Hospital system costs of artificial infant feeding: estimates for the Australian Capital Territory

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Abstract

Objective: To estimate the attributable ACT hospital system costs of treating selected infant and childhood illnesses having known associations with early weaning from human milk.

Method: We identified relative risks of infant and childhood morbidity associated with exposure to artificial feeding in the early months of life vs. breastfeeding from cohort studies cited by the American Academy of Pediatrics in 1997 as establishing the protective effect of breastfeeding. Data for ACT breastfeeding prevalence is assessed from a 1997 prospective population-based cohort study of 1,295 women. ACT Hospital Morbidity Data and DRG treatment costs were used to estimate the attributable fraction of costs of hospitalisation for gastrointestinal illness, respiratory illness and otitis media, eczema, and necrotising enterocolitis.

Results: Although initiation rates were high (92%), less than one in 10 ACT infants are exclusively breastfed for the recommended six months, mainly due to supplementation or weaning on to formula within the first three months and the early introduction of solids by breastfeeding mothers. This study suggests the attributable hospitalisation costs of early weaning in the ACT are about $1-2 million a year for the five illnesses.

Conclusions and implications: Early weaning from breastmilk is associated with significant hospital costs for treatment of gastrointestinal illness, respiratory illness and otitis media, eczema, and necrotising enterocolitis. These costs are minimum estimates of the cost of early weaning as they exclude numerous other chronic or common illnesses and out-of-hospital health care costs. Higher rates of exclusive breastfeeding would reduce these costs. Interventions to protect and support breastfeeding are likely to be cost-effective for the public health system.

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Breastfeeding is recognised as making a key contribution to infant and maternal health and providing economic benefits to the health care system. The Commonwealth Government's National Breastfeeding Strategy is a key component of its *Health Through Life* initiative.[1] The health care cost savings of breastfeeding for developing countries have long been accepted. Recent research has highlighted significant potential savings in developed countries such as Australia,[2] the United States,[3-5] and the United Kingdom as well.[6]

Questions were raised during the 1980s about the health policy significance of breastfeeding for industrialised countries[7] and the quality of existing studies.[8] Subsequently, the American Academy of Pediatrics' (AAP) recent 'Policy Statement on Breastfeeding and the Use of Human Milk'[9] has cited epidemiological research using predominantly middle-class populations from developed countries providing strong evidence that human milk and breastfeeding of infants significantly decreased risk for a large number of acute and chronic diseases including reducing the incidence and/or severity of diarrhea, lower respiratory infection, otitis media, bacteremia, bacterial meningitis, botulism, urinary tract infection and necrotising enterocolitis (NEC). There is also substantial evidence of long-term protective effects.[10-16]

Empirical studies in the US and the UK have assessed potential cost savings from increased breastfeeding by applying epidemiological methods to infer excess or attributable risks of illness from national data, on comparative incidence of illness in breastfed versus formula-fed infants.[3-5,17] In some cases these estimates were of hospitalisation costs, in other cases of health services expenditures (consultation, prescription and hospitalisation) or indirect costs garnered from various sources.[18-21]

Another study[2] estimated the avoidable costs of gastroenteritis, NEC, insulin-dependent diabetes mellitus (IDDM), eczema and neurodevelopmental impairment among term and pre-term infants in Australia. It used US and European estimates of incidence and hypothetical breastfeeding rates to model potential cost savings from various breastfeeding prevalences.

The aim of this study was to estimate for the Australian Capital Territory (ACT) the attributable hospital system costs of treating illnesses for which breastfeeding is established to be protective. We link for the first time at the population level estimates of ACT hospitalisation episodes for selected feeding-related morbidities with breastfeeding prevalence data from a corresponding local population, and then calculate the attributable cost of artificial feeding in this population using consistent, national, case-weighted data for public hospitals on treatment cost per episode.

The value of such a study for public health policy lies in its ability to:

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- Provide information and assist analysis of how health care resources are currently allocated.
- Identify potential health improvements or resource savings from interventions.
- Aid economic appraisal of cost effectiveness and policy priority setting.

Such information can also bring newly identified risk factors on to the policymaking, political or community agenda.

Method

Data for this study was derived from a number of independent sources. This information was used to estimate the attributable fraction of ACT costs of hospitalisation for selected conditions that are related to artificial feeding.

