Human milk - there's no other quite like it

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Introduction

Human breast milk is a unique fluid. It is very different from other mammalian milks and from infant formula.

Breast milk supplies nutrients which are important for brain development. The human brain continues to develop in the first two years and a number of nutrients such as iron have been shown to have lasting effects on development if temporarily deficient in this period. It has unique components, quantities and bio-availability of nutrients important to brain development. In contrast, the milk of other mammals is high in protein. The level relates to the rapidity of their body growth[1], important if you're expected to be independent in escaping your predators soon after birth!

Breast milk adapts to meet the needs of the baby. The constant changes in composition between and within mothers means that no two human milk samples are the same. It contains many factors which protect the infant from infection inlcuding live cells, immunoglobulins and oligosaccharides which are not present in infant formula. Even If formula companies could mimic the constituents of human milk they are unable to match its constant adaption and anti-infective properties. Although formula companies can claim their product is 'closest' to mother's milk; they cannot claim to be close to mother's milk.

For healthy full term infants of well-nourished mothers, human milk supplies all the dietary essentials needed for the first four to six months of life. During this period they require no supplements[2] apart from vitamin K at birth. Lactating mothers can meet their own nutritional needs by satisfying their appetite from increased consumption of foods chosen from the five group plan, including cereal products, preferrably whole grain, fruits and vegetables, meat or meat substitutes, fish and dairy products. Lactating mothers need to increase their intake of milk to 600ml or its equivalent per day.[3] It is cheaper to feed the mother the extra nutrition required than formula to the baby. In Australia it costs over $A1000 to formula feed an infant for the first year.

Breast milk constituents

The constituents of human milk not made in the breast can be affected by the mothers diet. Carbohydrates are manufactured in the breast and not known to be affected by dietary intake. Some fatty acids are derived from the diet, others come from maternal fat stores and others are made in the breast. The milk of a vegetarian mother will have more polyunsaturated fatty acids and linoleic acid. Some proteins in the maternal diet will appear in her milk[4] and may sensitise her infant. In general, if a mothers diet is adequate, giving her vitamin supplements does not increase the breast milk level.[5]

> **" Human milk supplies nutrients which are important fro brain development ... The milk composition changes between and within mothers ... "**

Human milk is resistant to maternal malnutrition and only in the following circumstances are problems due to specific breast milk constituent deficiency likely in a full term infant. Curiously, human milk does not contain sufficient vitamin K to prevent haemorrhagic disease of the newborn - a condition almost exclusively found in fully breast fed infants. All infants should receive vitamin K at birth.[6] Mothers from iodine deficient areas will need iodine supplementation to prevent goitre. Mothers who choose a vegan diet or who eat no animal products will require vitamin B12 supplementation to prevent neurological damage to their infant.[7] Mothers of darkskinned infants transferring to temperate or cold climates need to be aware that their infant may not have sufficient sunlight exposure to prevent rickets and extra vitamin D may be required.[8] Some infants have developed acrodermatitis enteropathica due to low breast milk zinc even though their mothers have normal zinc levels.[9] However this is usually occurs in infants born prematurely.

In this article unless otherwise stated quatities refer to average amounts in mature milk. However it must be remembered that even in mature milk, constituents vary with a number of factors (see Table 1).

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Table 1: Breast milk constituents vary with:
Gestational age
Chronological age
Time of day
Time during feed
Mother's Nutritional Status
Mother's Weight Gain in Pregnancy
Maternal Obesity
Mother's Diet
Primigravidity
Mother's Blood Group
Menstruation

Oligosaccharides are some of the most variable constituents and can be used as an example of the variation that occurs between and within mothers.They are the third most abundant milk solid after lactose and fat.There are over 130 described in human milk but not all are found in all mothers.Individual mothers maintain individual patterns throughout lactation. Oligosaccharides form part of the blood group antigens and the profile of oligosaccharides in a mothers milk will vary with her antigen groups (ABO, H, Lewis group and secretor status).

