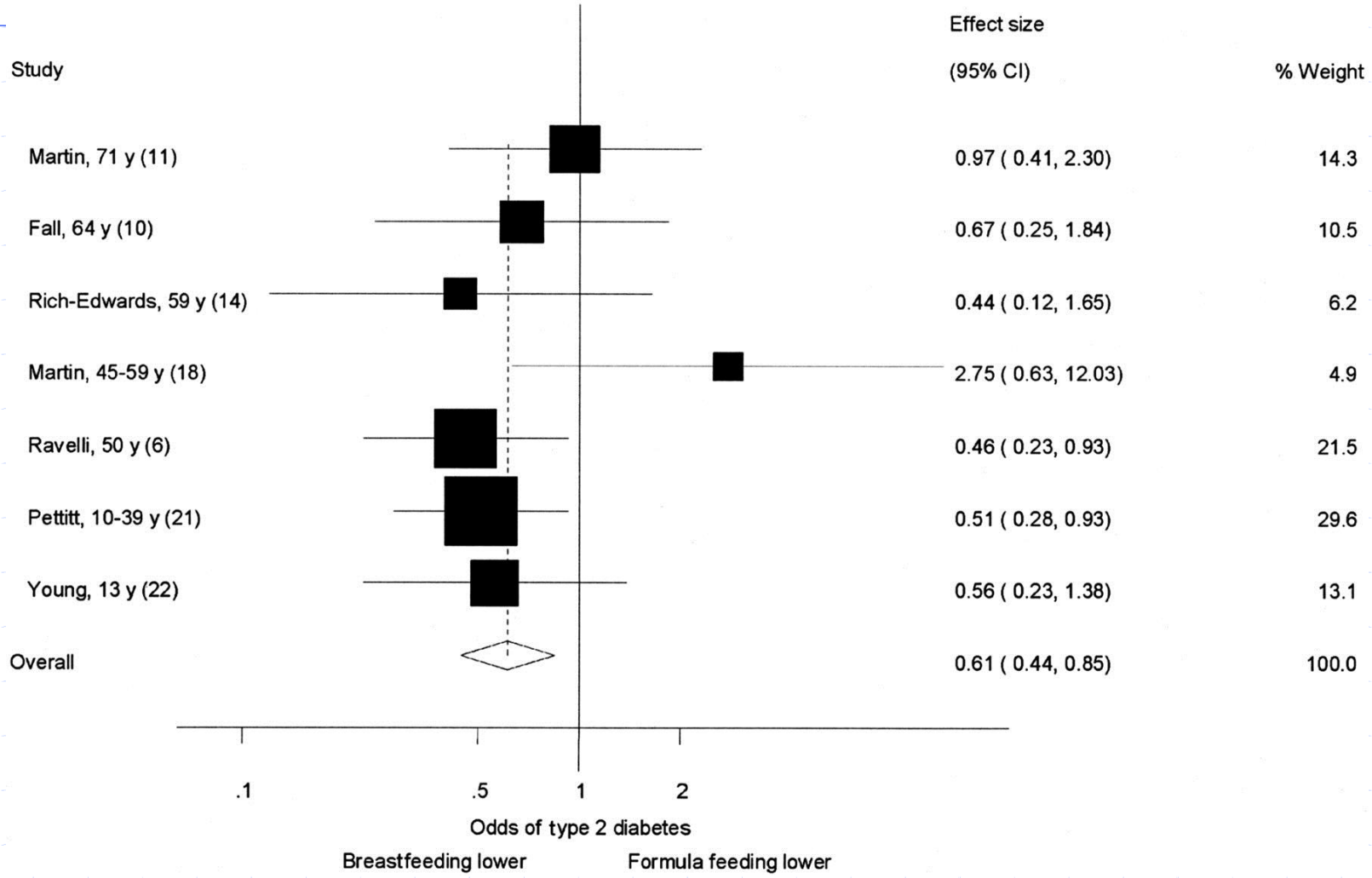
- Metaanalysis of studies... 1966-2000
- Analysis included 12 studies of >8000 children followed for 4.1 (1-8.4) years

Condition	OR	95% CI
Overall	0.70	0.60-0.81
FH of Atopy +	0.52	0.35-0.79
No atopy	0.73	0.62-0.86

Gdalevich M. J Pediatr. 2001;139:261-6

Odds ratios (95% CIs) of type 2 diabetes in a comparison of breastfed and formula-fed