Prevalence of exposure to formula or early solids

The prevalence of infants' exposure to artificial feeding was estimated using data from a prospective population-based study commenced in the ACT in 1997. The study population is described elsewhere.[22] In summary:

- The source population comprised all women resident in the ACT and planning to do so for at least six months, who were aged ≥16 years and gave birth to a live baby between March and October 1997 in any of the ACT's two public hospitals, two private hospitals, or at home.
- Exclusions: Women whose babies were admitted to the neonatal intensive care unit or adopted, and women who were critically ill, unable to give informed consent or complete the questionnaires for any reason or were participating in any other study.
- Study population: Of the women eligible and approached, 1,295 (70%) agreed to participate in the study, and of these, 1,193 (92%) were retained in the cohort to six months postpartum. Compared with all women who gave birth in the ACT in 1997, participants were slightly older, more likely to be in married or de facto relationships, to have given birth in private hospitals, to be private patients and to be of English speaking background.
- Exposure variables. Data were collected at four days, eight, 16 and 24 weeks postpartum for type of milk consumed, including breast milk alone, breast milk plus formula milk and other fluids only (formula), as well as separate data for each feeding group on consumption of solids. The World Health Organization (WHO) defines 'exclusive breastfeeding' as breast milk only, whether expressed, from a wet-nurse, or suckled by the mother. 'Predominantly breastfed' is where breast milk is the predominant source of nutrition and includes unlimited amounts of water or juices in addition to breastmilk.[23] We use the term 'exclusive' breastfeeding to mean breastfeeding or breastmilk only, with no solids. However, our survey did not collect separate information on consumption of juice or water. Thus our 'breastfeeding' category corresponds more closely to 'full' breastfeeding according to the detailed schema set out by Labbock and Krasovec,[24] who recommend that 'full' breastfeeding include 'exclusive' (no other liquid or solid given to the infant) and 'almost exclusive' (vitamins, minerals, water, juice, or ritualistic feeds given infrequently) breastfeeding.

Morbidity/outcomes

- Data source: ACT public and private hospital separations for the 12-month period 1 July 1996-30 June 1997 derived from ACT Hospital Morbidity Data.[25]
- Outcomes: The number of episodes of hospitalisation for gastrointestinal illness, NEC, respiratory illness, otitis media and eczema among infants and children up to and including four years of age.
- We excluded hospitalisation episodes among older children, where breastfeeding is less strongly protective. Evidence from the literature suggests breastfeeding has continued significant protective effects to at least two years for gastrointestinal illness;[26] 2-6 years for respiratory illness;[13,27] 3-10 years for atopic eczema;[12,28] and three years for acute and recurrent otitis media.[29-32]
- Diagnostic Classification: Data for age groups 0-12 months and 1-4 years were classified by principal diagnosis at the three or four-digit level according to the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM). This morbidity data was then mapped to AR-DRG 4.0 by identifying separations where the principle diagnosis at the ICD-9-CM three- digit level best corresponded to the morbidity outcomes measured in the epidemiological studies (i.e. 'gastrointestinal illness', 'respiratory illness', 'otitis media', 'eczema' and 'NEC').

Relative risk of morbidity

Relative risks (RR) of infant and childhood morbidity associated with exposure to artificial feeding in the early months of life versus breastfeeding were extracted from high-quality cohort studies cited by the American Academy of Pediatrics in 1997 as establishing the protective effect of breast feeding. The following principles guided our decisions for choice of RR estimates:

- To confine the scope of this study to a manageable number of conditions.
- To use only those conditions for which the epidemiological evidence was best substantiated.
- To provide a more systematic framework for selecting relative risks than previous studies of this kind.[2-5,17]

According to the AAP, the best evidence of a protective effect of breastfeeding is for diarrhea, lower respiratory infection, otitis media, bacteremia, bacterial meningitis, botulism, urinary tract infection and NEC. Therefore we:

- Examined all 21 studies that were cited by the AAP as constituting 'strong evidence' for the protective effects of human milk feeding against these conditions.
- Identified a range of relative risks for each condition from these studies.
- Through these studies and through a Medline search from 1996 to 2002, identified and examined 11 other studies from developed countries that estimated relative risks for

gastrointestinal illness, 16 for respiratory illness, six for otitis media and one for NEC, and six recent meta-analyses or systematic reviews.

- Selected a preferred estimate of relative risk for each condition based on study quality, rather than taking a weighted average. Where studies were of similar quality, we followed the approach taken by others[33] of giving greater credibility to studies that clearly measured the exclusivity and duration of breastfeeding because clear definition of infant feeding categories is particularly important for accurate estimation of relative risks in this area.[11,24]

The important methodological standards for assessing quality, based on methodological criteria established for breastfeeding research by Baucher[8] and Kramer,[34] were:

- Adequate statistical power.
- Avoidance of detection bias.
- Clear definition of 'breastfeeding', i.e. distinguishing 'exclusive breastfeeding' for at least four months from other categories of exposure to non-human milk intake, including feeding of solids.[11,24]
- Control for important confounding variables (for example, socio-economic status, maternal education, parental smoking, child care attendance, siblings).
- Clearly defined outcome events and information on the severity of outcome.

