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Including Household Production in the System of National Accounts (SNA) - Exploring the Implications of Breastfeeding and Human Milk Provision

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INCLUDING HOUSEHOLD PRODUCTION IN THE SYSTEM OF NATIONAL ACCOUNTS (SNA) – EXPLORING THE IMPLICATIONS OF BREASTFEEDING AND HUMAN MILK PROVISION

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ABSTRACT

Ignoring shifts from home production to market production seriously biases estimates of changes in societal well being, and policies which encourage market over non-market production distort the economy. This paper aims to illustrate the appropriate treatment of lactation within a national accounting framework and to show how human milk production may be measured and included in the core accounts. We consider how lactation work and output should be treated under SNA93, and we review methodologies of previously published estimates of the economic value of breastfeeding and human milk. We then discuss how national accounts should be adjusted to incorporate human milk production and the externalities associated with infant feeding methods. The most important finding is that human milk should, and can, be included in the core accounts as a home produced good for household consumption. This is because it is within the System of National Accounts production boundary, can be measured and valued reasonably easily and is quantitatively non-trivial. The current invisibility of lactation in economic statistics is misleading, and has important consequences for public policy, and economic efficiency and productivity.

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INTRODUCTION AND BACKGROUND

This paper addresses the issue of whether breastfeeding and human milk should be included in GDP, and how this would be done.

AIM AND METHODS

This aim of this paper is to consider the appropriate treatment of breastfeeding and human milk within the UN System of National Accounting (SNA) framework, and illustrate the appropriateness, practicality and relevance of measuring human milk production in GDP. Firstly the paper discusses SNA93 guidelines pertaining to how breastfeeding and human milk should be treated in a national accounting framework. We then review methodologies of previously published estimates of the economic value of human milk output, and present estimates for a representative selection of countries. The paper explores the policy implications of its current invisibility, and summarises the necessary adjustments within core GDP and capital accounting frameworks to incorporate infant feeding and its maternal and child health externalities.

The United Nations' System of National Accounts and national accounting treatment of goods

Substantially revised international guidelines for compiling GDP estimates, commonly referred to as SNA93, were published in 1993 (System of National Accounts 1993).[1] Like its predecessor, SNA93 (and SNA98) excluded from the core accounts the economic value of "own account" production of services by households. However, SNA93 now included a category for "own account" production of goods by households, which includes subsistence production in agriculture, and other goods produced by households for their own consumption, to be included within the core production boundary.

As Ironmonger and Soupourmas (1, p. 245) point out, SNA93 meant that;

> 'growing rice and chickens for use within the household is regarded as production of goods to be included in SNA production even if not for sale. Cooking rice and chickens for use within the household is regarded a production of meals and hence services not goods and is excluded from the SNA production boundary.'

The SNA93 changes in part reflected the reality that the subsistence economy is large in many countries, and in part reflected an acknowledgement of the economic importance of women's unpaid work in households. Recommended for the first time in SNA93 was the incorporation of unpaid work, including household work (such as domestic chores and

[1] Revised guidelines in 2008 (SNA08) made few substantive changes to 1993 guidelines and were implemented in Australia from 2008-09. See Australian Bureau of Statistics; 2011, p126.

childcare), volunteer work, and community work, but these were to go into “satellite accounts”.

The distinction between a good and a service in some areas is controversial among national accountants. Breastfeeding illustrates this — lactation produces a good, as well as a service, with the physiological process of lactation producing a good, and the act of nursing an infant providing a service. Consumption and production of the good, human milk, can be distinguished from provision and consumption of the service provided by the breastfeeding mother. For example, the economic value of breastfeeding as a food commodity derives from the nutritional and immunological (biochemical) properties of human milk itself which protect against malnutrition, infectious illness and immune system disorders (2, 3) Separate and distinct from this, nursing at the breast is an activity which contributes to the quality of households’ care services by delivering comfort and nurture to potentially enhance mother-child interactions, attachment and mental health and development, and by furthering normal jaw and speech development (4-7).

In this paper, the focus is on human milk as a food commodity, in the context of SNA guidelines on production of goods by households for their own consumption**.** Broadly, production of goods by households even if intended for their own final consumption, such as backyard production, food gathering, or on farm consumption of agricultural production, is to be considered as part of core GDP.

Human milk is a commodity produced by women, which can be stored and exchanged. As well as providing milk directly from the breast, mothers express milk to be fed to their own or sometimes other women’s infants, for example, in feeding bottles, cups or tubes. The extent of lactation as a commodity producing activity is indicated by the substantial commercial market in lactation aids such as breastpumps and bottles or storage bags which facilitate the process of ‘expressing’ (‘pumping’) milk from the breast, and storing and transporting milk for later use.

The type of container in which the milk is packaged and delivered to the infant is not relevant to its inclusion in the core national accounts — maternal lactation creates a good, milk**,** for own consumption within households, and this milk therefore falls within the core production boundary under SNA93 guidelines**.**

Families are acknowledged by national accounting experts to play an important role in building human capital through their unpaid work (for example, see Abraham and Mackie’s extensive discussion of households unpaid provision of health care and education) (8).

An inadequately fed infant will cost the health system, the education system (because of brain development), and society generally. Breastfeeding and human milk makes a unique contribution to human development through provision of species-appropriate nutrition and care for infants and young children. Evidence on its importance for health and development of infants has been accumulating for many decades. Lack of breastfeeding is now a recognised risk factor for a range of chronic disease in adulthood, as well as for acute infectious illness during infancy and childhood based on systematic reviews (9-11). A number of studies have linked artificial feeding with allergy, juvenile insulin dependent diabetes (IDDM), multiple sclerosis and other auto-immune diseases; Crohn's disease, ulcerative colitis in adulthood and other chronic digestive diseases; Sudden Infant Death Syndrome (SIDS); heart disease; childhood lymphoma; and obesity. Babies who are not breastfed have substantially higher risk of otitis media and diarrhoeal disease, severe

rotavirus gastroenteritis; respiratory illness, bacteraemia and bacterial meningitis, necrotising enterocolitis (NEC), botulism, and urinary tract infection (12).

Mothers' health is also adversely affected by premature weaning, through higher incidence of depression and mental illness Studies have linked short breastfeeding durations to higher rates of rheumatoid arthritis, cardiovascular disease and diabetes in women later in life (9, 13, 14). Over a million infants a year die needlessly from being deprived of breastfeeding, and improving breastfeeding practices is recognised as the most effective and cost effective intervention to improve mother and child health (15).

Breastfeeding and human milk benefits society economically through reducing health care costs. In recent decades several studies have estimated the attributable healthcare system costs of formula feeding (16-20). The cost of pediatric health care and premature death attributable to formula feeding in the United States was estimated at around US$13 billion a year (20); it is also a significant proportion of acute and chronic disease costs in Australia (21). A 2002 study in Australia found the attributable health system cost of premature weaning to be over A$100 million annually for just four acute conditions (19) Well conducted cohort and experimental studies in several countries provide strong evidence that people deprived of human milk or breastfeeding in infancy have poorer cognitive and academic achievement in later life (7, 22-25). Ending exclusive breastfeeding before 4 months is estimated to reduce IQ by 3-7 percentage points, with larger impacts for premature or small-for-gestational-age infants.

These contributions of breastfeeding to the quality of human capital have long term economic consequences. Drawing on recent advances in developmental neuroscience, Nobel Laureate James Heckman and colleagues (26-28) have shown the economic importance of early investments in children; the cumulative effects of early life experience on cognitive skills, socio-emotional functioning and health demonstrably affect later life earnings and productivity

Official imputations are routinely made under SNA93 guidelines for non marketed production of goods that are consumed on farm or by households but not actually marketed, such as subsistence production in agriculture, and goods produced by households for their own consumption (29, p. 46).

In the Australian system of national accounts (ASNA), imputations have been made for 'goods and services produced by persons in the course of their normal occupation and consumed by them' since 1997-98 when SNA93 was implemented (that is, an estimate is made, 'where practicable', for farm production consumed on the farm). An imputation is also made for 'goods produced by persons outside their normal occupations and consumed by them, that is, 'backyard production'. These estimates of the value of home-grown fruit, vegetables, eggs, beer, wine, and meat are included in the ABS estimates of final private consumption expenditure and therefore GDP (30, p. 126, 31). In 1997, this production amounted to just over A$1 billion in value, and an estimate for 'backyard production' is included on the income side of the accounts as part of gross mixed income. (29, p.46)

According to the Australian Bureau of Statistics (ABS);

> 'The SNA93 suggests that, in practice, goods produced in households for own use are to be included within the production boundary if the production is believed to be quantitatively important in relation to the total supply of those goods in the country concerned'. (29, p. 46)

In its notes to the current Australian national accounts, the ABS (30, p. 131) explains that,

> "Imputations are made for some goods and services which are not sold in the market place and therefore are not amenable to direct measurement. Imputation is confined to a small number of cases where a reasonably satisfactory basis for the valuation of the implied transaction is available, and where their exclusion could result in distortions in the accounts."

However, human milk production is not currently measured in the economic statistics of any country except Norway. Even human milk that is expressed or pumped from the breast to be sold (or donated) for feeding to babies by nurses, childcare workers, or orphanage staff, is not counted as production in GDP. A stark illustration of the inconsistency and its implications for the visibility of women's contribution to the economy is the emerging commercial market in human milk products.

A private company in the US now obtains milk donations from mothers and processes the milk for sale to hospitals (see the company website at http://www.prolacta.com/). The business is based on milk donated by mothers, which is then processed and packaged for sale to health institutions. The value of commercial processing, packaging and sales of this human milk based product will in practice be included in GDP, as it is (apparently) 'produced' by a firm, and a monetary transaction occurs when the company sells the finished product. Notably though, the crucial input to this corporate production and sales is human milk, supplied to the company by mothers at zero or minimal cost. These donations of milk to the company — and therefore women's immense contribution to the value of the corporate production, value added and profitability which is counted in GDP — are not, in practice, counted at all. The household output of human milk is omitted even though the exchange is an economic flow and should therefore be counted as either a donation (transfer) or a monetary transaction if the milk is sold (30, p. 74, 31, p. 129-30).[2] That is, where mothers are producers of human milk products, and exchange it in markets, the market value of their production and donation will remain invisible in GDP despite the promise offered by SNA93 to value women's unpaid economic contributions.[3]

As the ABS comments (31, p. 28)

> With the exception of own account household services, SNA93 recommends coverage of the production of all goods and services that legally enter the market and also that part of production which does not enter the market but for which a realistic value can be imputed using closely related or analogous market transactions...

[2] Transactions without a quid pro quo are 'transfers' in the national accounts. Donated milk is considered a 'transfer' and does not add to production under national accounting principles, although the transfer of value from one sector (households) to another (e.g. the firm) should be measured and netted out in GDP. If a payment to the supplier is made to cover the 'expenses' of supplying human milk, the amount of the payment should be included in GDP measured at cost. Hence if women want to ensure their contribution meets the criteria to be counted in GDP, they should not supply their milk free or at prices that are not 'economically significant'— they should at least require some payment for expenses in supplying it (this may include breastpumps and related equipment, packaging, electricity, delivery costs including for transportation and parking; some would also consider that costs should include a charge for time to express and deliver the milk).

