The costs of suboptimal breastfeeding in Ontario, Canada, and potential economic impacts from improving rates: A health system costing analysis

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Abstract

Background

Human milk from the breast is the healthiest option for human infants. All other sources of nutrition pose some risk to child, maternal and environmental health. There are significant costs to suboptimal rates of breastfeeding for children, families and society. In Ontario, Canada, breastfeeding initiation rates are high (over 92%), however exclusivity and duration rates drop over time. Suboptimal breastfeeding rates result in an associated cost burden for both families and the health care system.

Methods

We calculated the savings that the Ontario healthcare system would have benefited from had breastfeeding rates been higher, both from the time of hospital discharge and at 6 months postpartum. Using methods from similar studies carried out in the UK, US, Spain, Mexico and Southeast Asia we estimate the benefits of increased exclusive breastfeeding rates based on the lower incidence of childhood and maternal diseases for which there is robust evidence, including: lower respiratory infections, gastroenteritis, otitis media, childhood leukemia, necrotising enterocolitis, and breast and ovarian cancers. We used existing databases and literature to estimate the monetary cost of these diseases.

Results

It is estimated that suboptimal exclusive breastfeeding at 6 months of age for infants born in Ontario in 2019 costs the Ontario healthcare system about US $211 million per annum in treatment costs for five childhood and two maternal illnesses. Increasing exclusive breastfeeding (EBF) rate at 6 months (36.3%) to rate at discharge from hospital after delivery (64.9%) would save about US$73 million dollars per annum and about US$134 million if EBF rate at 6 months were increased to initiation rates (92.1%).

Conclusions

Interventions that facilitate the breastfeeding relationship and support families who want to feed their children human milk are cost effective, upstream investments in public health. Evidence based strategies aimed at helping to establish and maintain an exclusive breastfeeding relationship would contribute to lowering both the health burden on families and the associated fiscal burden on the Ontario healthcare system.

Background/Introduction

Human milk from the breast is the healthiest option for human infants. All other sources of nutrition pose some risk to child, maternal and environmental health.[1] Interventions that facilitate the breastfeeding relationship and support families who want to feed their children human milk are cost effective, upstream investments in public health.[2]

For children to obtain optimal growth and development, the World Health Organization and Health Canada recommend initiation of breastfeeding within the first hour after birth; exclusive breastfeeding for the first six months; and continued breastfeeding for two years or more, with complementary feeding starting at six months.[3,4]

In Ontario, the most populous province in Canada, most families want to feed infants human milk as breastfeeding initiation rates are an impressive 92.1%.[5] However, exclusivity rates fall to 64.9% at hospital discharge[6] and exclusivity rates at 6 months after birth are suboptimal at 36.3%.[5] Limited access to breast milk banks exist, though exclusivity rates for infants in the neonatal intensive care unit (NICU), are particularly low, with one report finding that only 32.9% of preterm (> 37 weeks) newborns are receiving human milk exclusively at NICU discharge to home.[7]

Notably, breastfeeding in Canada is influenced by social determinants of health. Children of white, educated, older, middle-class women are most likely to be fed human milk and for longer periods of time.[8–10] Human milk advocates and researchers conclude that to increase duration rates, we must surround families with relevant, evidence-based, breastfeeding friendly health and social supports that address the diversity of challenges to establishing the breastfeeding relationship.[2,9–11]

A global review of the health and societal benefits concluded that increasing breastfeeding to a near universal level could prevent 595,379 childhood deaths from diarrhoea and pneumonia each year, reduce 974,956 cases of childhood obesity, and prevent 98,243 deaths from breast and ovarian cancers as well as type II diabetes each year.[11] These avoidable deaths and diseases involve health system treatment costs of US$1.1 billion annually. Including losses associated with the cognitive impact of not breastfeeding, the total global economic losses estimated to be US$341.3 billion, or 0.70% of global gross national income.[11] Country level cost analysis studies reporting the costs of suboptimal breastfeeding rates on health care systems have been conducted in US[12,13], UK[14], Mexico[15,16], South East Asia[17], Spain[18,19], and within a number of other health care systems internationally[11]. Each study has demonstrated the significant return on investment the healthcare system would see in terms of reduced costs associated with reduced disease burden and death as breastfeeding rates increase.

Costing studies available in Canada include a Newfoundland data linkage study that found exclusively formula fed infants had higher average spending associated with hospital admissions, family doctor and specialist visits, and both mixed feeding and exclusively formula feeding was predictive of higher total healthcare service use.[20] In a recent cost-effectiveness simulation examining feeding modality for mothers with HIV in Ontario, Keshmiri et al[21] reported that exclusively breastfeeding is more effective and more cost-saving as an infant feeding modality than exclusively formula feeding when mothers living with HIV are on combination antiretroviral therapy and have virologic suppression; yielding a cost-savings of CAD$13,812 per additional infant.

In the present study, we sought to estimate the costs of suboptimal breastfeeding rates to the Ontario healthcare system and model the healthcare cost savings if exclusive breastfeeding rates in Ontario, Canada were increased. The project involved updating the systematic reviews by Renfrew et al[14] and replicating their efforts in a Canadian context. To our knowledge, no such costing data has been reported for Canada. A Canadian study is an important contribution to the international, national, and provincial discussions related to investments in breastfeeding supports as preventative health care policy and practice in high-income countries.

Methodology

We estimated the savings in treatment costs to the health system that could be achieved if exclusive breastfeeding rates were to increase in Ontario, Canada. We chose to build on the work of Renfrew et al[14] as we aimed to avoid overestimation of costs and chose to err on the side of conservative assumptions when making methodological decisions. Thus, the true scale of the impact of infant feeding on the Ontario healthcare system is likely to be much greater. The costing perspective was that of the Ontario health system. We utilised 2017–2018[5] exclusive breastfeeding rates at six months for modelling current health system cost burden and compared costs with scenarios of improved exclusive breastfeeding rates. These increases were modelled based on two scenarios; using 2017-18 exclusive breastfeeding initiation rates at birth and at hospital discharge after birth[6,7]. To achieve this, our methodology included literature reviews to identify input parameters and cost estimates. Our modelling focused on the 2019 live births and a hypothetical cohort of 100,000 women.