" Maternal smoking of as little as 4 - 10 cigarettes per day will significantly decrease milk production. "

Mothers of some blood groups lack the enzymes to make certain oligosaccharides and these will be absent from their milk.[10] The total amount of oligosaccharides in human milk varies. Levels are highest in colostrum and decline rapidly in the first three months of life.The rates at which individual oligosaccharides decrease varies so that the proportions change with time.[11]

From a small number of studied infants it seems that oligosaccharide levels are high in the milk of mothers delivering prematurely.[10] This may protect them from infection and supply extra sialic acid for their brain developement. It may be relevant to the much lower incidence of necrotising enterocolitis in breast fed infants.[12] Oligosaccharide content does not change significantly during the feed but they do change diurnally and levels are high in the evening.[13] Because oligosaccharides are made in the breast they are not expected to change with maternal diet. They are made by the lactose synthetase system which switches between producing lactose and oligosaccharides, so that the changes are the inverse of those seen in lactose which increases with the stage of lactation and is highest in the morning.

In contrast, fatty acids are partially derived from maternal fat stores, partially from the diet and partially manufactured in the breast (medium chain fatty acids). So that fat levels and profiles are affected by the maternal diet, time from the last meal, maternal weight gain during pregnancy, maternal obesity, and primigravidity.[14]

Volume

Breast milk production is governed by the infant's appetite and not by breast size which is largely determined by breast adipose tissue and is not a reflection of functional glandular tissue. Only in those rare instances where a mother has not experienced breast development during pregnancy, or has a unilateral breast (the other is likely to be dysplastic) or has had breast surgery with periareolar incisions, is the breast likely not to lactate adequately. Maternal smoking of as little as 4-10 cigarettes per day will however significantly decrease milk production.[15]

The major component of human milk is water (Table II). Breast milk output is not increased by increasing the mothers fluid intake.[16] Breast fed infants do not require additional water, even in hot dry climates.[17] The volume of milk produced is largely dependent on an autocrine system. Removing milk from the breast removes a substance that inhibits milk production and allows the breast to increase its content before the next feed. Conversely if milk is not removed, this factor acts locally to inhibit production and if left, as in weaning, involution occurs.[18]

Knowledge of the importance of removing milk from the breast to encourage lactogenesis has led to instructions to empty the first breast.[19] However babies do not empty the breast. Between 10-30% of milk is left even in malnourished mothers[20], and in infants with high intakes.[21] The amount removed is governed by the infant's appetite. This varies between infants from feed to feed and with time. The largest feed is usually in the morning at two months of age but in the evening at four to six months.[22] Intake is determined by the fat content of the milk, the infant adjusts the volume to keep the energy intake over 24 hours constant.[23] Just as the amount of milk removed varies between infants with some babies taking twice as much as others so does the rate of removal. Mother-infant pairs have characteristic rates.[24] So there are slow feeders and fast feeders, and big feeders and small feeders.

The most accurate way of knowing clinically whether an infant is getting sufficient volume is adequate growth.

Table 2: Breast milk constituents		
	Mature breast milk	Standard formula
Macronutrient	*Quantities per litre*	
Water (g)	876	870
Cho (g)	74	70 - 76
Fat (g)	42	34 - 38
Protein (g)	10	15 - 17
Energy (kj/L)	2900	2710 - 2850
Osmolarity (mosm/kg)	260	285 - 300
Source: The Feeding Guide, J. Allen		

Macronutrients

Macronutrients supply the energy needs of the bady, about 40% from lactose and 50% from fats. The quantities of these two constituents increase from birth. The constituents of breast milk given in the following tables compare average mature milk with standard infant formula suitable for the first six months. You can see that formula imitate breast milk in gross quantities of macronutrients but not the type of constituents.

Carbohydrates are the major human milk solid and lactose the main carbohydrate (see Table 3). Lactose is only produced in the mammary gland. It consists of two monosaccharides, one of these, galactose, is an important constituent of brain matter. The lactose content of the milk of a species correlates with its brain size. Amongst mammals, humans have one of the highest milk lactose content.[1] The amount increases during the first 3 months of life and it is higher in the morning feeds.[26]

Carbohydrates and Lactose

Lactose is digested in the small intestine, mainly the proximal jejenum. It is broken into its constituent monosaccharides which are then absorbed by specific carrier proteins. Absorption in the small intestine is incomplete. That which passes to the colon is fermented by bacteria.