In addition, the following factors were taken into account:

- Estimating the population-attributable risk from case-control studies can be problematic if the prevalence of exposure in the control group is not known to represent that in the population as a whole.[35] As cohort study estimates were unavailable for botulism, bacteremia, bacterial meningitis and urinary tract infection, these conditions were excluded from our estimates.
- Breastfeeding research meeting appropriate methodological standards has been lacking until very recently.[11] This limits the usefulness of pooled estimates, although meta-analyses are available for otitis media,[36] asthma,[37] and eczema.[38] Reflecting this situation, most studies cited by the AAP in its 1997 statement met only a few of the required methodological criteria. We therefore tested the plausibility of the relative risk estimates we extracted from the AAP studies by comparing them with findings from other studies identified in the literature search, as well as with results of recent published meta-analyses and reviews.

Cost of treatment

- The cost of each episode of hospitalisation was estimated as the average cost for the corresponding diagnostic related group (DRG) in Australian public hospitals (AR-DRG Version 4.0) for 1997-98.[39]
- DRG costs are derived from the annual National Hospital Cost Data Collection (NHCDC), which encompasses the average duration of hospitalisation associated with a particular DRG and includes estimates of average direct and overhead costs (for example, ward medical, nursing, pharmacology, pathology, catering and depreciation). The NHCDC for AR-DRG Version 4.0 was based on a retrospective collection and processing of 1997-98 data from a sample of 150 public hospitals and 46 private hospitals.
- Because ACT hospital cost data is not published at the level of detail required, we use national public sector hospital cost data. A weighted average cost is calculated where DRG average costs are applicable for several relevant DRG categories. The DRG average is weighted by NHCDC estimates of number of separations from national public hospitals in each relevant DRG category.
- These estimated average treatment costs per episode of hospitalisation are applied to corresponding categories of ACT hospital discharge data classified by the ICD-9-CM system to arrive at an estimate of aggregate costs of hospitalisation of infants and children in the relevant age groups for each of the conditions under study.

Table 1: Infant milk feeding in the Australian Capital Territory.

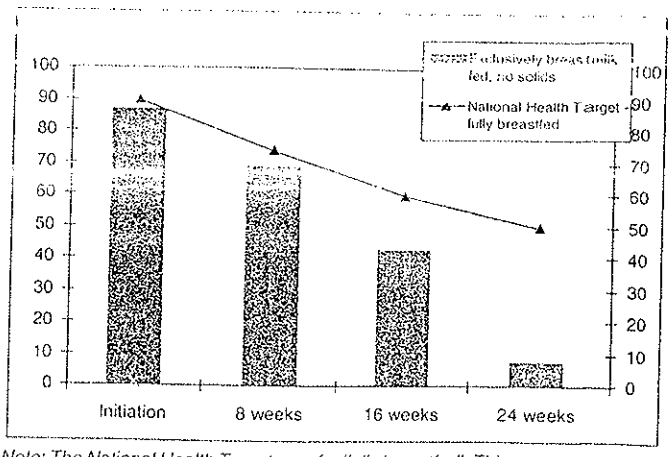
	Human milk only n (%)	Human milk plus formula n (%)	No human milk n (%)
Week 1	1,118 (87.3)	76 (5.9)	87 (6.8)
8 weeks	857 (68.3)	143 (11.4)	253 (20.2)
16 weeks	689 (56.6)	139 (11.4)	390 (32.0)
24 weeks	574 (48.2)	136 (11.4)	482 (40.4)

Source: Unpublished data from 'The ACT Experience – A Survey of Mothers', 1997.

Results

Complete data on time of introduction of solids and of type of milk fed was available for 1,183, 1,176, and 1,187 participants in the study at eight, 16, and 24 weeks postpartum respectively. Table 1 shows the type of milk consumed by ACT infants up to 24 weeks postpartum, and Figure 1 compares ACT feeding patterns with

Figure 1: ACT breastfeeding prevalence compared to national health targets for breastfeeding.