[3] This illustrates a more general issue that while measurement of household production makes downward adjustments to household production for the value of market inputs to that production, in practice, market production may not be reduced appropriately to adjust for the market sector use of non market inputs, which are largely unmeasured. Such a practice bias will have the effect of exaggerating the magnitude of market production *vis a vis* non market production, and masks the reliance of market production on goods supplied by households as inputs to market production.

The fundamental criteria for including a good in GDP is that it can be traded in a market, so that it can be valued in monetary terms using a market price. According to the ABS,

> 'In principle, production should be valued at market prices, which are generally transaction prices. In the absence of market transactions, valuation is made according to costs incurred or by reference to market prices for analogous goods or services' (30, p. 130).

The latter approach is known as the input valuation approach. As discussed further below, numerous human milk banks operate legally around the world, a market for wet nurses has operated for centuries, and women now supply their milk at cost or free to commercial firms via internet or other trading processes. The existence of markets in human milk means there is a price of a closely related or analogous product – a shadow price – from which to impute its economic value.

The arguments for the inclusion of human milk output in core national accounts, and the implications of breastfeeding and human milk for the capital accounts have been expanded on elsewhere (32). Briefly summarised, this would mean, for measuring national product;

- **adding** to measured GDP the annual market value of human milk produced, after
- **deducting** the goods cost of human milk production (additional food consumption for lactating mothers is already included in final consumption expenditures, but should be counted as intermediate consumption), and
- **deducting** from GDP an amount reflecting any reduction in market productivity by mothers which is <u>necessary</u> because they are breastfeeding.[4]

There should also in principle be adjustment for the negative externalities of artificial formula manufacture, distribution, and use, including **deducting** from measured GDP the public and private health expenditures associated with increased relative risks of infant and maternal ill heath from current levels of artificial feeding.

Lactation is also relevant to measuring a nation's capital stock. Current national accounting practice fail to properly value many activities leading to human capital creation (8, 33). The unique biological capacity and culturally acquired skills of women to breastfeed and lactate can be conceived of as a natural capital asset with a value equal to the capitalized value of its future net income stream. The actual and potential value of the asset is large (32).[5]

However, gaining the benefit from this breastfeeding asset requires skill and knowledge that is largely culturally acquired, mother to mother, or through public education and institutional or organizational channels. The ability of any society to maintain current or potential production levels of breastmilk depends on a supportive breastfeeding culture and institutions.

[4] This highlights that workplace or other barriers to employment by breastfeeding mothers may be economically inefficient, even if the benefit to employers of removing such barriers is small or if it is costly.

[5] For example, for a 50 year time horizon and at a 5 per cent discount rate, the present value of this human capital asset in 1992 was comparable to the value of Australia's public telecommunications company, then around A$30 billion, and greatly exceeds the value of Australia's livestock (A$17.9 billion) and plantation forests (A$4.5 billion) (Australian Bureau of Statistics 2000a). At BFPO levels of breastfeeding, the capitalized value of human milk production in Australia would be around A$100 billion, nearly three times its current level and comparable to the country's subsoil mineral assets.

In the following section we briefly compare existing estimates of the economic value of human milk with national accounting measurement and valuation techniques. We then present illustrative estimates of the economic value of human milk production for selected countries. We show that human milk not only should, but can, be included in the core accounts.

Estimates of the economic value of human milk production

It is usual to discuss unpaid household production in the context of household satellite accounts and issues surrounding the input valuation method for valuing unpaid labour services by households. However, attention has recently turned to measuring household production using the output approach (1, 34, 35).[6]

Input valuation has a number of well known and thoroughly debated deficiencies, including regarding relative productivity in households vs firms, appropriate wage rates for valuation, and the lack of accounting for non labour inputs (33). In recent years, a small number of studies have shown that the output method can be used to value household production of services such as meals through utilizing data such as from time use surveys on activity episodes. The output approach is also potentially practical for valuing household production of human milk. For example, Ironmonger and Sourpoulas value a children's meal at $7 in 2006. This approach might also be applied to the valuation of human milk production, if official time use data records infant feeding episodes and breastfeeding status.

As human milk is clearly a good, so within the core production boundary, it is also apparent that the value of its production can be analysed using the output approach to its measurement. The output approach values household production at its imputed output value, in the same way that 'in scope' household non-market production such as backyard production and farm production consumed on the farm, is valued in the core national accounts (29, p. 48).

Several studies have estimated the value of human milk by estimating output in physical units and then valuing it using market prices. The focus has been on measuring the economic value of breastfeeding by estimating losses in the volume and value of national food production due to declining breastfeeding. The method used in these studies is broadly consistent with the above preferred national accounting 'output approach' to measuring GDP.

For example, in the early 1970s, Alan Berg documented the expanding economic loss associated with formula feeding replacing breastfeeding in developing countries such as Chile, Kenya, Singapore and the Philippines (36). Likewise, nutritionist Jon Rohde (37, 38) calculated the quantities of human milk production for infants and young children in Indonesia during the 1970s and 1980s. Studies have also shown the macroeconomic value of mother's milk for parts of Latin America, Sub-Saharan Africa, and India (39-43). A study

[6] Indeed, commercial producers of infant food count their potential market in terms of infant feeding episodes; see http://www.theaustralian.com.au/archive/business-old/infant-idea-teetering-on-greatness/story-e6frg97f-1225718230269.) An infant's meal, if breastfed, could be calculated using time use data on the number of feeding episodes per day and valued at the cost per feed of sufficient quality. (For example, a typical baby aged 1-6 months will need a total of about 28-30 oz. of mothers milk (800-850ml) in a 24-hours period, which equals about 3 to 3.75 oz. (85-100ml) per feed, assuming 8 feeds a day.) In some countries this may be a viable alternative approach for valuing household production of human milk using the output method. The Australian Time Use Survey does not presently collect the necessary data on infant feeding activity or breastfeeding status to allow this approach to be taken. However, the approximate number of meals supplied to all 300,000 Australian infants born in 2010 is 900 million p.a. for 8 feeds a day.

using a model developed by the Academy for Educational Development & UNICEF to estimate economic benefits of breastfeeding for policymakers in developing countries (44) has been used to estimate the volume of human milk produced in China at around 4 billion litres in 2001.

The above studies used the cost of replacing breastmilk with cows milk or formula to infer its economic value. However, this 'mothers milk equals cows milk' approach to valuing breastfeeding and human milk was challenged from the 1990s, in part due to new feminist perspectives on valuing women's economic contributions (45).

Since the 1990s, studies of the value of human milk production in have used market prices for human milk to indicate its economic value. Data on mothers' milk consumption has been included in Norway's Food Balance Sheets, alongside estimates of consumption of meat, eggs, and other food which are important in the local diet (46). These estimates are based on a methodology published in a 1994 study by Oshaug and Botten (42). These authors calculated that in 1992 production of human milk in Norway was 8.2 million liters, with an approximate value of $US400 million per annum. Production of human milk was valued using a market price for human milk — the cost of banked human milk traded by Norwegian hospitals, 344 Norwegian kroner ($US50) per litre in 1992. Official Norwegian estimates show that in 2011, Norwegian infants up to 2 years old consumed an estimated 10.5 million liters of mothers' milk.

A more recent study of human milk production in countries in sub-Saharan Africa by Hatloy and Oshaug (43) noted that at that time in Norway, hospitals paid US$21 per liter and sold it to other hospitals for US$36-47 per litre. While observing that identifying an exact value for human milk was difficult, the authors noted that its price was very high and judged that a 'very conservative and very low price' would be $1 per litre; at that price, the GDP of Mali and Senegal would have been increased by 2-5 per cent if the value of human milk were included in GDP.

The same valuation approach was adopted in research evaluating human milk production in Australia for the same year (47, 48). The Australian study estimated human milk production for infants and young children up to two years of age at around 33 million kilograms per annum in 1992. (Table 1, reproduced from the Australian study, illustrates the methodology for estimating the volume of human milk production.) This had a value of A$2.2 billion at a `market alternative' shadow price of A$67 (US$50) per litre.[7] This was equivalent to around 0.5% of GDP, or 15% of public spending on health. It was also equal to around 6% of private final consumption expenditure on food at that time. By comparison, retail sales of commercial formula milk were estimated to be around A$135 million in that year (Smith, Ingham and Dunstone 1998).

Estimating the production and consumption of human milk is relatively simple and accurate - breastmilk is "the only food commodity for which production equals consumption, that is, there are no 'post-harvest losses' or 'plate waste'" (Greiner, Almroth et al. 1979). The main variables in such estimates of human milk production are:

- the number of infants of the relevant age;

[7]This study took the price of expressed human milk traded by milk banks in Norway (344 Norwegian kroner ($US50 or A$67 per litre) as the `market alternative' price for breastmilk in Australia, there being no human milk banks operating in Australia at that time. Exchange conversions for 1992 were at $A1 = $US.75.

- estimated daily volumes of breastmilk production;
- breastfeeding prevalence;
- cost of inputs to human milk production, and;
- the value or `price' of human milk.

Number of infants

WHO, UNICEF and other health authorities recommend exclusive breastfeeding during the first six months of life and continued breastfeeding along with appropriate complementary foods until two years, or beyond (49). These recommendations applies to all countries because substantial acute and chronic morbidity impacts are evident for both developing and industrialized country settings (9-11), despite lower mortality in the latter.

The first data requirement is for the number of infants and young children (aged 0 to 2 years) alive during the estimation period/year. The estimated number of births in selected countries in 2010 comes from the UNICEF 'State of the World's Children' database (50). The selected countries include developing and developed countries, and of large or moderate population size. The number of children born in a given year is taken to also be the number of children living the following year. This is for simplicity as there is little change from year to year in the number of children born. No adjustment is made for infant or young child mortality during the accounting year, consistent with most previous studies.

Prevalence of breastfeeding

Studies of human milk production rely on estimates of national breastfeeding prevalence. For example, Oshaug and Botten used available official data on breastfeeding prevalence in Norway at ages 3, 6, 9, and 12 months and beyond to extrapolate national breastfeeding prevalence at each monthly interval up to 2 years of age, as do the official estimates of Norwegian production of human milk. Likewise the 1992 study for Australia used estimates of breastfeeding prevalence from a variety of national, State and local collections or studies by official or non-official researchers.

In this study, breastfeeding prevalence for the selected countries around 2006-10 is based mainly on readily accessible international data collections on infant and young child feeding and nutrition (50-52). For some countries, data was not available for every month to age 2; for these, monthly breastfeeding prevalence was through graphical interpolation of available data points. Because data on exclusive and partial breastfeeding is not consistently available by month of age, we use data on the prevalence of any breastfeeding. In some developing countries, and for some children, breastfeeding extends well past the second year of life; estimates in this study assume infants are breastfed up to two years of age only, and exclude milk intakes for children over 2 years.

Estimates of human milk production at 'biologically feasible potential output' ('BPFO') levels were also made. These estimates assume 95% prevalence of breastfeeding from 0-2 years; according to the World Health Organisation (WHO), around 95–98 percent of women are physiologically capable of breastfeeding (53). Human milk production at 'BPFO' levels would involve exclusive breastfeeding until 6 months of age, and then continued breastfeeding for up to two years of age or beyond.

Average daily production of human milk

Previous studies of human milk production have used varying assumptions about daily production levels. To facilitate comparisons, this study uses the conservative milk intakes assumptions that are used to compile official estimates of mothers milk production in Norway (46, p. 71).