The American Journal of Clinical Nutrition

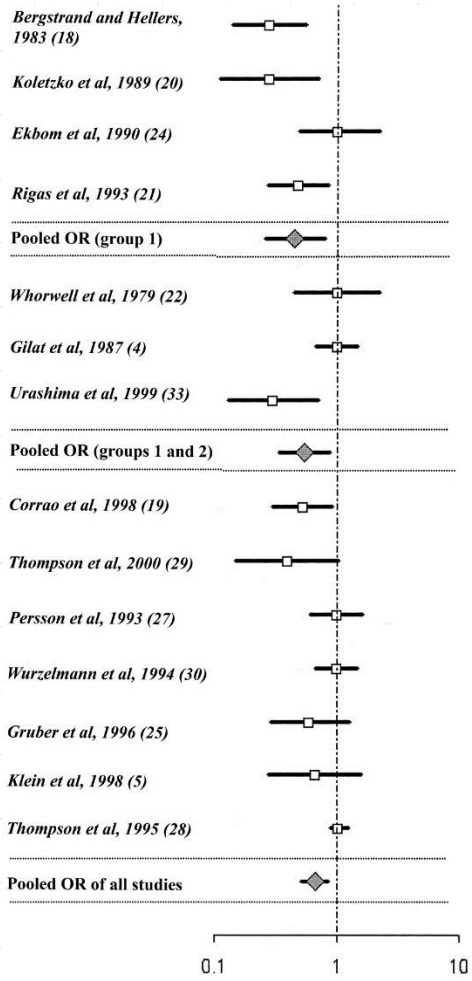


Owen C G et al. Am J Clin Nutr 2006;84:1043-1054

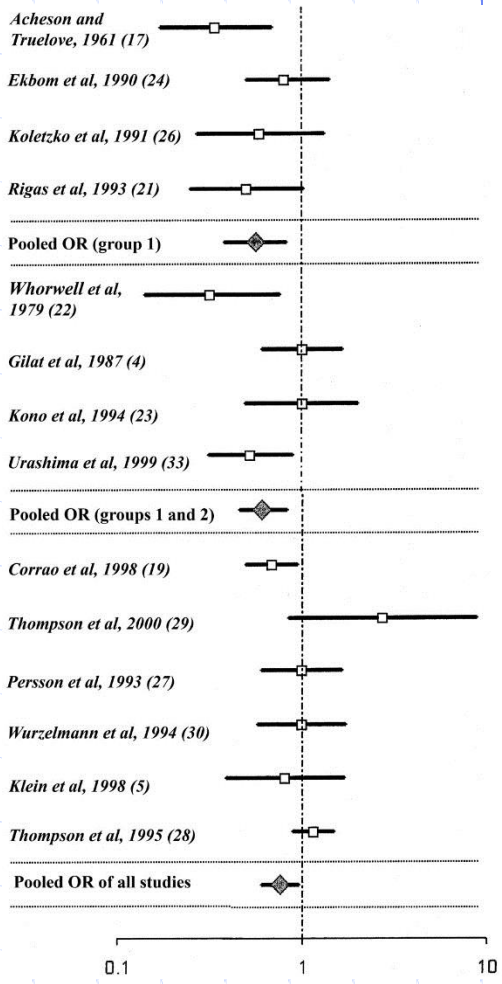
Breast-feeding and Inflammatory Bowel Disease

Crohn's Disease (CD), Ulcerative colitis (UC)

- Metaanalysis included 17 studies
  - 6100 pts with CD
  - 7216 pts with UC
- Pooled estimate, random effects model
  - CD—0.67 (95% CI: 0.52, 0.86)
  - UC—0.77 (95% CI: 0.61, 0.96)
- Limitations
  - All but 2 studies were case-control studies
  - Breast-feeding definition



Crohn's Disease (CD)



Ulcerative colitis (UC)

Klement E et al. Am J Clin Nutr 2004; 80:1342-1352

Breast-feeding and cognitive development[1]

Metric	Effect of breastfeeding vs formula feeding	Comment
Head Circumference[2]	Less likely to have significant decrease in HC: OR 0.48, 95% CI 0.24, 0.99	Brazil, Dose dependent, Adjusted for SES
Brain white matter[3]	Dose dependent increase in CNS white matter development	
IQ[4]	Artificial feeding decreased IQ by 5.9 points at 6.5 yrs of age	PROBIT (Kramer in Belarus)
School achievement[5]	BF>9 mo associated with 0.5 to 0.8 more grades of schooling	Brazil, not associated with SES
Moving up social class[6]	41% (95% CI 10% to 82%) more likely to move up a social class	England, controlled for other SES variables

1. Tawia S. Breastfeeding Review 2013; 21(3): 15-20. 2. Ferreira H. Breastfeed Med. 2013;8:294-301. 3. Deoni SC. Neuroimage. 2013 Nov 15;82:77-86 . 4. Kramer MS. Arch Gen Psychiatry 65: 578-584. 5. Victora S. Acta Paediatrica, 2005; 94: 1656-1660. 6. Martin RM. Arch Dis Child 92: 317-321

Conclusion

- Breastfeeding is "the gift that keeps on giving" throughout the entire lifecycle
- Breastfeeding is particularly important in the developing world because of:
  - Prevention of infectious disease and related growth failure
  - Prevention of obesity related adult disease whose prevalence is increasing
  - Possible compensation for cognitive development problems conferred by poor nutrition
- Breastfeeding promotion is imperative regardless of any other interventions.