Table 3: Type of constituents: carbohydrates	
Breast milk	Standard formula
Quantities per litre	
Lactose (68-72 g)	Lactose
Oligosaccharides (18.5 g)	
Glucose (0.14 g)	
Galactose (0.12 g)	

Lactase is produced in the brush border cells as an inactive proenzyme which is cleaved and then transported to the brush border membrane where it is anchored by a hydrophobic sequence. Humans are unusual amongst mammals in that lactase can persist into adulthood. In most mammals the levels drop rapidly with weaning but in human they decline during childhood and adolescence. This varies according to ethnic group. 80-90% of Asians, blacks and most ethnic group develop acquired hypolactasia. Northern Europeans and other milk drinkers are the exceptions. The decline in intestinal lactase starts at different ages - by 3 years in blacks and Mexicans and 10-20 years in Fins. Adult type alactasia appears to be related to alteration in the processing of prolactase to lactase. Subjects with primary adult type hypolactasia do not have lactose intolerance during infancy since the enzyme deficiency is not present at birth. True congenital lactase deficiency is rare.[27]

There has been recent interest in whether lactose intolerance could explain unsettled behaviour in some infants. Given the above this is unlikely and although our own early studies showed raised breath hydrogen in unsettled babies[28], lactase given in a double blind placebo controlled trial had no effect on their behaviour or breath hydrogen.[29]

In humans, brush border lactase activity appears around 10 weeks gestation and rises gradually to 34 weeks when it is 30% of the fullterm newborn level and then rapidly to term reaching levels of 70% at 35-38 weeks. Lactase in infants born premature increases rapidly in the first week after delivery, even in those enterally fed. Despite defective absorption of lactose by prematures, only a small percent of lactose energy is excreted.[30] The colonic microflora salvage and convert the unabsorbed lactose to lactate, short chain fatty acids, hydrogen, and carbon dioxide which is excreted in the breath.

Oligosaccharides

Oligosaccharides are ubiquitous in nature. Human milk is unique amongst placental mammals in being rich in oligosaccharides although they are also found in marsupial milk.[31] They are the third most abundant human milk solute. They consist of five monosaccharides arranged in combinations of three to eleven units. Oligosaccharides containing N-acetylglucosamine are the bifidus factor in human milk. They promote the growth of bifidobacteria in the infant colon. Breast feeding produces faeces with a low pH and acetic acid as almost the sole metabolic byproduct of intestinal flora. This inhibits the growth of many potentially pathogenic bacteria. In contrast formula feeding, cows milk feeding or giving comps to breast fed children leads to a higher pH and a more complex profile of volatile fatty acids in the stool.[32]

Oligosaccharides in human milk mimic the cell membrane receptors for a growing list of pathogens including Eshrichia coli, Streptococcus pneumoniae, Campylobacter

pylori, Candida albicans, Pseudomonas aeruginosa, Mycoplasma pneumoniae and Influenza viruses A, B and C. By binding the pathogen, oligosaccharides inhibit their adhering to epithelial cells and may thereby protect the infant from infection.[33]

Sialic acid is one of the five monosaccharide components of oligosaccharides. It is a receptor for neurotransmitters in the central nervous system. In the rat, lower levels have been associated with irreversibly impaired learning behaviour. Also in the rat, adding sialic acid to the diet was associated with increased levels in cerebral and cerebellar gangliosides and glycoproteins.[34] Of the numerous glycosidases found in human milk[35] and in the infant intestine, only neuraminidase could be expected to digest oligosaccharides.[36] This splits off sialic acid. In breast fed infants, free sialic acid in the faeces increases with maturation suggesting this enzyme may be active in vivo. Therefore oligosaccharides may be a source of sialic acid for infant ganglioside ghycoproteins and glycolipids. We have shown high levels of sialic acid in breast milk at a time of rapid synthesis of these substances.[11]

Fats

One of the notable curiosities about breast milk is the high cholesterol level (see Table 4). Serum levels in breast fed children are higher than in formula fed.[38] The maximal difference occurs at about two months of age and disappears on weaning. Within breast fed children, the serum level does not relate to their daily cholesterol intake. Serum cholesterol is mainly endogenous. Cholesterol is essential for myelination, hormones, vitamin D metabolites and cell membrane integrity. In spite of the major intake differences no effect of this has been documented.[39] There is no long term difference in serum cholesterol levels between breast and formula fed children.