Disease selection and literature searches

The process of selecting seven priority illnesses was based on an extensive search of the literature. We reviewed and updated the systematic reviews conducted by Renfrew et al[14] to identify high-quality studies and parameters to include in the model where Canadian data was missing. Refer to Supplemental File 1 for details of the search strategy. The results of the reviews can be found in Supplemental Files 2–4. Review A involved updating the systemic search for existing systematic reviews of infant feeding and health and cognitive outcomes in high income countries by Renfrew et al[14] (Supplemental File 2). Review B

was a systematic search and identification of Canadian studies (Renfrew's Review B was a focus on UK studies) examining health outcomes related to infant feeding (Supplemental File 3). Review B offered a picture of the available Canadian data on breastfeeding outcomes. Review C was a review of economic impact (cost of illness) studies related to infant feeding from comparable industrialized, high-income countries and informed our overall approach to the study (Supplemental File 4). For review A, we developed a screening tool with exclusion and inclusion criteria and another researcher applied the screen to 10% to check reliability of the screen. Using the approach outlined by Renfrew et al,[14] we had a series of meetings with the research team to discuss the state of the evidence from Reviews A and B. We also consulted with two Canadian researchers with expertise in specific diseases relationships to breastfeeding in our decision-making process. We chose childhood and maternal illnesses with the most robust evidence of association with breastfeeding, where review studies were available to predict the effect size with confidence, and where it was possible to conduct an economic analysis that was relevant to the Ontario health care system.

Using the results from our analysis of reviews A and B we chose to model the cost burden and potential cost savings from healthcare expenditures incurred by Ontario's health system in treating five childhood illnesses: lower respiratory tract infection (LRTI), gastrointestinal infection (GI), acute otitis media (AOM), necrotizing enterocolitis (NEC), child leukemia; and two maternal illnesses: breast and ovarian cancer. A number of diseases with relationships to breastfeeding were excluded from our analysis. We excluded diseases where there is currently a lack of a strong evidence of association, diseases where there are complicated relationships with feeding modality, diseases where there were challenges with modelling the disease impact on the Ontario healthcare system, and where there were limitations in available data. Our inclusion and exclusion decisions were also guided by a concern for containing the scope of the study. Once the shortlist of outcomes was determined, further online database and literature searches were carried out to identify the following model parameters: breastfeeding rates (current practice); incidence of outcomes; incidence of care episodes (outpatient consultations, and hospitalisation) specific to the selected conditions; unit costs of treatment for each condition or unit-costs of care episodes.

Cost modelling framework and assumptions

We utilised a 7-step framework for modelling the identified outcomes. This framework builds on common methods utilised in previous studies[12,14] and is illustrated in Fig. 1.

Adapted from Renfrew et al[14]

For step one, we utilised three exclusive breastfeeding rate scenarios: (1) current rate (36.3%) at six months; (2) increasing current rates at six months to rates at hospital discharge (64.9%); (3) increasing current rate at six months to initiation rates at birth (92.1%). These three Ontario breastfeeding rates were chosen based on the accepted practice in other costs analysis studies, and the availability and reliability of infant feeding data from sources in Ontario. The initiation and 6 month exclusivity data is reported in a Public Health Agency of Canada report[5] and is from Canadian Community Health Survey data (2017–2018). The exclusive feeding at hospital discharge rate is reported by Baby-Friendly Initiative Ontario (BFION)[6] and is from BORN (Better Outcomes Registry & Network) Ontario data collected in participating Ontario hospitals. For step two, the reference population for pediatric outcomes was the number of live births and for maternal outcomes, the number of primiparous women. We adjusted the number of live births with estimates of infant and neonatal mortality rates obtained from Statistics Canada (2019)[26]. In step three, the reference population was divided into two groups based on their breastfeeding status. To determine the number of disease cases and care episodes for each breastfeeding scenario, we utilised two approaches. For LRTI, AOM, and NEC, we relied on evidence from literature of the incidence of illnesses based on breastfeeding status (exclusively breastfed [EBF] and formula fed [FF]) (see Supplemental File 1). For child leukemia, breast and ovarian cancer, we relied on a differential incidence equation obtained from previous studies.[12,14] The equation used is $x = s/\left(br + 1 - b\right)$, where x is the diseases incidence in non-breastfeeding group, s is the overall incidence of identified disease, b is the current breastfeeding rate, r is the odds ratio in favour of breastfeeding, and xr is the incidence of disease in breastfeeding group. In line with Renfrew et al[14] assumption, we used the formula when the odds ratio approximates the risk ratios. Applying the estimates above in step five, we determined the number of children and women with outcomes of interest

and obtained the incidence of care episodes and multiplying this with the unit cost of care per. episode disaggregated by inpatient and outpatient costs where available. For maternal outcomes, we used a simple Markov model (cancer, no-cancer, death) to estimate treatment cost for a cohort of 100,000 women followed over their lifetime. In step six, annual treatment cost per each modelled breastfeeding scenario were compared with the current rate to obtain cost savings. Since input parameters were obtained from multiple sources with different methodologies including sample design, sample size, and definition of breastfeeding, to examine the uncertainties in modelled costs, we used deterministic sensitivity analyses to examine the impact of varying the odds ratios and unit costs used in the models. To do this, we utilised the confidence intervals in the selected model parameters.

Costing approach and perspective

The cost model for estimating the healthcare costs of select infant and maternal illnesses attributable to suboptimal breastfeeding can be summarised using the equation below:

$$C\left(\beta X_{it}\right) = \beta_0 + \sum\nolimits_i \beta_j X_{ijt}$$

1

where X_{it} is a vector of explanatory variables (predictors of cost) for patient i in period t whose j^{th} element is $X_{ijt}$and $\beta$is a vector of regression coefficients whose j^{th} element is β_j. β is unique to particular treatment algorithm and $t$represents a specific time period, so that the basic unit of observation is the patient-time.