Additional food costs of breastfeeding

Consistent with national accounting practice of measuring value added, estimates of human milk production need to adjust for input costs. The main input cost to human milk production is the additional food needed for the lactating mother.[8] Our earlier research has shown that these additional food intake costs are not substantial because lactation induces partly offsetting changes in metabolism and activity levels (47). Using an Australian survey of food costs (54), we estimated additional food intake costs for lactation at around A$101 for the first year and A$73 for the second year, making the input cost of breastmilk production in 1992 around A$15 million pa. Producing biologically feasible potential levels of human milk was estimated to cost A$45 million. For this study, it is assumed that additional food costs are of insignificant magnitude and this is not examined further.

Markets in milk and valuation of human milk production

National accounting principles suggest that production should be valued at market prices, as reflected in market transactions. An important methodological question is how breastmilk should be valued or priced. Most human milk production is not supplied to the market, and most human milk consumed is not acquired in the market. This is not a problem unique to valuing human milk production, as for example, most meals are supplied by households in the home, and not acquired in the market, even if meal inputs are purchased. However, it is possible to value meals at home using market values. Likewise there are growing markets in human blood, tissues and organs, which present some comparable issues of valuation for national accounting purposes.

According to national accounting practice, in the absence of market transactions, breastmilk can be valued by reference to market prices for similar goods or services, or if that is not feasible, according to the costs of its production. Where markets exist, reference to the market price is the preferred approach to valuing human milk.[9] Markets exist for human milk. Hospitals and milk banks exchange and sell donated breast milk in many countries throughout the world. Corporations now acquire and sell it to hospitals. Human milk is also

[8] The first studies of the economic value of breastfeeding during the 1970s used estimates of food intake based on excessive recommendations for additional food for lactating mothers of 500 - 1000kcal/day. More recent studies show a substantial contribution to the energy cost of lactation comes from reduced maternal activity, use of stored reserves, and increased metabolic efficiency during lactation. Based on this, our Australian estimates of the net value of breastmilk production assumed an additional energy intake of 300-400kcal/day (1260-1280 kJ/d), estimating the 1992 food cost of lactation for Australian women using data from the survey by Bundrock (2002).

[9] An alternative to examining market prices of human milk is to use survey data from 'willingness to pay' studies, which are routinely conducted for non marketed goods and services such as environmental values, and are also used in market research. However, no such study is currently available for human milk. Also, this is unlikely be practical for valuing human milk in various countries on an ongoing basis for national accounting purposes, and using this methodology to measure willingness to pay is inferior to using market prices which reflect revealed rather than stated preferences.

traded on the internet, and some women supply human milk through employment as wet nurses.[10]

In recent years these markets for human milk have been developing and expanding rapidly due to recent advances in human milk science and laboratory techniques (55) As former WHO advisor James Akre wrote recently, caregivers of infants may be seeking peer-to-peer donor milk in order to avoid the risks inherent to formula feeding. 'In many settings breast milk and breastfeeding have been undervalued, and the nutritional merits and safety of infant formula exaggerated ... The result: infant formula is considered the "obvious" alternative to a mother's own milk (56). However, international infant feeding recommendation for the past 25 years have described a nutritional hierarchy in which breast milk remains the food of choice for babies who are not fed at the breast (57). These guidelines rank bovine milk formula sixth as an alternative to breastfeeding, after various other sources of human milk. (See Figure 1).

In a growing number of countries, hospitals maintain human milk banks to provide mainly for premature babies or other newborns who cannot receive their own mothers' milk. Some facilities exchange and sell donated breast milk to other hospitals or milk banks. Milk banks operate in a number of countries in Latin America, Europe, and Asia as well as in the United States and Canada. A recent summary of milk banking in the United States is found in Carney (58)

In 2009, there were more than 300 milk banks throughout the world in about 38 countries. Many are located in European countries (France 19, United Kingdom 18, Switzerland 6), North and South America (Brazil has 187 banks, United States 11), Scandinavia (Sweden 27, Norway and Finland 15 each), but India has 7, South Africa 6, and Australia 2.(59)

The volume of milk shared or traded is significant and has been growing rapidly (55, 58, 60). For example, in 2011 the eleven North American milk banks distributed 2.2 million ounces (60 megalitres) of human milk, a tripling since 2004 (580,768 oz). Milk was supplied in 39 US states (and 264 cities) and 3 Canadian provinces (and 7 cities).

In many countries, such as France, Germany, and the Scandinavian countries, Canada and Great Britain, parents do not have to pay out of pocket to receive this service for their infants. Some argue that in the United States, the growth of donor milk banking has been hindered and the population underserved due to lack of federal public health policy supporting donor milk banking or regulation of its operations.(57)

North American milk banks charge a processing fee to hospitals or insurers to offset milk bank's overhead costs. This fee ranges from $3 to $5 per ounce, plus shipping costs. In value terms, this represents market turnover of US$11 million annually. Norway's 13 milk banks operating are all in hospitals (61) At the main Oslo hospital where 2000 of the country's 60,000 annual births occur, the milk bank collects around 1000-1100 litres of human milk p.a. There is a charge of $100 for milk provided to other hospitals (62). In 2007, there were 17 milk banks in the United Kingdom receiving about 5000 litres of milk from donors for

[10] This means an approximate market price per litre of human milk supplied can be derived using hourly wages and hours of work. For example, a wetnurse employed for 8 hours a day might be assumed to supply between around one third and all of daily milk output depending on the age of the infant. Younger exclusively breastfed infants need feeding round the clock, whereas the milk intake of older or partially breastfed infants might be met entirely by daytime feedings.

pasteurisation and use on neonatal units. (61) Donor milk suitable for a NICU was priced at £289.12 (US$502) pounds per litre in a 2009 United Kingdom economic evaluation (63).

Milk banks generally do not pay donors. Milk is donated by mothers. In Europe, hospitals or milk banks provide donors small gifts such as stationary as recompense for their effort. In some countries mothers receive some payment to cover their costs. For example, in Norway, donors supply for 6 months, and are given a free hospital grade breast pump, and US$20 per litre to cover electricity and travel expenses.(64)

Individuals have also responded to demand for breast milk by expanding and developing networks and systems for milk sharing and exchange, facilitated by the internet (60). Internet-based milk sharing has grown rapidly since 2010 and is now operating in nearly 50 countries (60). Websites such as 'Eats On Feet' and Human Milk 4 Human Babies help mothers to share their milk with other mothers. Recipients pay donors for shipping costs only.

On the other hand, websites such as Only The Breast operate systems for trading milk, its policy being mothers are compensated for costs including their time. Breast milk is bought and sold on this site for about US$2-3 an ounce, or US$131 a litre in North America. In the United Kingdom the price ranges from UK$2-$5 though usually is offered at around UK$5 (UK$7.83) per liter.

In the United States, human milk exchange is increasingly corporatized. Though historically conducted on a not for profit basis, recently, for-profit companies have entered the milk banking market. A private company sells standardised human milk for use in neonatal intensive care units at a price of around US$1183 (A$1429) a litre. The same company produces a human milk fortifier for use in NICUs which sells for over $6000 per litre. A not for profit organisation associated with the company was established in 2007 to provide human milk to needy infants in Africa, and had provided 267,682 ounces (7,362 litres) of breast milk by the end of 2010. Such charitable organisations shipped human milk as emergency relief to the Philippines in 2009. It can be estimated that via this route the company received inputs of around 1 million oz (28,000 liters) of human milk products in less than around five years.[11]

Shipments of milk to the South Africa, the Philippines, and Haiti by various charitable organizations during recent humanitarian crises also points to the potential for international trade in human milk.

If market prices are not suitable, then national accounting practice is to measure its value through the input costs of producing it. The amount of time it takes to express milk can be estimated and an appropriate wage rate applied to value the opportunity cost of time. How much time women are actually willing to 'pay' to supply breastmilk for their infant can also be inferred from time use studies, along with breastfeeding prevalence rates which indicate revealed preferences. Some data exists to do this (for example, in a recent Australian time use study) (65).

For this study, within the context of national accounting and GDP measurement, human milk production is valued by reference to the price charged for human milk sold by milk banks.

[11] The amount shipped to Philippines was reportedly 25% of the milk donated to the firm. See http://www.breastmilkproject.org and http://www.philstar.com/Article.aspx?articleId=809970.

There are several reasons for this approach. Currently, milk banks appear to represent the largest, most established and institutionally organized market in human milk. At the practical level, transactions and the price at which they occur are more likely to be documented (and reported publicly) by such organizations; this permits comparisons of prices over time for some countries, and reflect sale, not offer prices. The milk bank pricing method is also preferred conceptually because the value placed on donated human milk by medical facilities and health professionals may best reflect an informed consumer's 'willingness to pay' for human milk production, and incorporates an element of societal rather than market perspective of economic value. Milk supplied by milk banks also most closely approximates mothers own milk because there are controls on quality.

RESULTS

Household production of human milk; Estimates for 2006-2011

This section presents estimates of human milk production for selected countries. It also presents estimates of the economic value of production under a scenario in which all infants are breastfed, representing achievement of the 'biologically feasible potential output' (BFPO).

Births and breastfeeding rates

The number of infants born annually for each of the selected countries is set out in Table 2. Norway's population was around 60,000 in 2010, while China's was 16,486,000. Worldwide, UNICEF reports around 134,754,000 births annually. Globally, it is estimated that 37 per cent of infants are breastfed in the first 6 months of life, with around 74 per cent breastfed to 6 months, 55 per cent still breastfeeding at 12 months, and 28 per cent still breastfed at 2 years (Table 3). Milk intake assumptions are at Table 4a.

Estimates of milk production for each of the selected countries are summarized in Table 5 and detailed in the Appendix tables. It can be seen that production ranges from 11 million liters a year in Norway, a small industrialised country with relatively high breastfeeding prevalence, to China where households produced 3336 million litres annually. In the United States, production was around 525 million litres a year.

Market price of human milk

Oshaug and Botten's (42) study of the value of milk output in Norway used the local milk bank price of 344 kroner ($US50) to place an economic value on it. In recent years, milk banks have been selling human milk for around US$3 an ounce ($US85 per litre) in the United States. In Norway in 2009 it was being sold for €130 ($US100) per litre and mothers were paid US$20 a litre by some hospitals to cover 'expenses' (64). Some other countries also reimbursed donors similar amounts.

Human milk sold on internet milk trading sites such as Only the Breast also typically commands a price of US$3 per ounce for mothers with health certification, which is the upper end of the pricing range for milk on offer.

Table 6 summarises some easily accessible sources of information about market transactions in human milk. To value the production of human milk in economic terms in this study we used a market price of $US3 per ounce ($US85 per litre).

Actual and biologically feasible potential output ('BFPO') levels of human milk production, 2010

The estimated value of human milk production in 2010 ranged from just under $US1 billion in Norway to $US304 billion in China. Worldwide production totals 23,313 million liters, valued in 2010 prices at $US1,983 billion (Table 5).

Breastfeeding prevalence in most countries is well below its biologically feasible potential. As shown in a previous study, if breastfeeding had been at BFPO levels in Australia in 1992, the value of human milk production would have been A$3.4 billion higher, with a potential volume of production estimated of 84 million kg p.a. This was potentially worth around 1.3% of GDP, or 40% of public sector spending on health. Alternatively, it represented around 17% of private final consumption expenditure on food in Australia (47, 48).