Table 4: Type of constituents: fats

Fats	Breast milk	Standard formula
Oils	Variable. 98% as triglycerides	Blends of oils (such as corn, coconut, oleo palm, soy and vegetable), lecithin and milk fat
Fatty acids	Saturated	Blend gives a similar saturated, monounsaturated and polyunsaturated profile
	Monounsaturated	
	Polyunsaturated:	
	- *linolenic (18:2n-6)*	+
	- *linolenic (18:3n-3)*	+
	- *longer chain n-6 (arachnidonic) and n-3 (docosahexaenoic) series*	-
Cholesterol	15 - 20 mg/kg/day	2.5 mg/kg/day
	phospholipids	
	prostaglandins	

The other notable difference between the fat composition of breast milk and formula is the presence of longer chain polyunsaturated fattty acids.[40] Mammalian cells cannot introduce an unsaturated bond at the n-6 or n-3 position of the fatty acid chain so they must be provided from the diet by linolenic and linoleic acid which have 18 carbon chains. However normal cell function requires 20 and 22 carbon chain, n-6 and n-3 polyunsaturated fatty acids. These are found in the phospholipids that make up the dynamic fluid core of all cell membranes. They are also present in human milk and breast fed infants have higher plasma and erythrocyte levels than formula fed infants. In prems, the plasma level decreases in formula fed infants suggesting that the chain elongation-desaturation enzymes are not fully mature.[44] Adding them to formula is not easy as the balance as well as the amount is important. They compete for the same desaturase enzyme and there is inhibition of these enzymes by their reaction products so that disproportionate amounts of one may interfere with production of others.

Table 5: Some constituents of whey protein

alpha-Lactalbumin
Lactoferrin
Lysozyme
Serum albumin
Immunoglobulins
Hormones and growth factors
Enzymes

Measures of visual acuity have been used in a number of studies as a measure of cell membrane function and correlated with erythrocyte longer chain polyunsaturates. Visual evoked responses (VEP) and forced choice preferential looking (FPL) are better in breast fed than formula fed prem and term infants. In Uauy's study[42], at 4 months VEP was 20/85 for formula fed and 20/65 for human milk fed infants and mean FPL acuities were 20/130 and 20/110 respectively. At 3 years, stereo acuity measured by operant preferential looking (OPLSA) was 42.1 ñ 5 seconds of arc compared with 92.8 ñ 86.1 for formula fed. 92% of the breast fed infants had a OPLSA of < 40 sec of arc (i.e. were fully mature) compared with only 35% of formula fed infants.

Protein

Proteins have a nutritional role in supplying energy and amino acids to the infant as well as many physiological functions. The majority of human milk proteins have several biological functions in the mammary gland or after ingestion by the infant. Proteins are largely manufactured in the breast from amino acids taken up from the blood stream but some such as immunoglobulin are transferred from blood or extracellular fluid.[43] The protein content of colostrum (2.3 g/dl) drops in transitional milk (1.6 g/dl). Mothers delivering prematurely have temporarily higher levels.

Whey proteins include alphalactalbumin. In the breast alpha-lactalbumin regulates the production of lactose and oligosaccharides. It has no enzyme activity of its own but changes the affinity of protein A to make lactose in preference to oligosaccharides. Alpha-lactalbumin forms 20-39% of total human milk protein and is a major source of amino acids. It also binds calcium and zinc and may contribute to their high bio-availability.