The costing approach utilised a provider perspective focussing on specific cost centres. Unitary costs for inpatient, outpatient, and medication care were estimated where available else, we relied on treatment cost for illnesses. We relied on the reviews for obtaining estimates of key parameters that are drivers of healthcare costs. These estimates covered incidence of inpatient and outpatient care visits per disease episode, and average length of inpatient stays and outpatient visits. Table 1 presents a summary of key parameters and data sources that inform this costing study. We relied on the Ontario Case Costing Initiative (OCCI)[22] for inpatient and outpatient costs for LRTI, GI, AOM, and NEC, and on literature for treatment costs for childhood leukemia, and maternal breast and ovarian cancer. For the three cancer-related outcomes (child leukemia, breast and ovarian cancer), we discounted future treatment costs to 2020 costs using a 3% discount rate. Cost parameters obtained from the literature review were inflated/deflated to 2019 Canadian dollars using the Bank of Canada inflation calculator[23] and then converted to the United States dollar using exchange rate estimates from the World Bank.[24]

Table 1
Key data sources and assumptions

Parameter	Description	Source
Number of live births	140,541 live births in Ontario (2019)	Statistics Canada[25]
Infant and neonatal mortality rate	4.6 infant and 3.6 neonatal deaths per 1000 live births	Statistics Canada[26]
Number of primiparous women	Hypothetical cohort of 100,000 women	Analyst's assumption
Exclusive breastfeeding rate	36.3% (rate at six months); 64.9% (rate at hospital discharge after delivery); 92.1% (breastfeeding initiation rate); 64.6% (any breastfeeding)	PHAC, 2022[5]; BFI Annual report, 2019[6]
Lower respiratory tract infection		
Incidence of LRTI	37% among FF and 25% among EBF	Quesada et al, 2020[27]
Incidence of care	23% cases visit outpatient care; 6% have inpatient stays	Renfrew et al, 2012[14]; CIHI[28]
Duration of care	3 days in inpatient care per episode; 1.9 days outpatient visits per episode	OCCI[22]; CIHI[28]
Cost of care	US $911 (US $222- US $8,112) per inpatient stay; US $166 (US $99 – US $11,660) per LRTI case in outpatient care	OCCI[22]
Gastrointestinal infection		
Incidence of GI	31% among FF and 14% among EBF	Quesada et al, 2020[27]
Incidence of care	22% cases visit outpatient care; 44% have inpatient stays	Sargeant et al, 2008[29]; Caudle et al, 2009[30]
Duration of care	3.6 days in inpatient care per episode; 1.9 days of outpatient visits per episode	OCCI[22]; CIHI[28]
Annual cost of care	US $1,055 (US $810 – US $9088) per inpatient stay; US $166 (US $144 – US $1,338) per GI case in outpatient care	OCCI[22]
Acute otitis media		
Incidence of AOM	37% among FF and 25% among EBF	Quesada et al, 2020[27]
Incidence of care	94% cases visited a health professional	Dubé et al, 2011[31]
Duration of episode	2.2 AOM episodes per annum; 5.9 days per AOM episode	Dubé et al, 2011[31]
Annual cost of care	US $97.71 (US $ 87 – US $1,919) per AOM case in outpatient care	OCCI[22]
Necrotising enterocolitis		

FF = Formula fed; EBF = Exclusively breastfed; CIHI = Canada Institute of Health Information; OCCI = Ontario Case Costing Initiative; CCS = Canadian Cancer Society; US$ = United States dollar; NICU = Neonatal Intensive Care Unit; CNN = Canadian Neonatal Network;

* actual incidence numbers are available upon request

** min and max cost estimates from OCCI

Parameter	Description	Source
Breast feeding rate	32.9% of premature newborns are EBF at NICU discharge	CNN[32]
Incidence of NEC	7% among AF and 1% among EBF	Quesada et al, 2020[27]
Incidence of care	We assume all newborns with NEC receives care	Analyst's assumption
Duration of care	32.9 days in inpatient care days per admission	OCCI[22]
Distribution of treatment	31% of cases would need surgical treatment while 69% would need medical treatment only	Rees et al, 2010[33]
Annual cost of care	US $60, 326 (US $42,035 – US $87,658) per NEC case treated in NICU	OCCI[22]
Childhood leukemia		
Incidence of acute leukemia	7.0 cases per 100,000 population of 0–4-year-olds in Ontario	Statistics Canada[34]
Lifetime probability of infection	1.70% lifetime probability of developing leukemia in Canada	CCS[35]
Lifetime probability of death	0.9% lifetime probability of dying from leukemia in Canada	CCS[35]
Survival rate	94% predicted 5 year observed survival proportion	CCS[35]
Breastfeeding and leukemia risk	0.89 (0.84–0.94 CI) decreased risk for newborn ever breastfed	Amitay et al, 2015[36]
Annual cost of care	US $113,462 (US $102,758 – US $132,187) per case	Oliveira et al, 2017[37]
Breast cancer		
Incidence of breast cancer	Incidence of breast cancer per 100,000 female population disaggregated by 5 year age groups (15 years and above)*	Statistic Canada[34]
Lifetime risk of disease	1 in 8 Canadian females will have breast cancer in their lifetime	CCS[35]
Lifetime probability of death	1 in 33 Canadians females will die from breast cancer in the lifetime	CCS[35]
Predicted survival rate	95% predicted 5 year survival proportion for Canadian females	CCS[35]
Lifetime breastfeeding duration	15.6 months weighted lifetime breastfeeding duration for parous women	Tschiderer et al, 2022[38]
Breastfeeding and breast cancer risk	0.74 (0.68–0.80 CI) decreased risk for women with > 12 months lifetime breastfeeding	Chowdhury et al, 2015[39]

FF = Formula fed; EBF = Exclusively breastfed; CIHI = Canada Institute of Health Information; OCCI = Ontario Case Costing Initiative; CCS = Canadian Cancer Society; US$ = United States dollar; NICU = Neonatal Intensive Care Unit; CNN = Canadian Neonatal Network;

* actual incidence numbers are available upon request

** min and max cost estimates from OCCI

Parameter	Description	Source
Annual cost of care	US $28, 879 (US $8,384 – US $41,266)** per case	Oliveira et al, 2013[40]
Ovarian cancer		
Incidence of ovarian cancer	Incidence of ovarian cancer per 100,000 female population disaggregated by 5year age groups (15 years and above)*	Statistic Canada[34]
Lifetime probability of disease	1 in 75 Canadian will have ovarian cancer in their lifetime	CCS[35]
Lifetime probability of death	1 in 90 Canadians will die from ovarian cancer in the lifetime	CCS[35]
Predicted survival rate	45% predicted 5 and 36% predicted 10 year survival proportion for Canadian females	CCS[35]
Breastfeeding and ovarian cancer risk	0.72 (0.65–0.80 CI) decreased risk for women with 6–12 months lifetime breastfeeding	Chowdhury et al., 2015[39]
Annual cost of care	US $70,821 (US $41,722 – US $145,526) per case	Hurry et al, 2021[41]
FF = Formula fed; EBF = Exclusively breastfed; CIHI = Canada Institute of Health Information; OCCI = Ontario Case Costing Initiative; CCS = Canadian Cancer Society; US$ = United States dollar; NICU = Neonatal Intensive Care Unit; CNN = Canadian Neonatal Network;		
* actual incidence numbers are available upon request		
** min and max cost estimates from OCCI		

Finally, to explore how sensitive our estimates are based on chosen input parameters and since all relationships between breastfeeding and illness outcomes are associations, we performed deterministic sensitivity analysis by varying some of the disease and cost parameters. We varied treatment costs using minimum and maximum costs from the OCCI,[22] and disease odds ratios using confidence intervals. Analysis was performed in Microsoft excel.