Table 5 compares potential production in 2010 with actual production for the selected countries. This gives some indication of the scale of the gross economic loss from substituting commercial bovine or plant based infant formula for household supply of human milk for infants. Worldwide, production is just over half of the biological capacity, with losses of around $1,397 billion. The United Kingdom utilised only a fifth of its households' capacity to produce human milk, its poor breastfeeding practices resulting in that country foregoing 79 per cent of its potential output. The Philippines on the other hand utilized two thirds of its capacity due to high levels of continued breastfeeding, notwithstanding its relatively low exclusive breastfeeding rates.

DISCUSSION

It has been demonstrated previously (32, 66) that breastmilk should be measured in GDP under existing SNA guidelines. This finding was endorsed in 2009 by the Commission on the Measurement of Economic Performance and Social Progress ('S-S-F Commission'), who wrote;

> "There is a serious omission in the valuation of home-produced goods – the value of breast milk. This is clearly within the System of National Accounts production boundary, is quantitatively non-trivial and also has important implications for public policy and child and maternal health." (67)

Previous studies have also shown that in Australia the value of human milk is quantitatively important, and of a magnitude that is comparable with other production – like 'backyard production' of food, or on-farm consumption of farm product — for which values are already imputed in the Australian System of National Accounts.

This paper has extended previous research not only by showing how human milk production fits into a national accounting framework, but also by producing illustrative estimates of gross output for a representative selection of countries. Key findings include;

- The volume of human milk output can be measured through a simple methodology that is available for most countries

- A reasonably satisfactory basis for the valuation of human milk output is available from existing markets in human milk.

- Production of human milk is quantitatively important and of significant economic value, including in relation to total market production of commercial infant formula and foods. For example, alongside human milk production estimated here around $US45 billion in the United States, the commercial baby food/formula market in that country is reported to be $US1.5 billion a year. Likewise, in China the market for commercial baby milk/food is reportedly around $US3-6 billion p.a., versus a current production of human milk worth $US304 billion (see Table 7).

The above means breastmilk not only should, but can, be counted in GDP. The markets for human milk are expanding rapidly due to technological and demand factors. Exclusion of the value of transactions in human milk could result in distortions in economic statistics and the national accounts. The market for human milk includes corporate processing of substantial volumes of donor milk for sale to NICUs at very high prices. Under current national accounting practice, the contribution of free or low cost inputs to production by mothers is unmeasured and invisible, whereas corporations' value added is measured but exaggerated. International trade in human milk is potentially large, both to meet demand during humanitarian crises, and to arbitrate between the high demand, affluence and human milk scarcity in developed countries, and the significant potential milk supply and poor economic opportunities for women in developing countries.

The relative magnitude of human milk production in both developed and developing country economies is large, and emphasizes the extent of the production loss implicit in present practices of early weaning from exclusive breastfeeding. Human milk production in many countries is presently only around a fraction of its BFPO level.

Such calculations highlight the economic relevance of addressing cultural and institutional barriers to breastfeeding. Breastfeeding is not primarily an economic activity, and cultural and institutional factors exert powerful effects on breastfeeding prevalence. However, as we have argued previously (47, 68), breastfeeding decisions and behaviours are influenced by economic factors such as its time opportunity costs, and markets supplying low cost, bovine milk alternatives to human milk. Breastfeeding and human milk production 'competes' with women's other paid and unpaid work activities, and with commercially marketed baby food products for maternal time and money resources. That is, at the population level, the 'price' of breastfeeding is economically significant, in the sense that price affects how much breastmilk women will 'supply' and how much they are willing to pay for it with their time or purchase with their money.

The main determinant of the production volumes estimated above is the number of infants born each year who are (or could be) breastfed. The estimates of the volume of human milk production are conservative. Table 4b compares the assumed estimates of daily milk volume in Table 4a with the most recent estimates by WHO (69).[12] This illustrates that studies of

[12] The previous study for Australia used the same daily milk production levels as the 1994 Norwegian study by Oshaug and Botten; an average 650 g/day (670 ml/day) for the first year, and 300 ml/day for the second (Table 1). The implied milk production during the first 2 years of life is about 340 litres of milk per infant, compared to conventional assumptions that adequate intake is 375 litres (Berg 1973). Berg assumed production of 850 ml per day for the first 6 months of exclusive breastfeeding, 500 ml per day until 18 months, and 200 ml a day from 19-24 months. Greiner, Almroth et al. (1979) assumed daily milk production volume averaged 722 ml for the first 4 months of life, 600 ml for the 4-12 month age group, 400 ml for 12-24 months, and 300 ml for 24-36 months. Rohde's study of Indonesia assumed production during the second year of breastfeeding averaging 250 ml (ranging from 200-450 ml) per day. The 2002 study by Aguayo and Ross used the lower end of estimates of intake for each age group published by the World Health Organisation (WHO) in 1998; milk produced and

milk intake vary widely for developed and developing country settings and for exclusive compared to partial breastfeeding.[13]

In this study we used estimates of daily milk production that are at the lower end of estimates from the most recent research, and that are more applicable to developing country settings where studies suggest average milk production is somewhat lower. The estimates are based on averages for all breastfed babies including those only partially breastfed, and are likely to underestimate milk production in countries where exclusive breastfeeding is of long duration or highly prevalent, or mothers are well nourished and healthy. Ultrasound measurement has been used to show that actual milk production by well nourished Australian women is well below biological potential and well above the range of 0.7-0.9 kg/day that had been taken as the maximum for human lactation (70).

If we assume the upper end of the range of daily milk production of around 850 ml found for mothers exclusively breastfeeding during the first six months, the volume of biologically feasible potential milk production rises, for example, by 1.2 million litres or 9 per cent in Norway, and by 356 million litres (10 per cent) in China.

Conversely, new mothers in developing countries may be too poor to spare time for exclusive breastfeeding. If we assume daily milk intakes in the first six months are more in accord with the relatively low partial breastfeeding yields of around 600 ml found for poorer mothers in developing countries (Table 4b), estimated human milk production worldwide falls by 10 per cent, with a 15 per cent drop in the United Kingdom.

We also ignore production and consumption of human milk by children over 2 years of age, which is known to be substantial due to many young children worldwide breastfeeding beyond that age (37).

On the other hand, the estimates make no adjustment for infant mortality. This means that production is slightly overestimated for countries with relatively high infant death rates such as the Philippines (23 per 1000), compared to countries like Norway and Australia (3 to 4 per 1000) and the US (7) (50). The impact on output will nevertheless be small.

Complete measures of breastfeeding prevalence for the whole period from birth up to 2 years of age are not available for some countries, and are not usually available annually. Collection of breastfeeding prevalence data needs to be improved to better measure this economic resource. However, infant feeding practices do not change quickly, and follow predictable patterns across age groups. Hence, a country's human milk production is likely to be fairly stable from year to year, and varying mainly with medium to longer term changes in the birth rate and infant feeding practices.

The economic values of national milk productions estimated in the study are high, but the method of valuing human milk is in accord with well established national accounting guidelines and practices. As noted earlier, national accounting practice is that where no exchange values are available in the market, a good should be valued by reference to the market value of similar goods. This is the direct 'market alternative' approach. If a market price does not exist for a similar product, then it should be valued at the cost of producing,

consumed in the first 6 months was assumed to be between 617g for partially breasted and 714g for exclusively breastfed, from 7-12 months 616g, and from 12 months, 549g.

[13] Pooled standard deviations from the sample size weighted means were large, ranging from 42 to 249 for different settings, infant ages and degree of breastfeeding exclusivity.

that is, on an input basis. Two alternatives are available for input pricing; the 'replacement cost' or 'opportunity cost' approaches.

A strength of this study compared to other economic studies of breastfeeding and lactation is that viewing human milk as a good enables the use of actual market prices for human milk to value non traded production, as is preferred in a national accounting framework. This means that unlike most previous studies, it is not necessary or appropriate to use formula milk prices to value human milk output. Commercial infant formula, whilst used for a similar purpose, it is not a similar product. The expansion of human milk trading and exchange enables valuation of human milk with reference to the market values of human milk products. Table 8 summaries prices from various markets in human milk and using different valuation approaches and techniques.

We have argued previously that the price of human milk sold by milk banks — a 'market alternative' price — is the conceptually preferred measure of the value of human milk for the purpose of national accounting and economic analysis (47, 48). Such a market price is most consistent with national statistical procedures for valuing market production on an output basis. Net production values can be directly compared with national accounting aggregates such as Gross Domestic Product (ABS 1992). Using a milk bank price also helps ensure quality is comparable with the quality of mothers own milk, as such milk has been screened and tested and in some cases pasteurised to minimise risks of transmitting disease. This is a particular issue with the direct output measurement approach. While it has a number of advantages over input measurement methods, it assume that the quality of output of firms and households is the same. As Fitzgerald and Wicks point out,

> *A priori*, it is not obvious whether firms or households produce the higher quality output. Firms, by definition, hire "professionals" to do their work. On the other hand, households consume their own HP and thus have a direct incentive to maintain quality control'. (35, 132)

Hence, the question arises as to whether human milk supplied by other mothers including through markets is of a comparable quality to mothers' own milk delivered to infants in the household. Milk obtained from a third party is higher risk than mothers own milk because of the possibility of transmission of viruses or bacterial contamination during processing. However, milk obtained from a milk bank may be assured to be of a higher 'quality' from a consumer perspective because donors are screened and tested (and in the US and UK, the milk pasteurized to ensure low bacterial levels). Pasteurisation is known to prevent the transfer of HIV and related viruses. Some vitamins and immunological properties are lost through pasteurisation. Milk banks vary in their approach regarding the quality of donor milk including with regard to risk management, or suitability for premature, sick or vulnerable infants. Where there is a known donor and low risk of AIDS, the use of unpasteurised milk is considered acceptable. Norwegian milk banks screen donors, and test initial milk samples, using unpasteurised milk. Milk samples are also randomly tested. There have been no cases of disease transmission through donor milk in Norway (64).

Milk sold on the internet by mothers who offer certification appears to command a higher price than milk offered by mothers who do not. Mothers are invited to pay for a blood test via the online trading site. This suggests that prices are being differentiated for risk and elements of quality. Milk produced by mothers of newborn infants is also offered at higher prices than more mature milk, again suggesting price differentials related to 'quality' attributes.

A donor human milk based human milk fortifier made by concentrating large quantities of human milk to replicate the enriched qualities of early milk ("colostrum") has been found to be economical for use in the NICU because of its effectiveness in preventing necrotizing entercolitis (a very costly and often fatal condition of premature infants). The current price is around $6.25/mL ($6,250 per litre), plus the $3 per oz ($85 per litre) cost of donor human milk charged by non-profit human milk banks to use with the HMF (71).

Following from this, it can be argued that it is unlikely that the quality of human milk supplied in the market is of a higher quality than that produced by households for their own children's consumption, hence the market price is likely to be an underestimate rather than an overestimate of the true economic price to the extent there are differences in milk quality provided in the market versus in households.

From the above it is argued in this paper that human milk is a good, in scarce supply, and it is appropriately viewed in its own right from an market or economic pricing perspective, not as a form of commercial infant formula.