Lactoferrin is the second most abundant whey protein. It is species specific. Infant monkeys given milk fortified with human lactoferrin do not increase their iron intake[44]. Neither do human adults. The lactoferrin receptors in the human intestine are species specific and decrease with age. Lactoferrin increases in iron deficient mothers making more iron available to the infant. Inspite of low levels of iron in breast milk its high bioavailability ensures adequate supplies for the healthy term infant up to 4-6 months of age. After that additional iron is required, for example iron fortified cereals taken with a ascorbic acid containing food such as fruit to enhance the iron absorption. Because lactoferrin is not fully saturated it inhibits the growth of bacteria by mopping up free iron.

Bioactive substances in human milk are usually present in the highest concentration in early lactation and decline with time. They include immunoglobulins, mostly secretory IgA but IgG and IgM are also present. Their specificity is dependent on the mothers antigen exposure. There are over twenty digestive enzymes present in human milk. One is alpha-amylase which is acid tolerant and therefore would be expected to pass the stomach and be active in the intestine. Whereas pancreatic alpha-amylase is nearly absent in the first 4-6 months.[45] There are over 33 hormone like substances in breast milk including pituitary hormones, brain-gut peptides, growth factors, steriods and non steroid hormones. These may act locally or may be absorbed intact to act systemically. The presence of these in human milk may explain the earlier maturation of a number of systems in the breast fed infant.[43]

The role of caseins is primarily nutritional. Human milk caseins are structurally and physiochemically different from bovine caseins. This affects the curd formation, gastric emptying and intestinal transit times in breast fed infants.

Table 6: Breast milk constituents: minerals

	Mature breast milk	Standard formula
Minerals	*Quantities per litre*	
Na (mmol)	6	7 - 10
K (mmol)	15	14 - 20
P (mg)	146	210 - 420
Ca (mg)	348	420 - 640
Fe (mg)	0.8	7 - 12
F (mmol)	1.31	varies with water

Source: The Feeding Guide, J. Allen

Minerals

Table 6 shows that breast milk has low levels of calcium, phosphorus and iron. In spite of this, breast milk usually has adequate mineral and trace element contents for feeding full term infants except for fluoride, and selenium in countries such as New Zealand where intakes are low.[46]

The high bioavailability of iron in human milk has already been discussed. Ferritin levels in breast fed infants are higher than formula fed in the first three months. Adequate iron intake is important as a number of controlled studies have shown that infants with iron deficiency anaemia score lower on tests of mental development. Whether these effects are reversible and whether they occur with irion deficiency without anaemia is still debated.[47] Ensuring iron sufficiency in the first two year is important.

Human milk is unusual in its low phosphorus content. There are several advantages to the infant. It is essential because of the acid pH of the faeces of breast fed infants which inhibits the growth of pathogenic bacteria; the newborn kidney tolerates excess phosphorus poorly with the potential for hypocalcaemic tetany and under conditions of infectious stress it makes metabolic acidosis less likely.[48] Calcium in human milk has a high bioavailability due partially to the presence of lactose and lactalbumin.

Vitamins

Vitamin levels in breast milk are lower than their formula counterparts but apart from vitamin K, deficiencies are unusual due to their high bioavailability. Deficiency of vitamin A and E are not seen in breast fed infants. Absorption of fat soluble vitamins is enhanced by the lipid profile of breast milk. Deficiencies of thiamine and vitamin C are rare.

Vitamin D levels in breast milk vary with maternal exposure to sunlight. Vitamin D is an unusual vitamin as it is not

Table 7: Breast milk constituents: vitamins		
	Mature breast milk	Standard formula
Vitamin	*Quantities per litre*	
A (IU)	1900	2500 - 5500
Thiamine (µg)	160	260
Riboflavin (µg)	360	390
C (mg)	43	52
D (IU)	22	500 - 1200
K (µg)	15	55
Source: The Feeding Guide, J. Allen		

found in significant quantities in food items apart from oily fish. The body depends on ultraviolet radiation converting a previtamin in the skin to vitamin D3. This is then converted to 25 hydroxy vitamin D in the liver and the most active form, 1,25 Hydroxy vitamin D in the kidney. Hydroxylation is the newborn is immature. In contrast to formula, breast milk contains 25 and 1,25 vitamin D. Hence bioactivity is high but there is still not sufficient to prevent rickets.[49]

The infant also requires some exposure to sunlight. The amount required is very low. In a temperate climate for a white child with only hands and face exposed, only two hours per week is required.