Note: The National Health Targets are for 'fully breastfed'. This means 'exclusively' or 'almost exclusively' breastfed. ACT infants fed human milk only, with no formula or solids, are categorised as 'fully breastfed'.[22,69]

Table 2: ACT hospital separations, infants and children (aged 0-4), 1996-97: conditions where there is 'strong evidence' that breastfeeding is protective.

Category of illness	ICD-9-CM codes	Total infant feeding related separation
Gastrointestinal	008-009, 530.81, 558.9, 783.1, 783.4	235
Acute otitis media	381-382	270
Respiratory	460, 462-466, 480, 485-487, 493, 786.2	692
Eczema	691,693	4
NEC	777.5, 777.8	9

Source: ACT Hospital Morbidity Data, 1996-97.

the National Health Targets for full (exclusive or near exclusive) breastfeeding.

By 24 weeks postpartum, only 8% of infants were still fully breastfed, solids most commonly having been introduced between 17 and 24 weeks postpartum. Of 820 women who reported providing only human milk to their babies at eight weeks postpartum, six had introduced solids within the first eight postpartum weeks. Thus at eight weeks postpartum 814/1,183 or 68.9% of infants received only human milk and no solids, while at 16 weeks the prevalence of full (i.e. exclusive and nearly exclusive or predominantly) breastfeeding had fallen to 43.4% (see Figure 1). With this 43% prevalence of full breastfeeding at 16 weeks, we use an estimate of exposure prevalence of 60% to examine the attributable cost of exposure to artificial feeding.

Table 2 reports the number of hospitalisations in the ACT in 1996-97 for the illnesses specified. It excludes all hospitalisations of children aged five or more and estimates the proportion of hospitalisations in age categories 1-4 years by assuming an even spread of hospitalisations within this age category. Six hundred and ninety-two infants and children aged 0-4 years were hospitalised for respiratory illness, 270 aged 0-3 years for acute otitis media, 235 aged 0-2 years for gastrointestinal illness, four aged 0-4 years for eczema and nine for NEC. NEC was only identified in hospitalised infants under 12 months of age.

The relative risks of illness for not 'breastfed' compared with 'breastfed' infants from the literature cited by the AAP on these illnesses are summarised in Table 3. All studies controlled for important potential confounding variables and the relative risk estimates below are for morbidity, not for hospitalisation, unless otherwise specified.

The relative risk of gastrointestinal illness estimated in the five studies cited by the AAP statement ranged from 1.9 to 13.5. We used 5.5 as our preferred relative risk estimate. This is based on the Dundee study[40] and shows the effects on hospitalisation for gastrointestinal illness in the first year of life of exclusive breastfeeding for at least the first 14 weeks compared with no breastfeeding.

Establishing the most plausible relative risks for 'respiratory illness' is complex because this includes respiratory infection as well as allergic conditions such as asthma or recurrent wheeze. Because of the ambiguity in measuring morbidity outcomes and risks of exposure, some studies' inadequate treatment of confounding factors (notably smoking and allergic parental history) and lack of data on the atopic status of patients hospitalised for respiratory illness, we assumed a relative risk of 2.4 for respiratory illness in the total population.[41] This had regard to evidence of a two-fold higher risk of respiratory infection that has since been found for children aged seven years in the Dundee study follow-up,[13] and also corresponds closely to findings for recurrent wheeze at age two years.[42]

Estimates of the relative risk of acute otitis media ranged from 1.1 to 3.7 in healthy term infants[29,43] and 11.5 in breastmilk fed infants with cleft palate.[31] Our preferred estimate for hospitalisation due to otitis media is 2.1.[44] Again, the estimate of relative risk from this study is conservative, as the reference population of 'not breastfed' included a large proportion of infants who were fully or partially breastfed to four months of age which was compared with those exclusively breastfed for more than six months.

A prospective cohort study of 256 Finnish infants found a six times lower incidence of atopic dermatitis at age three years among those with a history of prolonged breastfeeding (that is, breastmilk the sole source of milk to age six months) than those with little

Table 3: Relative risk of illness in non-breastfed infants compared with breastfed infants from literature cited by AAP: conditions where there is 'strong evidence' that breastfeeding is protective.