Another possible 'market alternative' price is given by current internet transactions in human milk. The price of human milk on the internet is very similar to the US milk bank price ($2-3 per litre plus shipping), for donors with health certification. This similarity gives force to the argument that $3 per oz is a valid reflection of the market value of human milk.

Using milk banking pricing for valuation facilitates comparisons over time with previous studies using the same pricing approach to value human milk output. Most importantly, it also has the advantage of using prices and 'willingness to pay' from a relatively well informed 'market', driven by demand from health practitioners and medical decision makers as well as derived from maternity care consumers. The economic theoretical `willingness to pay' concept raises a number of fundamental issues about `agency', and `externalities' in the infant feeding context, as well as about information and preference formulation problems. Willingness to pay for health benefits will also in reality reflect the current inadequate state of public knowledge about the health and development consequences of feeding bovine based milk to human infants and so may understate the true social value. Nevertheless, better educated mothers will be willing to pay more than less educated mothers, and poor mothers would be less willing to pay than wealthier mothers. It can be argued that the price which well educated Norwegian health providers and relatively affluent US women will pay for human milk obtained from milk banks is likely to reflect a relatively informed view of its health benefits.

While human milk is typically not viewed as an scarce resource subject to economic pricing, a recent article in *Pediatrics* observed that with a variety of entities now competing to obtain this resource,

> 'demand is rapidly surpassing the current supply. This relative scarcity poses ethical challenges for patients, health care providers, researchers, individual milk, banks, and organizational leaders in human milk-banking.'(55, 1187)

Criticisms of this approach may include that most human milk supplied to infants is not supplied through milk banks, but by infants' own mothers. Economic analysis of markets in human milk is also complicated by a significant 'donated' component of transactions even where there are commercial or not for profit human milk markets or online milk trading.

A similar situation arises from applying market prices for other household goods, such as meals, or even human tissue, blood or organ donation, where most of production is unmarketed, and market value is set by a small number of perhaps unrepresentative market transactions. However, turnover in these markets is not insignificant; the number and diversity of buyers and sellers is expanding rapidly.

The milk bank price may be criticized for reflecting the costs of supply and the particular economic and institutional characteristics of a specific, small, and restricted market. The stage of development and depth of the market in mothers' milk can be questioned; some countries may not yet have significant trading in human milk or employment for wet-nurses. The market price for donor milk may also be set in an imperfect market and relatively insensitive to short term supply and demand factors, because of the not for profit status of milk banks and institutional or other non market constraints on payments to donors. Pricing mechanisms may be relatively undeveloped and little used in the allocation of product in this market.

It might also be argued that internet trading of human milk better reflects economic pricing than milk banks. However, the online market is at present in its early stages of development, and active trading is mainly in North America. Also, mothers can contribute milk to either or both of these markets, and mothers can in principle obtain milk either from a milk bank[14] or privately. Hence, prices in the internet market are likely to influence to at least some extent the supply of donor milk to milk banks and vice versa. Akre and Gribble argue that these exchange mechanisms are complementary rather than competing, because exclusion criteria used by milk banks prevent willing donors, and because milk banks almost exclusively provide supplies to the sick and the hospitalized while online trading caters to a wider market. Milk banks and internet milk exchange and sharing is connected but not by competition;

> … the expanding network of mother-to-mother milk sharing might well spur human-milk banking by increasing awareness of the significance and availability of breast milk, persuading more qualifying mothers to donate, and thereby increasing both the number of banks and the available milk volume. (60, p. 2)

To test the validity of milk bank prices as a value for human milk output, we consider the prices resulting from other valuation methods. A conventional economic technique for valuing unmarketed products in national accounts is the 'replacement cost' method (Australian Bureau of Statistics 1990). This approach, for example, would value the milk producing functions of the mother by estimating the cost of employing a wet nurse, which is a form of professionalized employment at breastfeeding that has long been a commercial activity ((72, 73) It is possible to derive the cost of obtaining human milk supplies from the cost of employing a wet-nurse. If for example, a professional wet-nurse could provide around 800 ml a day during an 8 hour shift, its current market value would be around US$62.50 per litre based on reported daily wages for a wet-nurse (Table 8). In the United States, wet nurses offer their milk at around US$50 per day (ranging up to US$150-200 per day where childcare or housework services are also offered).

The opportunity cost method is the most contentious and least preferable approach to input pricing of unmarketed goods. This input cost approach can value 'difficult to price' products such as human blood or sperm at the time cost people pay to obtain it. Blood and sperm products are a good parallel because like breastmilk only a small amount is actually traded,

[14] Purchase of donor milk through milk banks is mainly by hospitals or health insurance funds, so uninsured mothers or in hospitals that do not purchase donor milk may not in practice be able to access this market.

although total population `supply' and `demand' is very large. One difficulty is in determining whether a general wage or a specific wage is most appropriate for valuing the time of mothers, who may not be employed. An estimate of the time cost of expressed breastmilk can be derived by estimating the time it takes to express breastmilk, including transportation or traveling costs. An estimate of the time cost of expressed breastmilk can be derived, for example, by assuming that on average, expressing 150 ml (5.3 oz) of breastmilk would take approximately 1 hour including transportation or travelling costs.[15] Because of potential selection bias, identifying an appropriate wage is difficult. However, using the wage rate of $11.16 per hour used by the ABS (74, p. 23) for valuing `other housework', to approximate the value of nursing mothers' time, we estimated the shadow price for donated human milk in Australia in 1992 using an opportunity cost approach to be around A$75 per litre. This was about 12 per cent more than the value based on the A$67 (US$50) price charged by milk banks at that time (47).

Using these alternative valuation methodologies (market price of expressed milk versus replacement wage cost or time opportunity cost) did not alter the order of magnitude of the value of human milk production for Australia in 1992 (48).[16] Even using the very low, US$1 per litre flagged by Hatloy and Oshaug for valuing global output of human milk in 1997, the economic value of milk produced by households remains very large; $525 million in the United States, over $3 billion in China and $23 billion worldwide.

Some studies have used the price of formula to value human milk, and it may be suggested that the market price of human milk should be adjusted downward to move it toward the much lower market price of formula.[17] For reasons noted above, this study argues that the market price of artificial formula is not a valid indicator ("shadow price") of human milk value, and its price has only limited relationship to the value of human milk. Artificial formula milk is not an equivalent product to human milk. It is less similar to breastmilk or breastfeeding than human milk which is sold or donated in various markets. That expressed breastmilk or other mothers' milk, not artificial formula, are the first recommended alternatives where a mother cannot breastfeed (75, 76), emphasises that the latter is not the closest substitute for human milk.

Various market failures suggest the market price of breastmilk substitutes will underestimate the true value of human milk and breastfeeding. Because infants who are weaned prematurely from exclusive breastfeeding have higher incidence of various acute and chronic morbidities

[15] Time taken to express human milk can vary considerably. The mother of a premature baby might travel three or four times a day to a regional hospital to deliver supplies of her expressed milk for her baby for several weeks until the infant is discharged into home care. It may take this mother an hour or more to express small amounts of around 50 ml, and the time cost of supplying this milk is very high. At the other extreme would be a mother with a well established milk supply who expresses 100-150 ml in around 15-45 minutes, then stores the milk for once or twice daily transportation to a milk bank, for use by her childcare service provider, or take to her sick baby in hospital.

[16] Using the replacement cost (A$55 per litre), rather than `market alternative' price approach, human milk production in Australia in 1992 was worth A$1.8 billion. Using the opportunity cost approach, with a price of $77 per litre, human milk production in 1992 was A$2.5 billion.

[17] To estimate the cost of replacing human milk from recent declines in breastfeeding in Chile, Kenya, Singapore, and the Philippines, Alan Berg (1973) used a price of US$240 per ton of formula. The study by Ted Greiner, Stina Almroth, and Michael C. Latham (1979) for Ghana and the Ivory Coast estimated the value of national human milk production by calculating the local cost of the formula and bovine milk that would be necessary to provide the equivalent caloric value if breastfeeding mothers switched to artificial feeding. Likewise, Jon Eliot Rohde (1974) used the avoided cost of purchasing cow's milk for Indonesia's 1 and 2-year-olds to calculate that the value of extended breastfeeding equaled 80 percent of the country's health budget.

('health externalities'), the market price of artificial formula milk will be an underestimate of its true price unless;

a) consumers possess perfect knowledge about the nutritional and health impacts of not breastfeeding and make informed choices;

b) the infants' feeding "preferences" are meaningful, forward looking, and faithfully reflected in decisions taken by their caregivers; and,

c) there are no societal "externalities" in the production or consumption of breastmilk.

However, many health risks of not breastfeeding are borne by the community (and the infant), not the parent. Gaps or time lags in accumulation of knowledge about the adverse health and development consequences of formula feeding mean that the market price is most likely to understate the true economic value. The mother or caregiver, as "agent" for the baby, may also not properly reflect the infant's preferences or "willingness to pay" in her purchasing decisions. The market price does not account for the additional health costs associated with this feeding product, so it understates the true market cost of infants consuming breastmilk substitutes and therefore does not represent the full economic value of breastmilk. The health costs of formula are sometimes borne by government (rather than the family), or the child (for example lesser future earning power due to poorer health or cognitive skills and productivity.

The negative externalities or health costs of inappropriate infant feeding are especially high in developing countries, but as noted earlier, even in developed countries, the public and private health costs of premature weaning from breastmilk are substantial. This is because infants who are weaned prematurely have 2-5 times higher incidence of acute infectious illness and hospitalization (77), and a 30 per cent or more increase in risk of later life chronic disease (21).[18].

These economic studies did not examine effects on maternal health. As noted earlier, mothers health is also adversely affected by not breastfeeding or weaning prematurely.

The economic value of avoiding all known and presently unknown costs must be accounted for in a valid 'shadow price' of human milk. The true economic value ('shadow price') of human milk is higher than the market price of formula, to reflect these positive social externalities of avoided health costs (47, 78).

Accounting for human milk: Implications of current practice

Despite its significant magnitude compared to production of food for infants by firms, in practice the national accounts of virtually all countries ignore all human milk produced by households (mothers). This means that production of mothers' milk is rendered invisible to those who use economic statistics and GDP estimates to determine public policy priorities.

The ability of women to breastfeed represents a significant economic productive capacity, yet the production flow from this human capital asset is not recorded as contributing to GDP or

[18] For example, McNeil and colleagues found that any formula use in the first 6 months is significantly associated with increased incidence of otitis media (OR: 1.78, 95% CI: 1.19, 2.70 and OR: 4.55, 95% CI: 1.64, 12.50 in the available studies; pooled OR for any formula in the first 3 mo was 2.00 (95% CI: 1.40, 2.78).

economic well-being, or even acknowledged as a service in the satellite accounts recommended by SNA93.

Ignored as well are the health and cognitive benefits from breastfeeding, which affect the quality of the human capital stock and the productivity of the future labor force. This is because improved cognitive achievement and better long term health affects higher later life earnings and productivity. For example the effects of iron insufficiency among children aged 0-14 which affects cognitive development by 8 percentage points or half a standard deviation was estimated to cost China 3 per cent of GNP annually in lost labour productivity (79). While there are ethical and methodological barriers to high quality research in this field, well conducted cohort and experimental studies contribute strong evidence that those deprived of human milk or breastfeeding in infancy have poorer cognitive and academic achievement and mental health in later life (7, 22, 24, 80, 81). A major cluster randomized trial sponsored by the WHO involving more than 17,000 children found that weaning from exclusive breastfeeding before 4 months was associated with an average IQ disadvantage of around 3–7 percent at age 6 (7) The contribution of breastfeeding to the quality of human capital therefore has potentially important long term economic consequences. This is an important area for future economic research.