Insert Table 1 *approximately here.*

Results

Potential cost savings

Lower respiratory tract infections

Pediatric LRTIs (e.g. bronchitis, pneumonia, bronchiolitis and respiratory syncytial virus [RSV] and others often caused by influenza and parainfluenza viruses) pose a significant burden on families and healthcare systems worldwide.[42] According to a recent global analysis, there is an estimated 47,000 cases of LRTI among Canadian children under 5 each year with LRTI mortality occurring in 2.5 Canadian children age 5 and under per 100,000 (95% UI 2.0–3.0). A BC study found that LRTI was the primary diagnosis accounting for 32% of hospitalizations for diseases of the respiratory system in children less than 19 years of age and 76% for infants < 1 year of age.[43] An analysis of the burden of RSV on the health care system and families in Alberta found that 13.4% of all infants hospitalized with RSV over two seasons had intensive care unit admission, and average ICU stay for these infants was 6.5 days. Families had average out-of-pocket expenses of $736.69 (CA), and the average time both parents spent in hospital was nearly 7 days (164.0 hours). The study found RSV impacted parent work absenteeism, work

was impaired, and parents exhibited significant stress.[44] It is notable that childhood respiratory infections are associated with material deprivation in Canada, particularly among First Nations and Inuit communities.[45,46]

Lack of breastfeeding has been identified as a risk factor for morbidity and mortality in children with acute lower-respiratory infections. In a systemic review and meta-analysis, Horta and Victora[47] reported breastfeeding reduces the prevalence or incidence of respiratory infections (respiratory, lower respiratory tract infection or pneumonia) by 32% [pooled relative risk: 0.68 (95% confidence interval: 0.60; 0.77)], reduces the risk of hospitalization for respiratory infection by 57% [pooled relative risk: 0.43 (95% confidence interval: 0.33; 0.55)] and mortality from lower respiratory tract infections was also reduced [pooled relative risk: 0.30 (95% confidence interval: 0.16; 0.56)].

In Ontario, we calculated that increasing EBF rate at six months to rate at hospital discharge after delivery and initiation rates would save about 14,751 cases of LRTI per annum and 28,781 cases per annum respectively (Fig. 2). This would result in about 901–1,758 fewer hospitalisation and 3,451–6,734 fewer outpatient visits for improving current EBF rates at six months to hospital discharge and initiation rates. Such savings in number of cases and healthcare utilisation would save the Ontario health system about US$4.6 million – US$9.1 million in treatment costs (Fig. 3).

Gastrointestinal Infections

Sargeant, Majowicz and Snelgrove[48] observed that acute GI represented a significant health burden in Ontario, with a monthly prevalence of 8.6%. They reported that about 1 and 5 Ontarians will seek care from a health care professional for GI symptoms including nausea, diarrhea and vomiting. Horta and Victora[47] report “more intense breastfeeding practices” were associated with 31% reduced risk of diarrhea incidence of [pooled relative risk of 0.69 (95% confidence interval: 0.58; 0.82)] compared to “less intense breastfeeding”. The relationship is stronger for infants aged ≤ 6 months, with a corresponding pooled relative risk 0.37 (95% confidence interval: 0.27; 0.50)

Breastfeeding also decreased the risk of hospitalization from diarrhea [pooled relative risk: 0.28 (95% confidence interval: 0.16; 0.50) and diarrhea mortality [pooled relative risk: 0.23 (95% confidence interval: 0.13; 0.42)].

In Ontario, increasing exclusive breastfeeding (EBF) rate at six months to rate at hospital discharge after delivery and initiation rates would save about 12,359–24,113 cases of GI per annum respectively (Fig. 2). This would result in about 2,719–5,305 fewer hospitalisation and 5,388–10,513 fewer outpatient visits for improving current EBF rates at six months to hospital discharge and initiation rates. Such savings in number of cases and healthcare utilisation would result in about US$9.4 million – US$18.5 million savings in treatment costs (Fig. 3).

Acute Otitis Media

Acute otitis media (AOM) is one of the most common cause of health care visits and antibiotic prescriptions for children.[31,49] In their study of Canadian families who reported having AOM, most (94%, 151 of 161) visited with health professionals and the average time required for medical examination was 3.1 hours in an emergency department and 1.8 hours in an outpatient clinic. Most diagnoses resulted in antibiotics use. They also found that 38% of caregivers missed work during this time. A meta-analysis examining the relationship between AOM and breastfeeding reported that exclusive breastfeeding during the first 6 months is associated with around a 43% reduction in ever having AOM in the first 2 years of life.[50] Increasing EBF rate at six months to rate at hospital discharge after delivery and initiation rates would save about 13,944–32,229 cases of AOM per annum respectively (Fig. 2). This would result in about 13,107–30,295 fewer outpatient visits for improving current EBF rates at six months to hospital discharge and initiation rates. Such savings in number of cases and healthcare utilisation would result in about US$2.3 million – US$5.5 million savings in treatment costs (Fig. 3).

Necrotizing Enterocolitis

Necrotizing enterocolitis (NEC) is one of the most common causes of morbidity and mortality in NICUs, with mortality rates between 15–30%.[51,52] Compared to mother or donor milk, formula feeding preterm or low birth weight infants increases their

rate of growth, but nearly doubles the risk of necrotising enterocolitis, a potentially fatal intestinal disease [typical risk ratio (RR) 1.87, 95% CI 1.23 to 2.85; risk difference (RD) 0.03, 95% CI 0.01 to 0.05].[53]

Increasing EBF rate (i.e., mother's own milk or donor's milk) at discharge from NICUs in Ontario to the rates at hospital discharge after delivery for full-term infants will save about 153 cases, and 285 cases if rates at NICU discharge were to improve to initiation rates (Fig. 2). This would result in about US$9 million – US$16.8 million savings in annual treatment costs (Fig. 3).