Although colostrum vitamin K content is higher than mature milk, this is not sufficient to prevent haemorrhagic disease of the newborn in all infants. The incidence is approximately 4/1000 fully breast fed unsupplemented infants. The early form occurs in the first two weeks of life. The late form occurs from two weeks to three months and may be fatal. In approximately half the late presenting cases, other predisposing factors such as malabsorption are present. The early form is prevented by one oral or intramuscular dose of vitamin K at birth. The incidence of the late form is decreased from 1 in 17,000 to 1 in 25-70,000 or 1 in 400,000 by one oral or intramuscular dose respectively at birth. A recent study raised concerns about a possible association between intramuscular vitamin K and later childhood cancer. These concerns have not been substantiated by later workers.[51,52] In Australia the current recommendations are that all infants should be given either intramuscular vitamin K at birth or repeated oral doses in the first six weeks of life.

Using expressed breast milk

Expressed breast milk is often used when the mother is unavailable or the infant has congenital malformations or complications that make it unable to feed. The long term advantage of expressed breast milk over preterm formula in infants delivered prematurely has been well documented. Milk should be expressed in a clean (sterile) plastic or stainless steel (not glass) container. Because of the theoretical risk of transmission of a number of viruses from donor milk, expressed breast milk should not be pooled and where possible the infant given its own mothers milk. Because of its anti-infective properties, human milk is resistant to contamination when left at room temperature and can be left for surprisingly long periods before becoming contaminated. However this is not recommended where refrigeration is available.

Table 8: Breast milk anti-infective properties	
Antibacterial	Antiviral
Lactobacillus bifidus	Lipids
Secretory IgA	Secretory IgA
Components of complement	Unidentified macromolecules
Lactoferrin and transferrin	Cells - Interferon
Lactoperoxidase	- Phagocytosis
Lysosomes	- Specific IgA
Oligosaccharides	Oligosaccharides
Live cells	

Freezing, thawing and heat treating human milk all destroy some of its unique properties. Where used as an occasional feed this is not a problem but where used as a regular feed human milk should be stored at 40 °C deep in the refrigerator (not in the door) and used within 48 hours.[54] Heat treating destroys many components including proteins such as enzymes, immunoglobulins, lysosymes, and lactoferrin. Freezing destroys milk macrophages and lymphocytes and disrupts the fat globules. Bacteria multiply more rapidly in heat treated milk than fresh raw milk.

Breast milk contaminants

Medications

All medications taken by the mother are present in the breast milk and are bio-available to the infant.[55] In general these do not cause a problem but care should be taken in prescribing to breastfeeding mothers. Where there is doubt, information should be checked with a reference source[56] or a drug information centre such as the *Clinical Pharmacology Department of the Christchurch Hospital, New Zealand (Phone: +64-3-364 0900; Fax: +64-3-364 0902).* The medications listed in Table 9 should be avoided in the breast feeding mother.

Phenobarbitone and thiouracil may occur in plasma levels in the infant which exceed that in the mother. The dose the infant receives depends on the physicochemical properties of the drug and the maternal and infant pharmacokinetics of the drug. Drugs in breast milk may occur in the aqueous,

Table 9: Breast milk contaminants	
Drugs	Phenobarbitone, disphenoxylate, valium, thiouracil, lithium, etc
Environmental contaminants	Insecticides' byproducts of DDT, PCBs, organochlorines Lead
Social drugs	Alcohol, byproducts of cigarettes, caffeine, drugs of addiction
Organisms	Found in expressed milk: CMV, Hepatitis B, HIV, Rubella, Salmonella, Gp B Streptococcus, Staphylococcus

protein or lipid phase so that the concentration depends on the composition of the milk as well as the acid base characteristics, protein binding, and fat solubility of the medication. The maturity of the infant will affect their ability to metabolise and excrete drugs so that the postconceptional age of the infant is important in some instances.