By excluding human milk contrary to SNA93, national accounts already provide a misleading picture of national food production and consumption activities. Because expenditures on breastmilk substitutes such as artificial formula milk and commercial baby food are included in the core accounts, GDP is apparently raised by fewer mothers breastfeeding. This means GDP drastically overstates the gain in economic production from increased production and sale of commercial breastmilk substitutes. The increase in GDP from including sales of formula also overstates the gain in economic welfare because GDP incorporates as an economic gain the value of additional expenditures on health services needed to treat illnesses attributable to formula feeding. Present national accounting practice also wrongly implies that the dramatic drop in breastfeeding rates during the 1960s and 1970s improved national food output and economic growth and employment by raising commercial baby food sales and health spending, while increases in breastfeeding during the 1980s reduced economic output.

So why is human milk not included in core accounts? It meets the SNA criteria for a ‘good’, is quantitatively significant, and its exclusion distorts economic statistics and accounts, policy formulation and decision-making.

Objections might include a) that its production is not related to market activity or economic pricing, and b) that its inclusion would disrupt conventional measures of output, as the large size of household production swamps the value of market production in the total economy. Including household services in GDP may be said to detract from its usefulness to policymakers (82, 95). Accounting for household services through ‘satellite accounts’ allows analysis to be expanded without ‘overburdening or disrupting the central system’ (83, para. 21.4).

For example, when considering in 1990 whether unpaid work should be included in the SNA, the Australian Government was told unpaid work of households was not capable of being marketed and was not related to market forces as directly as goods. Although it was acknowledged that institutional and labour market changes could result in activities shifting into and out of the market sector over time, creating artificial changes in measured GDP, the Government was advised that unpaid work should be measured instead in separate but

consistent accounts because the market sector was the primary concern for macroeconomic policy considerations (84, 6-7).

In the case of lactation and human milk output, these arguments do not apply. Human milk produced by households is capable of being marketed, its sale and purchase is related to market forces including the low purchase price of alternatives and the time/opportunity costs of breastfeeding. Also, its production, delivery and exchange for money or as a gift should be of considerable concern to health economic policymakers and regulators despite not being in the market sector. Human milk production competes with the market sector, both in terms of commercial infant feeding productions and in female labour markets (68).

Exclusion of the economic value of human milk production from GDP measures means in Australia for example, that concerns at the viability of commercial firms producing less than $200 mill of market output per year dominate policy at the expense of the unpaid producers of $2 billion or more of household production. In the United States, public funds underpin the profitability of distributing free or low cost formula to around many households with children. WIC has recently provided between 57% and 68% of all infant formula sold in the United States (85), a market estimated to be around $US1.5 billion a year (Table 7). This raises questions about the economic efficiency and productivity cost of allowing sales of commercial infant formula to undermine breastfeeding and production of human milk that is potentially worth US$108 billion annually.

It is difficult to see why 'disrupting' the system by comparing these values is undesirable, or why overburdening policy analysis with data showing the magnitude of the related non market production is so disturbing to policy perspectives. Likewise, including breastfeeding in GDP would surely enhance monitoring and analysis of long term productivity trends and patterns in the food, nutrition and health sectors because of the long term consequences for maternal health and well being, as well as longer term human capital quality including cognitive performance, and chronic disease risk.

CONCLUSIONS AND IMPLICATIONS

Human milk is a tradable, storable and exchangeable good that is produced by households (specifically, by women), usually for (households) own consumption but increasingly bought and sold through markets as well as donated to market enterprises.

This paper has demonstrated the magnitude of actual and potential human milk production for a range of countries using standard national accounting concepts and guidelines. The economic value of production of human milk is quantitatively important relative to the supply of commercially marketed alternatives and by comparison with other goods which for which values are imputed in GDP. While the data presented on the value of human milk has some uncertainties, national accounts and GDP estimates already incorporate a range of economic statistics with varying reliability but still prove useful.

Under SNA93 and subsequent revisions, GDP should incorporate this substantial production of human milk by households for their own and for others consumption. It is practical to do so using the preferred output measurement method. The volume of human milk production can readily be estimated from regular collections of reliable national survey data on breastfeeding in many countries. Markets in human milk exist and are expanding rapidly with

changes in technology and market demand; these provide a basis for valuation of household production of human milk for the core national accounts.

Economic output as currently measured in GDP is incomplete and biased estimated of food production and national economic output. Not to include human milk in GDP/GNP is not only inconsistent with SNA guidelines, it also seriously distorts measurement of national food production. The non measurement of human milk production also devalues and makes invisible the quantitatively significant 'own account' contribution by women and households to the supply of an economically and socially valuable commodity.

The invisibility of this household food production seriously distorts public policy priorities. This works to the disadvantage of women and children because it means fewer economic and financial resources are allocated to important economic outcomes such as protecting and supporting breastfeeding, through for example, financing adequate quality maternity care services and mother and child health programs, and to regulating and funding labour market measures such as unpaid and paid maternity leave and breastfeeding accommodations in the workplaces.

It also means that public funds continue to underpin the profitability of the commercial baby food industry through programs distributing free formula, despite this displacing women's economically valuable production of human milk through breastfeeding which is worth much more to the economy.

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FIGURES

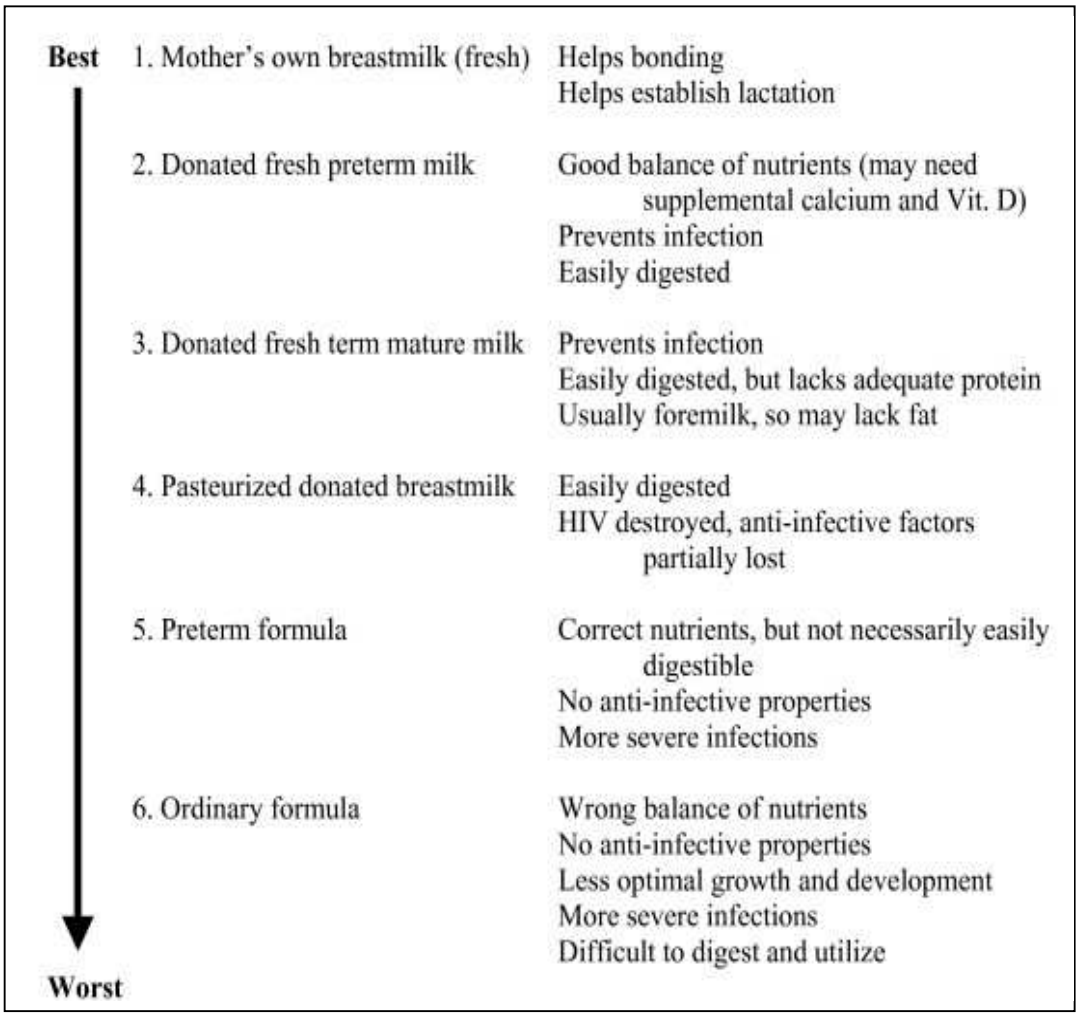

Figure 1: Milk for Low Birth Weight Babies: WHO Hierarchy of Feeding Choices from Arnold (57)

TABLES

Table 1 Human milk production in Australia, 1992

Age in months	Percent of infants breastfeeding	Average no. of infants living	No. of infants breastfed each month	Kg of breastmilk per infant per day	Estimated kg per month per infant	Production of breastmilk, million kg
0-1	76	264151	200755	0.60	18	3.67
1-2	70	264151	184906	0.60	18	3.38
2-3	64	264151	169057	0.70	21	3.60
3-4	58	264151	152415	0.80	24	3.71
4-5	53	264151	140000	0.80	24	3.41
5-6	48	264151	126792	0.70	21	2.70
6-7	43	264151	114906	0.70	21	2.45
7-8	39	264151	103019	0.70	21	2.19
8-9	35	264151	92453	0.60	18	1.69
9-10	33	264151	87170	0.60	18	1.59
10-11	27	264151	71321	0.50	15	1.09
11-12	24	264151	63396	0.50	15	0.96
12-13	20	257247	51449	0.40	12	0.63
13-14	18	257247	46304	0.30	9	0.42
14-15	15	257247	38587	0.30	9	0.35
15-16	12	257247	30870	0.30	9	0.28
16-17	9	257247	23152	0.30	9	0.21
17-18	8	257247	20580	0.30	9	0.19
18-19	6	257247	15435	0.30	9	0.14
19-20	6	257247	15435	0.30	9	0.14
20-21	5	257247	12862	0.30	9	0.12
21-22	5	257247	12862	0.30	9	0.12
22-23	4	257247	10290	0.30	9	0.09
23-24	4	257247	10290	0.30	9	0.09
					Total, million kg	33.23

Source: (48)

Table 2 Infant population- selected countries, 2010

Number of children aged 0-1 years	
Norway	60,000
Australia	303,000
United Kingdom	757,000
Philippines	2,344,000
United States	4,301,000
China	16,486,000
Industrialised countries	11,425,000
The World	134,754,000

Source: (50)