Childhood Leukemia

Childhood cancer is a leading cause of mortality among children and adolescents in high-income countries. In their meta-analysis of 18 case control studies, Amitay and Keinan-Boker[54] estimated that between 14–19% of all childhood leukemia cases may be prevented by breastfeeding for 6 months or more. Increasing EBF rate at six months to rate at hospital discharge and initiation rates would save about 63–89 cases of childhood leukemia per annum respectively (Fig. 2). This would result in about US $7.1 million – US $10 million savings in treatment costs (Fig. 3).

Breast cancer

The Canadian Cancer Society[35] reports that 1 in 8 Canadian women will have breast cancer in their lifetime and 1 in 33 Canadian women will die from breast cancer. In their meta-analysis of 50 studies, Chowdury et al[55] found that mothers who breastfed for > 12 months compared with those who did not breastfeed had a 26% lower risk of developing breast cancer. Increasing EBF rate at six months to rate at hospital discharge and initiation rates would save about 952–1,850 cases of breast cancer per annum respectively (Fig. 4). This would result in about US$36 million – US$71 million savings in lifetime treatment costs (Fig. 4).

Ovarian cancer

The Canadian Cancer Society[35] reports that 1 in 75 Canadian women will have ovarian cancer in their lifetime and 1 in 90 Canadian women will die from ovarian cancer. Chowdury et al[55] observed a 28% lower risk of ovarian cancer among women who had breastfed for six to 12 months than among women who had not breastfed (OR 0.63; 95% CI 0.56–0.71). Increasing EBF rate at six months to rate at hospital discharge and initiation rates would save about 186–293 cases of ovarian cancer per annum (Fig. 4). This would result in about US$13 million – US$20 million savings in lifetime treatment costs (Fig. 4).

Sensitivity analysis

Table 2 presents the results of the sensitivity analyses. Due to very high variation in costs from the OCCI, results were most sensitive to the cost parameters used. This is most evident in the estimated costs for the four childhood illnesses (LRTI, GI, AOM, and NEC). For example, using EBF rate at discharge, there is significant differences. Using minimum value for treatment cost estimates for LRTI, cost savings was about US$1 million per annum compared to US$70 million per annum if maximum treatment cost was used. For the three cancer outcomes, results were most sensitive to varying disease ORs since we relied on treatment costs from published literature which had narrower confidence intervals.

Table 2
Results from sensitivity analyses for exclusive breastfeeding at discharge and initiation rates, US $ million, 2019 prices

		Varying treatment costs			Varying disease odds ratio		
		Mean estimate	Low estimate	High estimate	Mean estimate	Low estimate	High estimate
Lower respiratory infection	Discharge rate	4.6	1.06	70.1	4.6		
	Initiation rate	9.1	2.7	183.7	9.1		
Gastrointestinal infection	Discharge rate	9.4	7.4	80.5	9.4		
	Initiation rate	18.5	12.1	126.6	18.5		
Acute otitis media	Discharge rate	2.3	1.6	35.6	2.3		
	Initiation rate	5.5	3.7	82.2	5.5		
Necrotizing enterocolitis	Discharge rate	9	2.6	13.4	9		
	Initiation rate	16.8	3.7	24.9	16.8		
Childhood leukemia	Discharge rate	7.1	6.7	8.3	7.1	6.9	9.2
	Initiation rate	10	9.9	11.7	10	9.6	12.1
Breast cancer	Discharge rate	36.9	1.5	39.2	27.5	25	31
	Initiation rate	71.7	15.5	76.3	53.5	49.9	57.7
Ovarian cancer	Discharge rate	13.1	7.7	27	13.1	11.6	15.5
	Initiation rate	20.7	12.2	42.6	20.7	18.7	23.1

Discussion

Summary

We have reported a conservative estimate of selected health care system costs of suboptimal support for breastfeeding in Ontario, Canada. We found that suboptimal breastfeeding at 6 months of age for infants born in Ontario in 2019 was costing the Ontario healthcare system about US$211 million per annum in treatment costs for five childhood and two maternal illnesses. Increasing exclusive breastfeeding rate at 6 months (36.3%) to rate at discharge from hospital after delivery (64.9%) would save about US$73 million dollars per annum and about US$134 million should EBF rate be increased to initiation rates (92.1%).

We have included an analysis of outcomes where there have been demonstrated robust relationships between human milk and disease prevention in children and mothers. We acknowledge that using the term “prevention” in the context of breastfeeding may be a misnomer. Human milk is the normal, biologically appropriate feeding method for human children. It may be argued

that breast milk does not prevent disease, as it is the norm. Rather, other forms of feeding, most notably infant formulas, are contributing to disease burden.

Limitations

Cost analyses are based on risk estimates of a relationship between breastfeeding and disease that are potentially impacted by confounding variables such as maternal health and health behaviours and other factors. In addition, for the child outcomes, we only considered the morbidity rates for the first two years of life. Further, it is likely that the true costs of suboptimal breastfeeding feeding rates to societies are much larger than we report here. This study does not capture the healthcare system costs of other diseases that emerging evidence suggests an association with lack of human milk, including: maternal diabetes,[55–63] SIDS (sudden infant death syndrome),[64] COVID-19,[65] Neonatal abstinence syndrome,[66–68] obesity,[53,57,69–87] and reduced intelligence.[88] Further, this study does not capture the costs of caregiver time that higher rates of childhood illness requires.[89] We have not calculated the environmental costs of non-human milk products.[90,91] It is likely impossible to capture the social-emotional costs, including the attachment, bonding and soothing benefits that are lost for infants and toddlers who are weaned early; or the emotional and spiritual costs related to the grief and loss some mothers experience over a breastfeeding relationship that was never established, or dissolved before they would have chosen.[92]