Outcome	Low estimate	High estimate	Preferred estimate	Source of preferred estimate	Definition of exposure variables[a]	Population attributable risk[b]
Gastrointestinal illness[c]	1.9	13.5	5.5	(Howie 1990)	never bf or bf <14 weeks vs ebf >13 weeks	73
Acute otitis media	1.1	3.7	2.1	(Duncan 1993)	bf <4 mo vs ebf >6 mo	40
Respiratory illness	1.3	6	2.4	(Wright 1989)	never bf or bf <4 mo vs bf >4 mo	55
Eczema	3.2	6	6	(Saarinen 1979)	bf <2 mo vs bf >6 mo	75
NEC	2	23.6	2	(Lucas 1990)	never bf vs any bf	38

Notes:
(a) 'bf' means 'breastfed'; 'ebf' means 'exclusively breastfed'.
(b) The population attributable fraction was computed using $P_e(RR-1)/(1+P_e(RR-1))$ where P_e is the prevalence of exposure to artificial feeding, and RR is the relative risk calculated as the ratio of the incidence of morbidity in artificially fed infants to the incidence in breastfed infants.
(c) Hospitalisation in first 12 months of life.
Source: see text under 'Relative risk of morbidity' heading.

Table 4: Treatment costs per episode of illness, DRG average cost, 1997/98.

Category of illness	ICD-9-CM	DRG	DRG description	Average cost per DRG ($)	Weighted average cost ($)
Gastrointestinal	008-009, 530.81, 558.9,	G68A	Gastroenteritis A <10 +Cc	2,962	
	783.1, 783.4	G68B	Gastroenteritis A <10 -Cc	1,275	1,484
Acute otitis media	381-382	D63A	Otitis media + URI+Cc	2,143	
		D63B	Otitis media + URI -Cc	1,237	1,422
Respiratory	460, 462-466, 480	E62A	Respiratory infection/inflamm + Ccc	5,726	
	485-487, 493, 786.2	E62B	Respiratory infection/inflamm+Smcc	3,634	
		E62C	Respiratory infection/inflamm-Cc	2,147	
		E67A	Respiratory signs and symptom+Cscc	2,173	
		E67B	Respiratory signs and symptom A<3-Cscc	1,275	
		E67C	Respiratory signs and symptom A>3-Cscc	1,076	
		E69C	Bronchitis and asthma A<50 -Cc	1,227	
		E72Z	Respiratory problems from neonatal period	3,611	
		E73A	Pleural effusion+Ccc	5,133	
		E73B	Pleural effusion+Scc	2,961	
		E73C	Pleural effusion-Ccc	1,935	2,412
Eczema	691, 693	J61Z	Severe skin disorders	1,603	
		J66A	Moderate skin disorders+Cscc	3,688	
		J66B	Moderate skin disorders-Cscc	1,695	
		J67A	Minor skin disorders+Cc	2,206	
		J67B	Minor skin disorders+Cc	810	1,303
NEC	777.5, 777.8	P04Z	neo, Admwt 1500-1999G+Sig Or Pr	41,516	
		P65A	neo, Admwt 1500-1999G-Sig Or Pr+Mmp	20,205	28,648

Source: See text under heading 'Cost of treatment'.

breastfeeding (less than two months of exclusive breastfeeding).[12,28] This study is preferred over a British randomised controlled trial (RCT) comparing 777 pre-term atopic infants supplemented with human milk to those fed preterm formula.[45] The latter was for preterm, atopic infants fed some human milk until discharge from hospital only, while the former was for healthy infants breastfed fully till six months compared with babies weaned before two months, measured severity as well as incidence and controlled for solid feedings. The Finnish study is therefore more comprehensive and more relevant to a general population than the RCT.

The preferred study of the relative risks of NEC is a RCT study of 926 preterm infants in the UK.[46] Infants of less than 30 weeks' gestation fed only formula milks had twice the risk of developing confirmed NEC than those fed any human milk, while among infants of longer gestation the relative risk of confirmed NEC for artificial milk fed babies was much higher. The study controlled for differences in feeding groups for various medical factors associated with NEC.

Calculation of measures of disease frequency including attributable and population-attributable risk is according to the standard formula[35] and assumes exposure to artificial feeding of 60% in the ACT population. This corresponds approximately to the ACT full (exclusive or nearly exclusive) breastfeeding rate of 43% at 16 weeks. Table 3 shows calculations of the population attributable risk (%) in the ACT for breastfeeding prevalence of 40%.

Table 3 also shows that the population attributable risk (%) varies between 38% and 75% at a 60% prevalence of exposure to artificial feeding and using the relative risks identified for these five conditions above. That is, between one-third and three-quarters of infant and child hospitalisations for these conditions in the specified age groups could have been avoided through exclusive or more prolonged breastfeeding in infancy.

Table 4 shows the DRG-based treatment costs per episode of hospitalisation for gastrointestinal illness, respiratory illness, otitis media, eczema, and NEC among infants and children aged 0-11. Because hospital separations data is classified by ICD-9 codes, and treatment costs by DRG, we have linked them with the categories of illness in the literature according to the definitions reported in this table.