Table 3 Breastfeeding prevalence, selected countries

AGE (*months)*	Norway	Australia	UK	Philippines	United States	China	Global
Initiating	98		76	-	77	95	-
1	95	75	67	92	73	95	74
2	91	73	59	85	68	95	74
3	88	70	50	85	64	91	74
4	85	69	34	74	60	88	74
5	82	63	33	74	55	85	74
6	80	60	18	63	51	81	74
7	75	42	17	63	47	78	55
8	69	42	8	63	42	74	55
9	63	42	0	64	38	71	55
10	56	42	0	64	34	67	55
11	48	42	0	64	29	64	55
12	46	42	0	54	25	60	55
13	25	42	0	54	21	57	28
14	19	18	0	54	16	53	28
15	15	18	0	54	12	50	28
16	13	18	0	54	8	46	28
17	11	18	0	54	3	43	28
18	8	18	0	39	0	39	28
19	7	18	0	39	0	36	28
20	6	7	0	39	0	32	28
21	5	7	0	39	0	29	28
22	5	7	0	39	0	25	28
23	4	7	0	39	0	22	28
24	4	7	0	39	0	18	28

Sources: see text

Table 4a. Daily milk intake of breastfed infants – Norwegian estimates

Age (months)	Average milk intake per infant per day (ml)	
	Oshaug & Botten 1992	*Norwegian Health Directorate 2011*
1	600	700
2	700	700
3	800	800
4	800	700
5	700	700
6	700	700
7	700	600
8	600	600
9	600	600
10	500	500
11	500	500
12	400	400
13	300	300
14	300	300
15	300	300
16	300	200
17	300	200
18	300	200
19	300	200
20	300	200
21	300	200
22	300	200
23	300	200
24	300	200

Source: (42), (46)
NOTE: 1 ounce = 28.35 grams

Table 4b. WHO (2002) Estimates of Milk Yields a)

Age (months)	Average per infant per day (g)			
	Developed countries		*Developing countries*	
	Exclusively breastfed	***Partially breastfed***	***Exclusively breastfed***	***Partially breastfed***
1	699	611	562	568
2	731	697	634	636
3	751	730	582	574
4	780	704	768	634
5	796	710	778	714
6	854	612	804	611
7	867	569	740	688
8	815	417	691	635
9	890	497	n.a.	516
10	n.a.	691	n.a.	n.a.
11	910	516	n.a.	565
12	n.a.	497	n.a.	511

Source: (69)
NOTE: estimates from meta-analysis, mean values, weighted for sample size

Table 5 Production of human milk – selected countries and aggregates, 2006-2010

Country	Actual human milk production volume (million liters)	Biologically feasible potential volume of production (million liters)	Actual value of milk production, US$ million	Biologically feasible potential value of production, US$ million	Lost production value US$ million	Lost production value % of potential
Norway	11	18	907	1,505	598	40
Australia	41	89	3,466	7,601	4,134	54
United Kingdom	47	223	3,980	18,989	15,009	79
Philippines	467	691	39,701	58,797	19,096	32
United States	525	1,269	44,649	107,887	63,238	59
China 2010	3,574	4,862	303,961	413,538	109,577	26
The World 2010	**23,315**	**39,744**	**1,982,942**	**3,380,192**	**1,397,251**	**41**
US price per oz		$3				
US price per liter		$85.05				

Table 6: Markets for human milk

Market	Price ($US per oz)	Location	Comment/source
Human milk banks			
HMBANA	$3-$5	USA	Currently there are 12 HMBANA member milk banks providing donor human milk in the US and Canada. HMBANA milk banks charge no fee for the actual milk, but charge a processing fee to offset the milk bank's overhead costs. This fee ranges from $3 to $5 per ounce, plus shipping costs. Each milk bank has the authority to determine the processing fee for its facility, which is the reason for the wide variation in price. https://www.hmbana.org/general-information
Norwegian milk banks	$3.42 (US$100 per litre)	Norway	13 milk banks were operating in Norway in 2009, all located in hospitals with level 111 NICUs. All preterm infants are offered donor milk if mothers mik is unavailable or insufficient, and all infants who need milk from the milk bank are offered it. Donors are given a free hospital grade breast pump, and US $20 per litre to cover electricity and travel expenses, and donate for 6 months. At the main Oslo hospital where 2000 of the country's 60,000 annual births occur, the milk bank collects around 1000-1100 litres of human milk p.a. There is a charge of $100 for milk transferred to other hospitals. (62)
PREM	n.a.	Aus	Perron Rotary Express Milkbank – King Edward Memorial Hospital, Perth WA. The newly established PREM milk bank in Western Australia dispensed 23,602 oz (650 litres) in 2009, and 31,481 oz (866 litres) in 2011 (http://issuu.com/tschaerli/docs/dr_ben_hartmann_final, 15th May 2012)
Standardised human milk formulations	US$35 (US$1183 per litre)		Prolacta products are for in hospital use only and the company does not supply or charge directly to parents for Prolacta products. The cost is absorbed by the hospital or covered by medical insurance, where the infant is prescribed human milk products. The company's website explains its 'co-promotion' arrangement with a major formula manufacturer, Abbott Ross, which is involved in promoting and distributing these human milk products to hospitals. http://www.prolacta.com/faq.php
Human milk fortifier	US$6.25/mL ($US6250 per litre) (71)	USA	http://www.prolacta.com/faq.php

Internet milk exchange			
Eats on Feets	n.a.	Milk share online	Available in 28 countries including USA, NZ, Aus. Costs are to cover postage and supplies (storage bags, packing in dry ice etc) only. Prices will vary depending on how many ounces, how packaged and distance between home and destination. http://www.eatsonfeets.org/
Milk Share	n.a	Milk share online	An educational resource and connection point designed to give mothers tools to explore private milk donation. MilkShare does no support the selling of breastmilk. Only in the USA. Costs as above for Eats on Feets. http://milkshare.birthingforlife.com/
Human milk 4 Human babies	n.a.	Milk share online	http://www.hm4hb.net/about.html
Only the Breast	US$1-$3	Online	Milk can be bought and sold, as well as shared (donated). Exchange is organised into various categories, including by age of the infant, fresh (rather than shipped frozen), milk bank certified mother, milk bank screened mother, bulk sales, local sales, fat babies, special diet (vegan etc). Site offers donor blood testing at $219.45.
	UK$2-8		Also has trading from Canada, United Kingdom and elsewhere http://www.onlythebreast.com/
Wet-nurse employment			
Wet-nursing	Daily rate between $50 and $200 (2012 prices). $1,000/week (2007 prices)	USA	Offered at between $50 and $200 per day. Also has trading from Canada, United Kingdom and elsewhere. http://www.onlythebreast.com/
Wet-nursing	$2585 (US)/month	China	http://www.time.com/time/magazine/article/0,9171,1612710,00.html (2007 article) Chinese wet nurses earned up to 18,000 Yuan/month in 2008. Exchange to USD is based on 2008 exchange rates. http://online.wsj.com/article/SB122220872407868805.html

Table 7: Infant formula and baby food market — estimated size

Country	Formula (baby food) market, $US
Norway	n.a
Australia	132 million (formula only) in 1992 (47)
United Kingdom	n.a.
Philippines	260 million (formula only) in 2003 (86) 420 million in 2006 ((87)
United States	1.5 billion (formula only) in 2010 (88)
China	3.3 in 2007 (89) 6 billion 2012 (90)
The World	9 billion in 2009 (91) (formula only) 31 billion in 2010 (92)

Table 8: Comparison of alternative prices for valuing human milk

Pricing Approach	Price (US$ per L)	Comment
Market alternative		
Human milk bank: Norway (1992)	50	Price cited in (42)
Human milk bank: Norway	100	Price cited in (64)
Human milk bank: USA	85	Price cited in (55)
Internet trading	28-87	
Wet nurse	63	See Table 6 above and text
Opportunity cost (1992)	75	

Appendix Tables

Appendix Table 1

	PRODUCTION OF HUMAN MILK NORWAY						
	Year: 2006	*Year: 2010*					
Age months	*Percent of infants breastfed*	*Average no. of infants living*	*No. of infants breastfed each month*	*Liters of breastmilk pr. infant pr. day*	*Estimated liters pr. month pr. infant*	*Annual production of breastmilk, million liters*	*Biologically feasible potential production of breastmilk, million liters*
Initiating	98	60394	-	-	-	-	-
1	95	58545	55618	0.7	21	1.2	1.2
2	91	58545	53276	0.7	21	1.1	1.2
3	88	58545	51520	0.8	24	1.3	1.4
4	85	58545	49763	0.7	21	1.1	1.2
5	82	58545	48007	0.7	21	1.0	1.2
6	80	58545	46836	0.7	21	1.0	1.2
7	75	58545	43909	0.6	18	0.8	1.0
8	69	58545	40396	0.6	18	0.7	1.0
9	63	58545	36884	0.6	18	0.7	1.0
10	56	58545	32785	0.5	15	0.5	0.9
11	48	58545	28102	0.5	15	0.4	0.9
12	46	58545	26931	0.4	12	0.3	0.7
13	25	58545	14636	0.3	9	0.1	0.5
14	19	58545	11124	0.3	9	0.1	0.5
15	15	58545	8782	0.3	9	0.1	0.5
16	13	58545	7611	0.2	6	0.0	0.3
17	11	58545	6440	0.2	6	0.0	0.3

18	8	58545	4684	0.2	6	0.0	0.3
19	7	58545	4098	0.2	6	0.0	0.3
20	6	58545	3513	0.2	6	0.0	0.3
21	5	58545	2927	0.2	6	0.0	0.3
22	5	58545	2927	0.2	6	0.0	0.3
23	4	58545	2342	0.2	6	0.0	0.3
24	4	58545	2342	0.2	6	0.0	0.3
					Total litres	**10.7**	**17.7**
					For 0-1 yo	10.1	13.0
					For 1-2 yo	0.5	4.7

Appendix Table 2

	PRODUCTION OF HUMAN MILK AUSTRALIA						
	Year: 2010	*Year: 2010*					
Age months	*Percent of infants breastfed*	*Average no. of infants living*	*No. of infants breastfed each month*	*Liters of breastmilk pr. infant pr. day*	*Estimated liters pr. month pr. infant*	*Annual production of breastmilk, million liters*	*Biologically feasible potential production of breastmilk, million liters*
Initiating	-	303000	-	-	-	-	-
1	73	303000	220281	0.7	21	4.7	6.1
2	70	303000	213009	0.7	21	4.5	6.1
3	69	303000	208161	0.8	24	5.1	7.0
4	63	303000	190587	0.7	21	4.1	6.1
5	60	303000	182103	0.7	21	3.9	6.1
6	42	303000	127866	0.7	21	2.7	6.1
7	42	303000	127866	0.6	18	2.3	5.3
8	42	303000	127866	0.6	18	2.3	5.3
9	42	303000	127866	0.6	18	2.3	5.3
10	42	303000	127866	0.5	15	1.9	4.4
11	42	303000	127866	0.5	15	1.9	4.4
12	42	303000	127866	0.4	12	1.6	3.5
13	18	303000	55146	0.3	9	0.5	2.6
14	18	303000	55146	0.3	9	0.5	2.6
15	18	303000	55146	0.3	9	0.5	2.6
16	18	303000	55146	0.2	6	0.3	1.8
17	18	303000	55146	0.2	6	0.3	1.8

