

# Infant Feeding Mode Predicts the Costs of Healthcare Services in One Region of Canada: a Data Linkage Study

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## Research article

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# Abstract

**Background** Few studies have examined the association between infant feeding mode (IFM) and costs related to healthcare service use (HSU) in Canada. The aim of this study is to evaluate differences in HSU and its associated costs by IFM, in an infant's first year of life in one region of Newfoundland and Labrador, Canada.

**Methods** Data from a prospective cohort study were linked to administrative databases to examine HSU during an infant's first year of life. The cohort study collected information on peri- and postnatal variables, including IFM during three stages that covered pregnancy through the first year postnatally. Consenting mothers provided their infants health insurance number for a data linkage to examine HSU by the infant. Outcomes included: hospital admissions, emergency room, family doctor and specialist visits. IFM was categorized as exclusively breastfed, mixed fed and exclusively formula fed. Descriptive statistics and multivariate analysis were performed to examine the relationship between IFM, maternal and child characteristics and costs associated with HSU.

**Results** The sample included 160 mother infant dyads who consented to the data linkage. Mothers were Caucasian (95.6%), 26 years or older (95%), partnered (97.5%), living in a household with income greater than \$30,000 CAN (98.1%) with a post-secondary education (97.5%). At one month 67% were exclusively breastfeeding, 20% were mixed feeding, and 13% were exclusively formula feeding. Overall \$315,235 was spent on healthcare service use for the sample of healthy full-term infants during their first year of life. Generalized linear modelling was performed to assess the effect of IFM on costs associated with HSU adjusting for confounders. When compared to exclusive breastfeeding, exclusive formula and mixed feeding were found to be significant predictors of the total costs associated with HSU during the first year of life ( $p < 0.05$ ), driven by costs of hospital admissions.

**Conclusions** Due to the human and economic burden associated with not breastfeeding, policies and programs that support and encourage breastfeeding should be a priority for governments and regional health authorities.

## Background

The importance of breastfeeding for infant health has been universally acknowledged and studied for decades. Human breastmilk offers a unique matrix of compounds for optimal growth, health and development in a newborn child [1]. Studies show that breastfeeding reduces the rates of infant morbidity and mortality, as well as decreases the risk of chronic illnesses in childhood [2]. Breast milk contains the immunological mechanisms that protect infants against common infections in infancy, as well as chronic diseases later in life [3,4,5]. Further evidence suggests the composition of breastmilk provides protection in the early months of life against infection severe enough to require hospitalization [6].

The World Health Organization (WHO) and Health Canada recommend mothers exclusively breastfeed their infants to 6 months of age, with continued breastfeeding with complementary foods to 2 years of life and beyond [7,8]. The recommendations by WHO are evidenced by numerous studies conducted worldwide that demonstrate the benefits of breastfeeding. There are also economic benefits associated with increased breastfeeding rates due to reduction in common infections, resulting in a cost savings from decreased use of associated healthcare services. Previous research in developed countries has demonstrated the economic benefit of increasing breastfeeding rates [9-12]. Bartick et al., showed that if 90% of infants were exclusively breastfed to the recommended 6 months, \$17 billion US dollars would be saved annually: \$3 billion in direct medical costs, with an additional cost savings of \$14.2 billion due to premature death due to reductions in ovarian and breast cancer deaths [9]. Another study conducted in Australia estimated hospital system costs of \$1-2 million annually for the treatment of common childhood infections (i.e., gastrointestinal and respiratory illness, otitis media, eczema and necrotizing enterocolitis) due to insufficient breastfeeding. The authors report the Australian healthcare system could save \$60-120 million dollars if breastfeeding rates increased from their current rate of 10% exclusively breastfeeding to 90-95% [10]. A study conducted in the United Kingdom estimated that approximately £26.8 million could be gained annually by avoiding the costs of treating four acute infections (i.e., gastrointestinal and lower respiratory tract infections, acute otitis media in infants, necrotizing enterocolitis in preterm babies) and breast cancer in women, if EBF rates increased to 65% at four months and 100% of babies were breastfed at hospital discharge [11].

In Canada, little is known about the economic impact of increasing breastfeeding rates, as few studies have examined the impact of infant feeding mode (IFM) on HSU [13-16]. Two studies concluded that breastfeeding was strongly protective against infections severe enough to require hospital admission; however, both studies were small and focused on Indigenous populations [13-15], and neither study conducted a cost analysis related to hospital admissions, emergency room (ER) visits or physician consultations. Further studies are required to investigate HSU and the costs associated in a Canadian context in order to better understand where an investment in interventions is needed to reduce the use and unsustainable expenditures.

This is critical as reports have examined Canada's healthcare performance, ranking us among the lowest of 11 developed countries [17]. The commonwealth report collects information from a variety of sources on a standardized set of metrics, based on care process, access, administrative efficiency, equity and healthcare outcomes. Within these categories, Canada has scored poorly in care process, equity and healthcare outcomes. The primary drivers of our low ranking includes Canada's comparatively higher infant mortality rate, long wait times for the ER and specialists, lack of availability of after-hours care, unreliable coverage for healthcare claims, and the high prevalence of chronic conditions [17]. With regards to healthcare expenditures, with exception of the Territories, the province of Newfoundland and Labrador (NL) reported the highest per capita healthcare expenditure in Canada, of \$7,443 [18]. Per-person healthcare spending is even higher for infants, in 2014 the per-capita cost of medical services for infants in their first year of life was \$10,800 [18].