How might the healthcare system in Ontario and elsewhere see the costs savings that would come from increased breastfeeding rates? Notably, while the breastfeeding relationship is an intimate, most often dyadic relationship, suboptimal breastfeeding rates should not be viewed as individual failings of mothers or their infants. There are often unseen systemic barriers to effective breastfeeding supports that have developed over time. Canada is a signatory but does not enforce the International Code of Marketing of Breastmilk Substitutes. In addition, hospital practices in Canada significantly impact the establishment and maintenance of the breastfeeding relationship.[10] The widespread acceptance of infant formula as an acceptable low risk substitute by health care providers pervades the health care system. Maternal and child health care should be guided by the growing body of science as it relates to human milk and best practices in maternal care.[2] Other systemic interventions could include: the expansion of midwifery services and a mother-centred model of care, increased access to donor milk for infants in the NICU, anti-racism efforts and decolonization of the health care system and ensuring that all Indigenous women have access to culturally relevant and safe pre and postnatal care. Interventions at the community level include: following the evidence when it comes to the Baby-Friendly Health Initiative (BFHI), including increased skin to skin within the hour after birth, and increased access to peer support and other community-based breastfeeding supports.

Conclusion

Establishing and maintaining the breastfeeding relationship is essential to maternal and child health. Our conservative cost analysis shows the possibility for significant cost savings if exclusivity and duration rates of breastfeeding in Ontario were improved. In Ontario, families want to breastfeed, as evidenced by very high initiation rates. However, the current system appears limited in supporting families to establish a *lasting* breastfeeding relationship. Systemic barriers exist including hospital practices that do not align with BFHI guidelines. An intersectional analysis examining race, class, age, education, and Indigeneity shows systemic human milk inequities in Canada. Existing evidence shows that increased breastfeeding will make our societies healthier and possibly more connected. Viewed as preventative medicine, relatively low-cost strategies aimed at increasing exclusive breastfeeding rates, especially for marginalized populations, would likely contribute to reducing the burdens on families and thereby lowering the fiscal burden of the Ontario healthcare system.

Abbreviations

AOM – acute otitis media

BFHI – baby-friendly health initiative

BFION – Baby-Friendly Initiative Ontario

EBF – exclusively breastfed

FF – formula fed

GI – gastrointestinal infection

LRTI – lower respiratory tract infection

NEC – necrotizing enterocolitis

NICU – neonatal intensive care unit

OCCI – Ontario Case Costing Initiative

RD – risk difference

RR – risk ratio

RSV – respiratory syncytial virus

SIDS – sudden infant death syndrome

Declarations

Ethics approval and consent to participate

The study utilised de-identified secondary data that are publicly available, thus ethics approval is not required.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are publicly available and sources can be provided by the corresponding authors on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

SH and MNO led the overall development of study and the development of the manuscript. MNO, SH, KN contributed to the development of the data collection methods and conduct of the data collection. MNO led the data analysis. SH led the review of the study protocol and approach. SH and KN provided expertise regarding lactation and data sources. All authors reviewed drafts of the manuscript and approved the final version.