In general problems do not occur where a medication, which is safe to use in an infant of that age, is taken by the mother at the time of breast feeding so that breast milk levels are at their nadir when baby next feeds.

Drugs

Human milk concentrations of amphetamine, cocaine[57], nicotine and tetrahydrocannabinol may be higher than the maternal plasma levels. Infants of cocaine users may convulse due to cocaine toxicity. Infants of smoking mothers will also absorb nicotine by passive smoking. Its byproduct, cotidine appears in the urine whether or not the baby is breast fed but levels are higher in the breast fed infant because of milk transfer.[58] The plasma level of ethanol in preterm infants whose mothers have drunk alcohol will be higher than in term babies and may be more than 50% of the maternal plasma concentration.[56] Regular exposure to alcohol in breast milk may be associated with poor motor development.[59] As with medications and environmental contaminants, exposure in utero to these substances has greater detrimental effects than exposure through breast milk. For example, infants exposed to cocaine, amphetamine, methadone and heroin show withdrawal symptoms in the newborn period and have higher rates of intrauterine growth retardation and prematurity in excess of that predicted by coexisting risk factors.

Caffeine in breast milk may be sufficient to make an infant jittery. About one per cent of ingested coffee appears in breast milk. The highest level occurs about an hour after ingestion. The half life in neonates is four days and drops to adults levels of 3 to 4 hours at 7 to 9 months. Infant restlessness is unlikely if the maternal intake is less than 300/mg per day. This is equivalent to 3-4 cups of instant coffee, 30 cups of tea, 10 cola drinks or 15 bars of chocolate.[60]

Infections

As for chemical contaminants in breast milk, infection in utero is generally more deleterious to the infant than infection from breast feeding. A number of viruses have been found in breast milk and may potentailly be transmitted to the infant. Antibodies to the organism are also found[61]. Generally, the benefits of breast feeding outweigh the risks of infection[62]. In developing countries it is recommended that infants of mothers with HIV breast feed.[63,64] For mothers with hepatitis C infection there is insufficient data to be sure of the risk of transmission through breast milk but it appears to be low.[65,66] Infants of mothers with hepatitis B should be given hepatitis B vaccine and immunoglobulin at birth and continue to breast feed. The infection rate of breast fed infants is equivalent to formula fed. Although cytomegalic virus can be transmitted by breast milk and the effects on the infant of intrauterine infection are profound, symptomatic acute infection or late sequelae have not been seen due to breast milk transmission[62].

Environmental contaminants

Several toxins including polychlorinated biphenyls, dieldrin and DDT have been found in breast milk.[67] DDT and dieldrin are higher in mothers who smoke. Meat and dairy products contribute strongly to breast milk concentrations of dieldrin and PCBs, and fish to PCB 118. Breast milk contamination can be minimised by not smoking and a moderate intake of animal products. To date toxic effects of these products have not been found in infants but caring for the environment will minimise levels in the population and therefore in breast milk.[68]

Summary

Breast milk is a complex fluid with hundreds of components that vary independently and interactively. The literature is often conflicting because of the difficulty of comparing different sampling and analytical techniques. For example one biochemical tool may measure only bound forms, another free forms.

Human milk alone meets the nutritional needs of fullterm infants of healthy mothers until four to six months of age. Over and above the nutritional advantages, breast feeding has many other psychosocial, economic and lifestyle advantages which are beyond the scope of this article.

There is unusual international consensus on the importance of breast feeding for infant health. The 1981 WHO International Code of the Marketing of Breastmilk Substitutes; the 1989 WHO and Unicef joint statement 'Protecting, Promoting and Supporting Breastfeeding - the special role of maternity services; The 1989 'Convention on the Rights of the Child' adopted by the general assembly of the United Nations; the 1990 'Innocenti Declaration on the Protection, Promotion and Support of Breastfeeding; the consensus of the 1990 World Summit for Children and the

WHO/Unicef Baby Friendly Hospital Initiative all recognise the extraordinary advantages of being breast fed.

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