Table 5 summarises the direct hospitalisation costs associated with artificial infant feeding for various relative risk assumptions. This table is adjusted on the basis discussed above to exclude hospitalisations of children assumed to be too old to be protected by breastfeeding in infancy. Our main estimates of relative risk are based on studies of the health risks of artificial infant milk feeding available to the AAP in 1996.

A small number of high-quality prospective studies and several meta-analyses have recently been published that provided further estimates of relative risk for some conditions.

Using these studies, we tested the sensitivity of cost estimates to different assumptions of relative risk. Table 5 shows the

Table 5: Relative risk (RR) of illness in non-breastfed infants compared with breastfed infants; sensitivity to relative risk and exposure estimates.

Outcome	Low RR estimate	'Pooled' RR estimate	Upper RR estimate	Attributable cost: low RR estimates ($)	Attributable cost: 'pooled' RR estimates ($)	Attributable cost: 60% exposure/ preferred RR estimates ($)	Attributable cost: upper RR estimates ($)
Gastrointestinal	1.9	1.8	13.5	236,736	218,963	492,667	595,708
Acute otitis media	1.1	1.4	3.7	28,324	96,851	198,953	309,405
Respiratory	1.3	1.25	3.1	243,967	208,609	730,132	891,665
Eczema	3.2	1.5	6	2,966	1,203	3,910	3,910
NEC[a]	2	(2)	23.6	96,686	(96,686)	96,686	240,121
Total				608,679	622,312	1,522,347	2,040,810

Note:
(a) No pooled or relevant new estimates are available for NEC.
Source: 'Low' estimates are from Beaudry,[70] Owen and Baldwin,[43] Frank et al.[71] Saarinen[28] and Lucas and Cole[46] for gastrointestinal illness, acute otitis media, respiratory illness, eczema and NEC respectively. Recent or 'pooled' estimates are from Raisler[49] and Scariati et al,[48] Uhari and Mantysaari,[36] Peat[47] and Gdalevich et al.[38] for gastrointestinal illness, acute otitis media, respiratory illness (asthma), and eczema respectively. High estimates are from Popkin and Adair,[72] Saarinen,[29] Wright et al.,[73] Saarinen[28] and Lucas and Cole[46] respectively.

various alternative relative risk estimates: 'pooled' estimates of 1.4 for otitis media,[36] 1.25 for respiratory illness,[47] and 1.5 for eczema[38] and a relative risk of 1.8 for gastrointestinal illness;[48,49] and 'lower bound' and 'upper bound' estimates from Table 3. The attributable hospitalisation cost of 60% of infants not breastfeeding in the ACT falls to $0.61 million and $0.62 million for the 'pooled' and lower bound estimates respectively. This shows that our results for attributable cost are most sensitive to the estimates of relative risk for respiratory illness. Using 'upper bound' relative risk estimates, the avoidable hospitalisation cost for a 60% exposure rate increases to $2.1 million.

To assess the effects of changing breastfeeding prevalence, we have modelled the attributable costs for breastfeeding prevalences between 5% and 90% (see Table 6). This shows that if virtually all infants were exclusively breastfed as recommended to around six months, with a small proportion of mothers physiologically unable to lactate, there would be up to a 5%[50] prevalence of exposure to artificial feeding in the ACT. At the other end of the spectrum, the 8% exclusive breastfeeding rate in the ACT at 24 weeks approximates a 90% exposure to the health risks associated with artificial infant feeding. Using a conservative definition of current exposure (the proportion of infants receiving no human milk at 24 weeks), 40% of infants are exposed to artificial feeding in the ACT. On this basis, the avoidable hospitalisation costs of artificial feeding are around $1.2 million a year in the ACT for the five conditions examined in this study.

Table 6: Attributable costs for various prevalence of exposure.

Exposure (%)	Attributable costs ($)
5	268,041
10	480,700
20	805,470
30	1,047,673
40	1,238,176
50	1,393,179
60	1,522,347
70	1,631,949
80	1,726,289
90	1,808,447

Discussion

Study results and significance

This study showed that less than 10% of ACT infants are exclusively breastfed for around the first six months of life, due to a) supplementation or weaning within the first three months and b) early introduction of solids among exclusively breastfeeding mothers.