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Figures

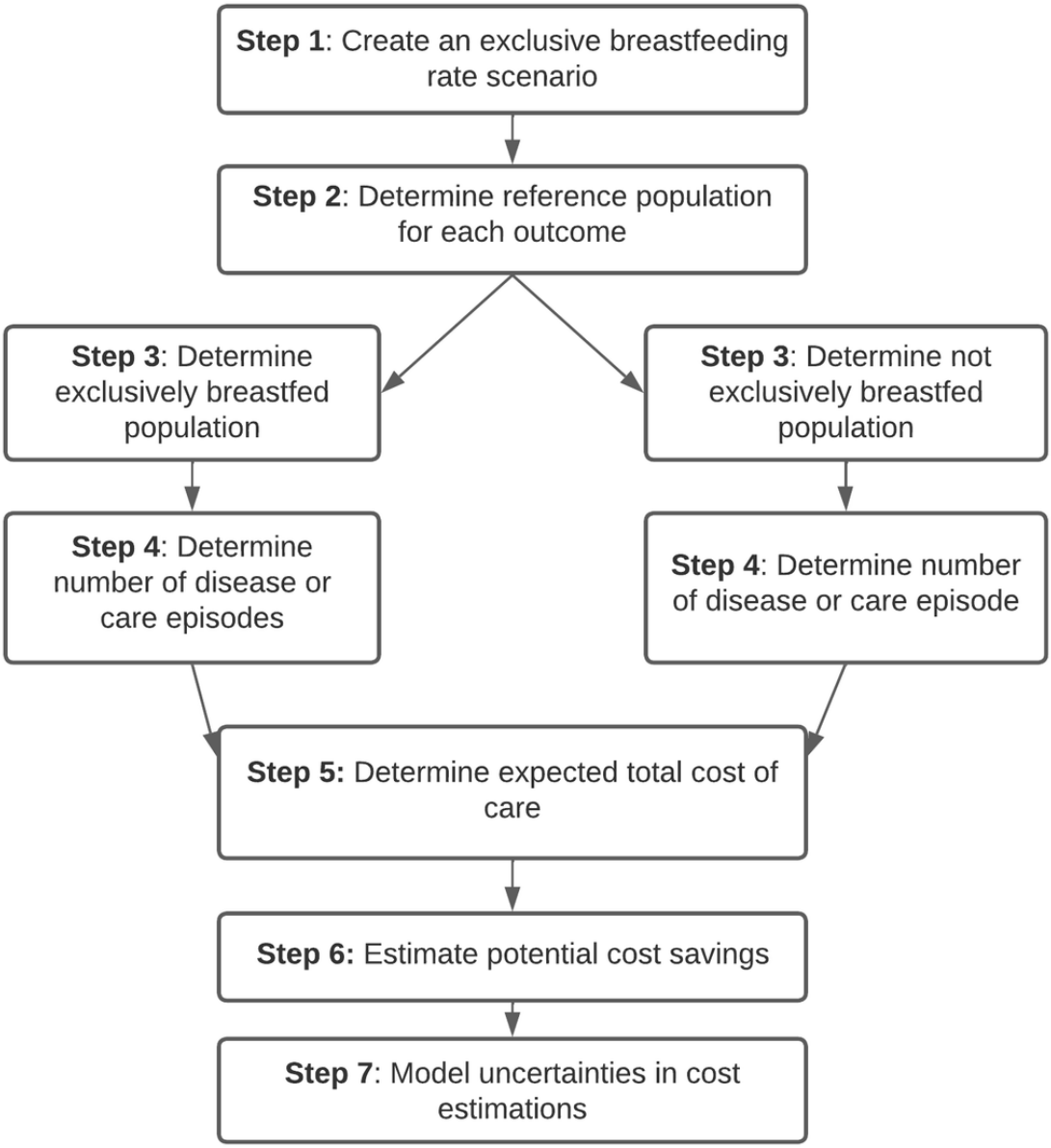

Figure 1

Process of economic modelling

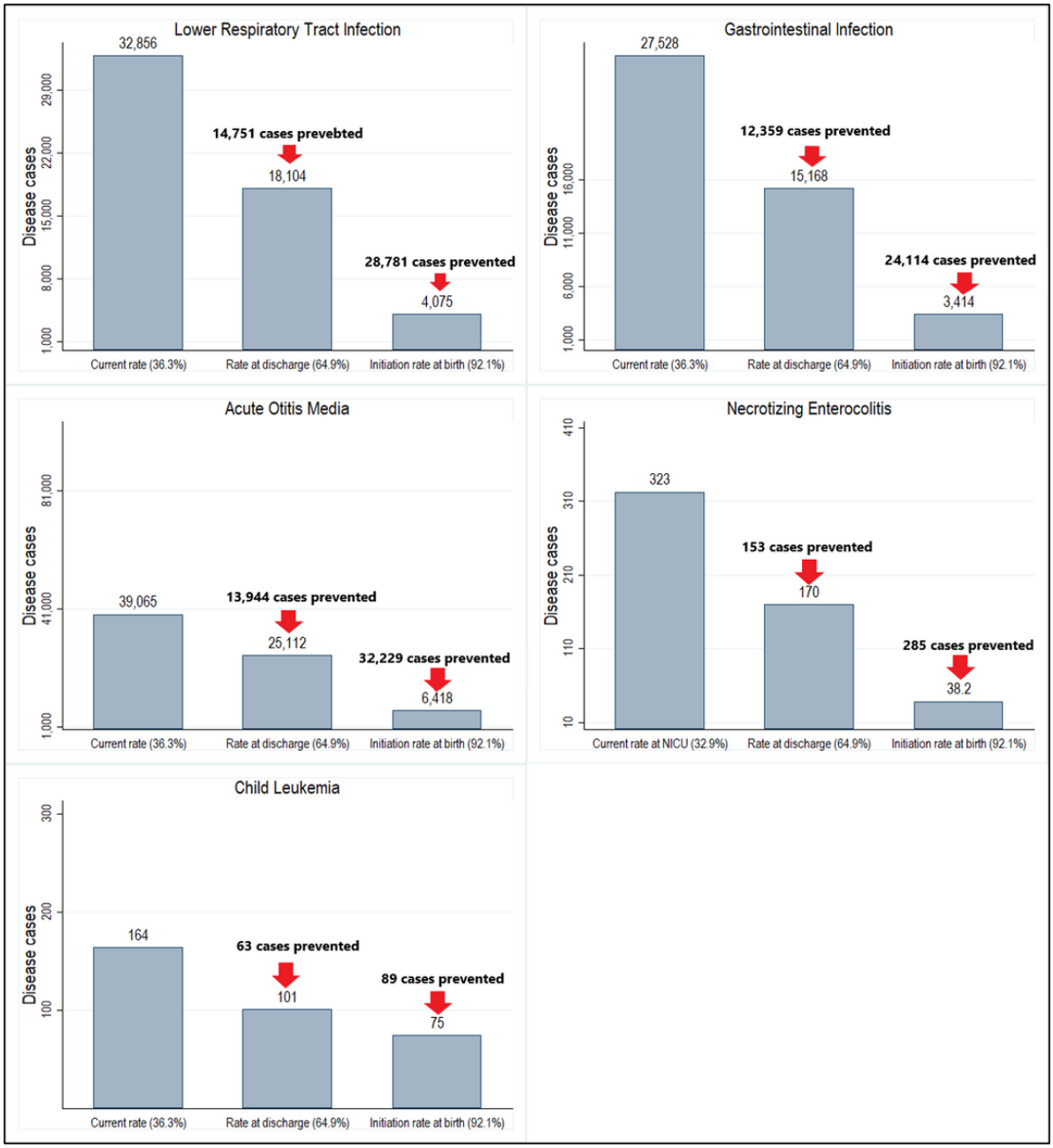

Figure 2

Number of disease cases prevented for five childhood illnesses – two breastfeeding rates