18	18	303000	55146	0.2	6	0.3	1.8
19	7	303000	22422	0.2	6	0.1	1.8
20	7	303000	22422	0.2	6	0.1	1.8
21	7	303000	22422	0.2	6	0.1	1.8
22	7	303000	22422	0.2	6	0.1	1.8
23	7	303000	22422	0.2	6	0.1	1.8
24	7	303000	22422	0.2	6	0.1	1.8
					Total	**40.8**	**89.4**
					For 0-1 yo	37.4	65.7
					For 1-2 yo	3.3	23.7

Appendix Table 3

	PRODUCTION OF HUMAN MILK UNITED KINGDOM						
Age (months)	***Year: 2005 Percent of infants breastfed***	***Year: 2010 Average number of infants living***	***No. of infants breastfed each month***	***Liters of breastmilk per infant per day***	***Estimated liters per infant per month***	***Annual production of breastmilk, million liters***	***Biologically feasible potential production of breastmilk, million liters***
Initiating	76	757000	-	-	-	-	-
1	67	757000	508768	0.7	21	10.8	15.3
2	59	757000	444880	0.7	21	9.5	15.3
3	50	757000	380992	0.8	24	9.3	17.5
4	34	757000	257380	0.7	21	5.5	15.3
5	33	757000	253217	0.7	21	5.4	15.3
6	18	757000	136260	0.7	21	2.9	15.3
7	17	757000	125441	0.6	18	2.3	13.1
8	8	757000	61553	0.6	18	1.1	13.1
9	0	757000	0	0.6	18	0.0	13.1
10	0	757000	0	0.5	15	0.0	10.9
11	0	757000	0	0.5	15	0.0	10.9
12	0	757000	0	0.4	12	0.0	8.8
13	0	757000	0	0.3	9	0.0	6.6
14	0	757000	0	0.3	9	0.0	6.6
15	0	757000	0	0.3	9	0.0	6.6
16	0	757000	0	0.2	6	0.0	4.4
17	0	757000	0	0.2	6	0.0	4.4
18	0	757000	0	0.2	6	0.0	4.4
19	0	757000	0	0.2	6	0.0	4.4

20	0	757000	0	0.2	6	0.0	4.4
21	0	757000	0	0.2	6	0.0	4.4
22	0	757000	0	0.2	6	0.0	4.4
23	0	757000	0	0.2	6	0.0	4.4
24	0	757000	0	0.2	6	0.0	4.4
					Total	**46.8**	**223.3**
					For 0-1 yo	46.8	164.2
					For 1-2 yo	0.0	59.1

Appendix Table 4

	PRODUCTION OF HUMAN MILK PHILIPPINES						
Age (months)	*Year: 2008 Percent of infants breastfed*	*Year: 2010 Average number of infants living*	*No. of infants breastfed each month*	*Liters of breastmilk per infant per day*	*Estimated liters per infant per month*	*Annual produciton of breastmilk, million liters*	*Biologically feasible potential production of breastmilk, million liters*
Initiating		2344000	-	-	-	-	-
1	92	2344000	2147104	0.7	21	45.7	47.4
2	85	2344000	1992400	0.7	21	42.5	47.4
3	85	2344000	1992400	0.8	24	48.5	54.2
4	74	2344000	1739248	0.7	21	37.1	47.4
5	74	2344000	1739248	0.7	21	37.1	47.4
6	63	2344000	1467344	0.7	21	31.3	47.4
7	63	2344000	1467344	0.6	18	26.8	40.7
8	63	2344000	1467344	0.6	18	26.8	40.7
9	64	2344000	1493128	0.6	18	27.3	40.7
10	64	2344000	1493128	0.5	15	22.7	33.9
11	64	2344000	1493128	0.5	15	22.7	33.9
12	54	2344000	1263416	0.4	12	15.4	27.1
13	54	2344000	1263416	0.3	9	11.5	20.3
14	54	2344000	1263416	0.3	9	11.5	20.3
15	54	2344000	1263416	0.3	9	11.5	20.3
16	54	2344000	1263416	0.2	6	7.7	13.6
17	54	2344000	1263416	0.2	6	7.7	13.6

18	39	2344000	914160	0.2	6	5.6	13.6
19	39	2344000	902440	0.2	6	5.5	13.6
20	39	2344000	902440	0.2	6	5.5	13.6
21	39	2344000	902440	0.2	6	5.5	13.6
22	39	2344000	902440	0.2	6	5.5	13.6
23	39	2344000	902440	0.2	6	5.5	13.6
24	39	2344000	0	0.2	6	0.0	13.6
					Total (million liters)	**466.8**	**691.3**
					For 0-1 yo	383.8	508.3
					For 1-2 yo	83.0	183.0

Appendix Table 5

	PRODUCTION OF HUMAN MILK UNITED STATES						
Age (months)	***Year: 2008 Percent of infants breastfed***	***Year: 2010 Average number of infants living***	***No. of infants breastfed each month***	***Liters of breastmilk per infant per day***	***Estimated liters per infant per month***	***Annual production of breastmilk, million liters***	***Biologically feasible potential production of breastmilk, million liters***
Initiating	77	4301000	-	-	-	-	-
1	73	4301000	3129021	0.7	21	66.7	87.1
2	68	4301000	2942314	0.7	21	62.7	87.1
3	64	4301000	2755608	0.8	24	67.1	99.5
4	60	4301000	2568901	0.7	21	54.7	87.1
5	55	4301000	2382195	0.7	21	50.8	87.1
6	51	4301000	2195488	0.7	21	46.8	87.1
7	47	4301000	2008782	0.6	18	36.7	74.6
8	42	4301000	1822076	0.6	18	33.3	74.6
9	38	4301000	1635369	0.6	18	29.9	74.6
10	34	4301000	1448663	0.5	15	22.0	62.2
11	29	4301000	1261956	0.5	15	19.2	62.2
12	25	4301000	1075250	0.4	12	13.1	49.7
13	21	4301000	888544	0.3	9	8.1	37.3
14	16	4301000	701837	0.3	9	6.4	37.3
15	12	4301000	515131	0.3	9	4.7	37.3
16	8	4301000	328424	0.2	6	2.0	24.9
17	3	4301000	141718	0.2	6	0.9	24.9
18	0	4301000	0	0.2	6	0.0	24.9

19	0	4301000	0	0.2	6	0.0	24.9
20	0	4301000	0	0.2	6	0.0	24.9
21	0	4301000	0	0.2	6	0.0	24.9
22	0	4301000	0	0.2	6	0.0	24.9
23	0	4301000	0	0.2	6	0.0	24.9
24	0	4301000	0	0.2	6	0.0	24.9
					Total (million liters)	**525.0**	**1268.5**
					For 0-1 yo	502.9	932.7
					For 1-2 yo	22.1	335.8

Appendix Table 6

PRODUCTION OF HUMAN MILK CHINA							
Age (months)	*Year: 2006 Percent of infants breastfed*	*Year: 2010 Average number of infants living*	*No. of infants breastfed each month*	*Liters of breastmilk per infant per day*	*Estimated liters per infant per month*	*Annual produciton of breastmilk, million liters*	*Biologically feasible potential production of breastmilk, million liters*
Initiating	95	16,486,000	-	-	-	-	-
1	95	16,486,000	15,661,700	0.7	21	333.7	333.7
2	95	16,486,000	15,652,896	0.7	21	333.5	333.7
3	91	16,486,000	15,078,903	0.8	24	367.2	381.4
4	88	16,486,000	14,504,910	0.7	21	309.0	333.7
5	85	16,486,000	13,930,917	0.7	21	296.8	333.7
6	81	16,486,000	13,356,924	0.7	21	284.6	333.7
7	78	16,486,000	12,782,931	0.6	18	233.4	286.0
8	74	16,486,000	12,208,938	0.6	18	223.0	286.0
9	71	16,486,000	11,634,945	0.6	18	212.5	286.0
10	67	16,486,000	11,060,952	0.5	15	168.3	238.4
11	64	16,486,000	10,486,959	0.5	15	159.6	238.4
12	60	16,486,000	9,912,966	0.4	12	120.7	190.7
13	57	16,486,000	9,338,973	0.3	9	85.3	143.0
14	53	16,486,000	8,764,980	0.3	9	80.0	143.0
15	50	16,486,000	8,190,987	0.3	9	74.8	143.0
16	46	16,486,000	7,616,994	0.2	6	46.4	95.3
17	43	16,486,000	7,043,001	0.2	6	42.9	95.3
18	39	16,486,000	6,469,007	0.2	6	39.4	95.3

19	36	16,486,000	5,895,014	0.2	6	35.9	95.3
20	32	16,486,000	5,321,021	0.2	6	32.4	95.3
21	29	16,486,000	4,747,028	0.2	6	28.9	95.3
22	25	16,486,000	4,173,035	0.2	6	25.4	95.3
23	22	16,486,000	3,599,042	0.2	6	21.9	95.3
24	18	16,486,000	3,025,049	0.2	6	18.4	95.3
					Total (million liters)	**3,574.0**	**4,862.4**
					For 0-1 yo	3,042.3	3,575.3
					For 1-2 yo	531.6	1,287.1

Appendix Table 7

Age months	*PRODUCTION OF HUMAN MILK WORLD Year: 2006* *Percent of infants breastfed*	*Year: 2010 Average no. of infants living*	*No. of infants breastfed each month*	*Liters of breastmilk pr. infant pr. day*	*Estimated liters pr. month pr. infant*	*Annual production of breastmilk, million liters*	*Biologically feasible potential production of breastmilk, million liters*
Initiating		134754000	-	-	-	-	-
1	74	134754000	99717960	0.7	21	2124.6	2727.5
2	74	134754000	99717960	0.7	21	2124.6	2727.5
3	74	134754000	99717960	0.8	24	2428.1	3117.2
4	74	134754000	99717960	0.7	21	2124.6	2727.5
5	74	134754000	99717960	0.7	21	2124.6	2727.5
6	74	134754000	99717960	0.7	21	2124.6	2727.5
7	55	134754000	74114700	0.6	18	1353.5	2337.9
8	55	134754000	74114700	0.6	18	1353.5	2337.9
9	55	134754000	74114700	0.6	18	1353.5	2337.9
10	55	134754000	74114700	0.5	15	1127.9	1948.2
11	55	134754000	74114700	0.5	15	1127.9	1948.2
12	55	134754000	74114700	0.4	12	902.3	1558.6
13	28	134754000	37057350	0.3	9	338.4	1168.9
14	28	134754000	37057350	0.3	9	338.4	1168.9
15	28	134754000	37057350	0.3	9	338.4	1168.9
16	28	134754000	37057350	0.2	6	225.6	779.3
17	28	134754000	37057350	0.2	6	225.6	779.3

18	28	134754000	37057350	0.2	6	225.6	779.3
19	28	134754000	37057350	0.2	6	225.6	779.3
20	28	134754000	37057350	0.2	6	225.6	779.3
21	28	134754000	37057350	0.2	6	225.6	779.3
22	28	134754000	37057350	0.2	6	225.6	779.3
23	28	134754000	37057350	0.2	6	225.6	779.3
24	28	134754000	37057350	0.2	6	225.6	779.3
					Total (million liters)	**23315.4**	**39744.3**
					For 0-1 yo	20270.0	29223.7
					For 1-2 yo	3045.4	10520.5