Although uncertainty about relative risk estimates and breastfeeding prevalence produces a wide range of cost estimates, this study shows that early weaning is likely to add between around $1 and $2 million annually to ACT hospitalisation costs of treatment of infants and children for gastrointestinal illness, respiratory illness, otitis media, eczema and NEC. This suggests that higher exclusive breastfeeding rates could produce significant potential savings in ACT hospitalisation costs for children aged 0-4 years. Extrapolated nationally, savings across the Australian hospital system could be $60-$120 million annually for these illnesses alone. Conversely, any decline in breastfeeding from current levels has substantial and adverse cost implications for the ACT public health system.

The largest costs savings come from reduced hospital admissions for respiratory illness and gastrointestinal illness. In the United States, NEC treatment and deaths are a substantial component of the economic costs of artificial infant feeding.[5] In 1992, authors of the UK randomised controlled trials on NEC foresaw that "early introduction of breastmilk into the diets of pre-term infants could make necrotising enterocolitis beyond 30 weeks a rarity".[46] This study bears out that prediction: in our study, where virtually all pre-term infants in the ACT receive human milk, NEC was only a minor cost component.

Study limitations

A weakness of our study is that we match hospitalisation data with risk exposures at the population level, not the individual level. The incidence of illness is implicitly incorporated in the results through using ACT hospitalisation data on the relevant ICD-9-CM categories. This approach permits more accurate and clinically relevant estimates of the cost of artificial feeding to the health system in a specific regional population, and are thus more likely to influence hospital decision-makers.[51] However, our method assumes that the prevalence of exposure to non-exclusive breastfeeding in the ACT hospitalised population of infants and children aged 0-4 years old can be accurately inferred from our population-based survey of breastfeeding prevalence. This means factors other than infant-feeding patterns cannot be excluded as factors contributing to the hospitalisation rate. It has been suggested, for example, that breastfed children may be less likely to be hospitalised than artificially fed children with the same illness, reflecting confounding factors such as mother's education levels or caregivers' propensity to hospitalise.[7,8] If so, the proportion of artificially fed infants in the sample population used to measure breastfeeding prevalence will differ from the proportion of hospitalised infants who are artificially fed. However, recent population studies using active surveillance and controlling for confounders such as socio-economic status suggest artificially fed infants are slightly more likely to need hospitalisation than those breastfed.[40,52] If this finding can be extended to the ACT, our assumption may underestimate artificial feeding prevalence among hospitalised infants and children. The implication is that our results would understate the attributable hospitalisation costs of artificial infant feeding. We have therefore shown how our attributable cost estimates would vary for different assumptions about breastfeeding prevalence in the hospitalised infants and children.

The breastfeeding survey data relates to infants born between March and October 1997, whereas hospitalisation data on which our estimates are based relate to 1 July 1996 and 30 June 1997. However, with breastfeeding prevalence stabilising in Australia from the 1980s after strong increases since 1972,[53] it is likely that our ACT breastfeeding prevalence data reasonably reflects its prevalence during the previous four years.

Lack of precision in categorising infant feeding method hindered our evaluation of exposure to risk of illness from artificial feeding as previously published studies have used unsatisfactory definitions of 'breastfed' or 'formula-fed'. Blurring the distinction between breastfed and formula-fed infants will tend to understate the relative risk of artificial feeding compared with breastfeeding. On the other hand, comparing exclusive breastfeeding for six months with exclusive formula feeding from birth would not accurately represent the comparative health risks for the ACT population.

Pooled risk estimates may also underestimate relative risks associated with formula feeding where the existing literature does not meet current standards for accurately measure breastfeeding exclusivity or duration.

Our study may somewhat overstate the attributable costs of artificial feeding for NEC in the ACT, as the prevalence of human milk feeding by premature infants was assumed in this study to be the same as for term infants, when it is much higher.

Limitation of the costing methodology

The economic costs estimated here are minimum estimates of the true public and private economic cost of early weaning because they exclude indirect and intangible costs and are limited to costs incurred in hospital. A full economic costing would include other direct costs of illness borne by the community, such as non-hospital medical and pharmaceutical costs, as well as indirect costs represented by lost household and workforce productivity associated with time and effort spent nursing sick infants and children at home, and effects on the quality of life. Out-of-hospital costs are potentially significant. In the United States, for example, for every $100 spent on treating hospitalised infants with gastrointestinal illness, a further $80 was spent on out-of-hospital treatment and indirect costs.[5] However, cost of illness studies often omit indirect and intangible costs because they are difficult to measure in dollar terms and because appropriate indicators of quality of life are still being developed, and treatment costs are much more difficult to estimate outside the hospital setting.