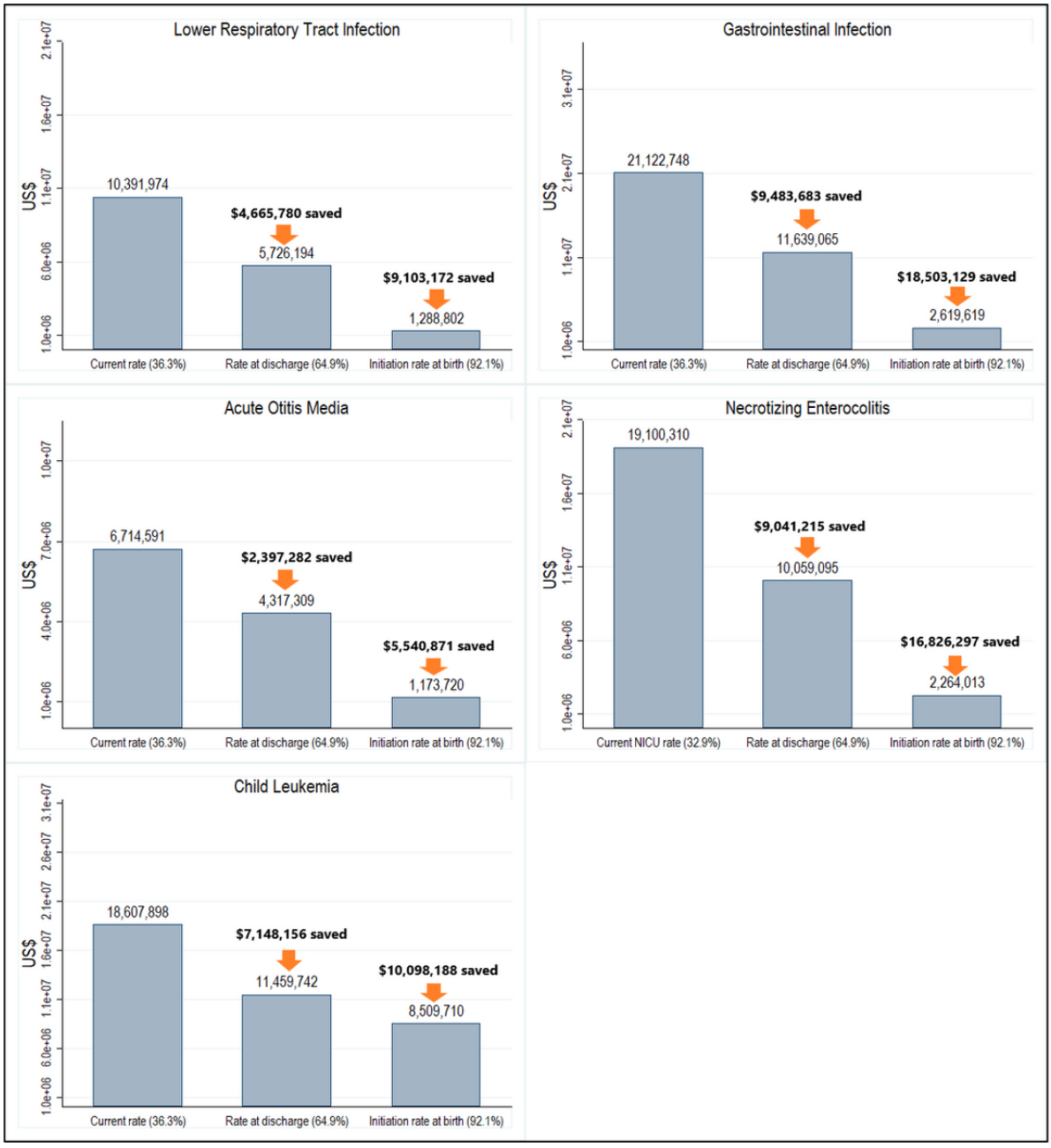

Figure 3

Treatment cost savings for reduction in cases of five child illnesses – two breastfeeding rates

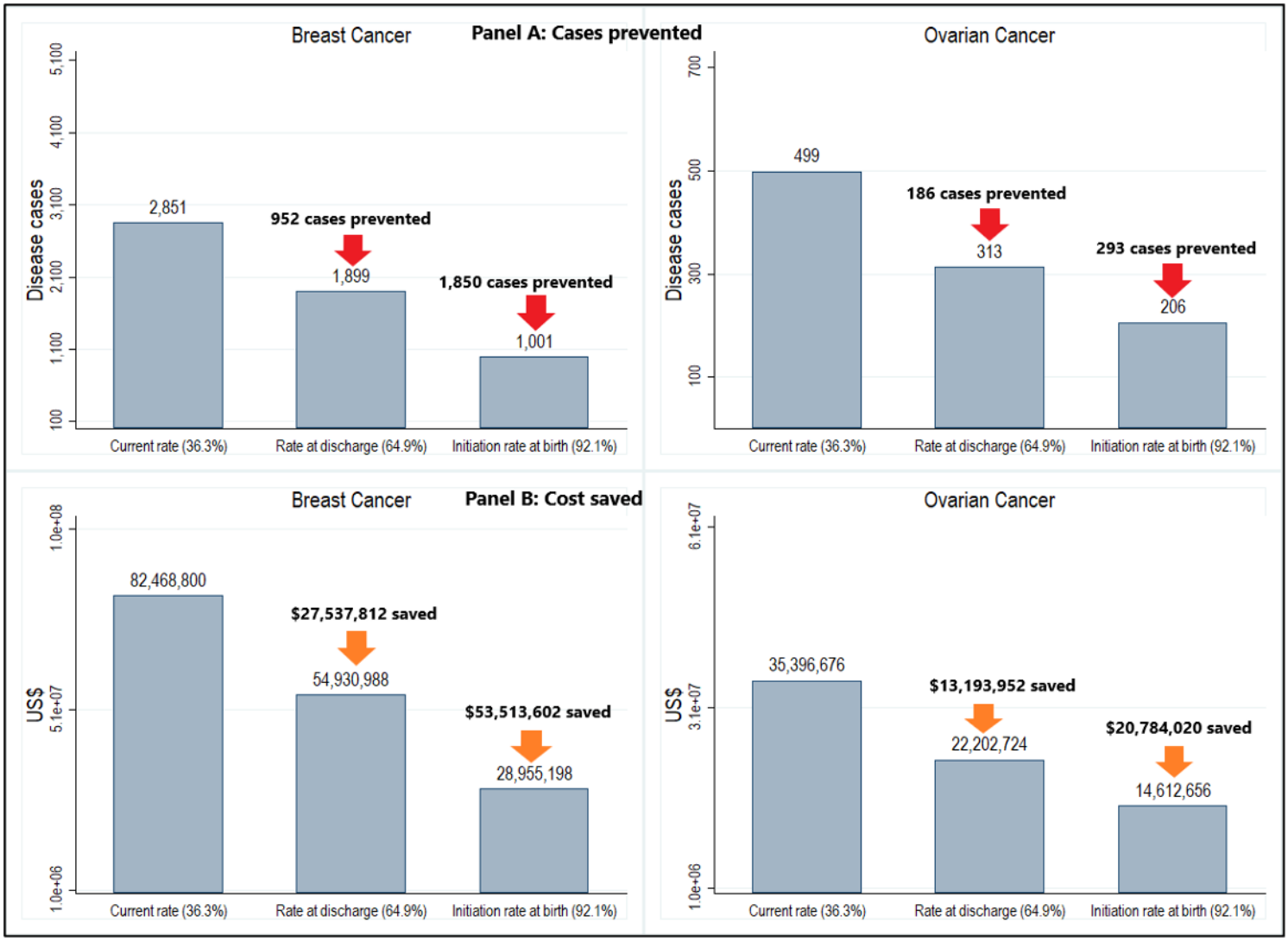

Figure 4

Savings in cases and costs for two maternal illnesses – two breastfeeding rates

Supplementary Files

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- SupplementalFile1SearchStrategyforReviewsABandC.docx
- SupplementalFile2ResultsofReviewA.xlsx
- SupplementalFile3ResultsofReviewB.xlsx
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