It should be noted that the DRG system is used to classify acute admitted patient hospital episodes and groups together similar clinical conditions with similar usage of hospital resources, in order to facilitate comparison of hospital costs and case-mix funding. It uses 'cost modelling' or data extracted from hospital clinical costing systems. Because the ICD-9-CM system is an indexing system for hospital and medical records, it is more precise than DRG groupings and reflects different considerations. Hence, patient-level costings using ICD-9-CM classifications may give different results from those using average DRG costs. Nevertheless, in the absence of patient-level cost data, the DRG average cost data provides a reasonable basis for costing ACT hospital separations.

Despite its limitations, this study is nevertheless useful for public policy because it shows that the attributable hospitalisation cost of artificial infant feeding is considerable in itself. It also indicates that indirect and intangible costs are also likely to be substantial as our estimates exclude several other chronic and costly conditions linked by research to lack of breastfeeding, such as insulin-dependent diabetes mellitus, Crohn's disease, ulcerative colitis, lymphoma, allergic diseases and other chronic digestive diseases. There is recent evidence of long-term adverse effects of artificial formula feeding on later obesity, high blood pressure and heart disease,[13,54] as well as pneumonia, gastroenteritis, respiratory illness, allergy and NEC.[14,55-57] Evidence is accumulating on significant advantages provided for cognitive development by breastfeeding.[15,58-60] It also benefits the long-term health of mothers.[61]

Future applications

Our study design did not permit individual matching of ACT hospital separation data with infant feeding data. Ideally, data collection for hospitalisation of infants and children would include such information to permit more accurate estimates. Future

research needs to update the estimates of relative risk in the present study to extend the analysis to conditions for which the AAP considered breastfeeding was 'possibly protective', or for which recent research has recently identified artificial infant feeding as a risk factor. It is important that research in this area consistently defines 'breastfeeding' according to recommended schema in order to avoid biased estimates. Future work should also extend the analysis to non-hospitalisation costs of illness, including medical, pharmaceutical and household productivity or time costs.

From a preventative health policy viewpoint in an industrialised country such as Australia, assessing the effects of changing the size of the exposed population is more relevant than changing relative risks. A recent large experimental study showed that breastfeeding support programs in a community setting can substantially increase breastfeeding and thereby reduce illness rates.[55] The significance of the PROBIT study, a cluster randomised trial in Belarus,[62] lies in its finding that a hospital-based intervention, the Baby Friendly Hospital Initiative,[63] can produce a 12-fold increase in exclusive breastfeeding at six months and double the probability of any breastfeeding throughout the first year of life, with benefits to child health even in a high breastfeeding population.[64]

Conclusion and implications

WHO and UNICEF recommend exclusive breastfeeding for around six months.[65] The AAP[9] concluded that:

> *exclusive breastfeeding is the ideal nutrition and sufficient for approximately the first 6 months after birth. ... In the first six months, water, juice, and other foods are generally unnecessary for breastfed infants.*

This study has shown that only a fraction of ACT infants (8%) are exclusively breastfed for around the first six months of life. This low prevalence of full/exclusive breastfeeding at six months is surprising in this relatively well-educated and affluent population. The ACT is already well below National Health Targets for full (exclusive or nearly exclusive) breastfeeding at six months, mainly because many breastfeeding mothers introduce solids from 16 weeks contrary to WHO recommendations. Although initiation rates of breastfeeding in the ACT are high, this drops off rapidly by eight weeks when one in five babies are no longer breastfeeding at all. Data from the National Health Survey[66] suggests this occurs disproportionately in lower socio-economic groups.

This study shows that early weaning may add between around $1 and $2 million annually to ACT hospitalisation costs of treatment of infants and children for gastrointestinal illness, respiratory illness, otitis media, eczema, and NEC. Extrapolated nationally, savings across the Australian hospital system could be $60-$120 million annually for these illnesses alone.

Public policies and breastfeeding support programs enabling mothers to avoid supplementation in the early weeks, or reducing cultural and commercial pressures on mothers for early introduction of solids, could significantly raise full or exclusive breastfeeding rates and reduce health costs. There is clear evidence that higher breastfeeding rates in the early weeks depends fundamentally on improved health care practices,[63] including in particular appropriate support and management of perceived inadequate milk supply and sore nipples.[67] Recent research in Western Australia[68] suggests that inappropriate advice from health professionals results in premature introduction of solids in the Australian population of breastfeeding mothers.

Along with recent evidence that interventions to support breastfeeding can substantially raise the prevalence of breastfeeding, this study suggests that public policies encouraging breastfeeding mothers to delay introducing solids to six months and reducing the extent of artificial feeding of infants under six months of age are likely to be cost-effective.

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