In addition, NL has the lowest breastfeeding initiation rates (71.9%) and the lowest six-month exclusive breastfeeding duration rates (13%) in Canada [19,20]. Although breastfeeding initiation rates in the province have improved over the last 30 years (35.3 to 71.9%), most women stop breastfeeding before 6 months [Personal Communications 2019, Perinatal Program NL]. With high healthcare expenditures and low breastfeeding duration rates, we sought to examine the impact of IFM on HSU and related costs during an infant's first year of life.

## Methods

Data collected from the *Feeding infants in Newfoundland and Labrador* (FiNaL) prospective cohort study were linked using the infant's health insurance number provided by the mother with administrative databases provided by the NL Centre for Health Information (NLCHI) to examine HSU and related costs by IFM.

## The FiNaL Study

The *Feeding infants in Newfoundland and Labrador* (FiNaL) Study was conducted to evaluate maternal attitudes and infant feeding practices in NL Canada through the administration of questionnaires at three time periods (phase 1,2,3). Methods have been previously published [21-23]. In brief, pregnant women in their third trimester of pregnancy (phase 1, n = 1283) were enrolled in the FiNaL Study and filled out a prenatal questionnaire. Additional questionnaires were administered postnatally at 1-3 months (phase 2, n = 658) and 6-12 months (phase 3, n = 554). Information including prenatal education, birth experience, feeding mode, psychosocial factors, socioeconomic factors and social supports were collected at each phase. Of the mothers who filled in all three surveys (n = 554), a sub-sample consented to being enrolled in the HSU data linkage study which was carried out in one region of NL.

Inclusion criteria for the FiNaL Study included: expectant mothers in their 3<sup>rd</sup> trimester of pregnancy, who were 18 years or older, English-speaking living in NL who gave birth to a full term healthy infant. Recruitment was carried out at prenatal classes, in offices of family physicians, nurse practitioners, obstetricians and through public health nurses and via social media outlets (i.e., Facebook) and posters. Participants were also recruited through telephone or email contact with a member of the research team in response to social media and posters placed in community settings. The questionnaires were completed in paper form (returned in postage-paid envelopes), by telephone or on-line by using Survey-monkey. The sub-sample for the HSU study met the larger study inclusion criteria.

## HSU Sub-sample

Mothers residing in the Eastern Health region of NL who were part of the FiNaL Study and had completed phase 3 were invited to participate in the HSU study and provided their infants health insurance number for the data linkage. Maternal and infant characteristics were chosen based on known associations with

IFM and based on information provided through the FiNaL Study. The FiNaL Study. These included demographic information on maternal age, income, marital status, smoking, parity (previous live births), delivery method, ethnicity, and socioeconomic status.

## Administrative data

The series of administrative data was created by the Health Analytics and Evaluation Services Department. Individuals level record data were extracted from the Provincial Discharge Abstract Database (PDAD) for hospital admissions, NLCHI Live Birth System (LBS) for demographics and infant characteristics, MCP Fee-for-Service Physician Claims (FFS) for family doctor and specialist visits, and the ER Module of the MediTech database (Eastern Health) for ER visits.

The PDAD contains, demographic, administrative and clinical data collected at hospitals when patients are discharged from inpatient and surgical day care services. The FFS data includes clinical and administrative information submitted by physicians who treat beneficiaries of the province's Medical Care Plan (MCP) for reimbursement. The FFS data that is managed by the NLCHI is an extract of the master database managed by the provincial MCP program of the Department of Health and Community Services. The LBS contains demographic, administrative and clinical data related to all live births that occur in the province of NL, both resident and non-resident. These data are used primarily for research and to provide aggregate statistical information. The MediTech ER (MTER) data was provided to the Centre by Eastern Health via secure managed file transfer.

Administrative data provided the FFS claims for the total amount paid to physicians and specialists for visits and consults, while Resource Intensity Weights (RIW) and the Cost for a Standard Hospital Stay (CSHS) through the Canadian Institute for Health Information (CIHI) were used to cost hospital admissions provided by the NLCHI. Costs of the ER visits were provided by the NLCHI and averaged to cost the use in 2015 Canadian dollars across the Eastern Health Authority of NL. Costs to the emergency department includes total direct operating expenses from ER primary accounts and total ER client visits statistical secondary account (Average = Total Direct Expenses/Total ER Client Visits).

## Measures:

*Duration & Exclusivity of Breastfeeding:* IFM was defined according to the World Health Organization (WHO) and United Nations Children's Fund (UNICEF) criteria. 'Exclusive breastfeeding (EBF)' was used when infant received only breast milk (i.e., including breastmilk that has been expressed or from a wet nurse) and nothing else, except for oral rehydration solution (ORS), medicines and vitamins and minerals when needed. 'Mixed feeding' (MF) was classified as an infant receiving breastmilk and other food or liquid including water, non-human milk, and formula. 'Exclusive formula feeding' (EFF) was classified as the IFM when infants were fed only breastmilk substitutes. The exclusive breastfeeding rate was available to 1 month.

*Healthcare Service Use Outcomes:* The primary outcomes examined for HSU were: hospital admissions, emergency room, family doctor and specialist visits. Administrative data from the NLCHI was linked to provide a comprehensive dataset on healthcare service HSU use during the infant's first year of life. Costs examined reflect costs to the payer and examine direct HSU costs, over a one year time horizon of an infant's first year of life.

## Data Linkage

Deterministic linkage was used for linking the FiNaL Study and administrative data provided by the NLCHI. The infant's health insurance numbers were given a unique study identification code, which provided an easy method of linkage to the prospective cohort dataset upon return of the PDAD, FFS, LBS, and MTER datasets. Administrative datasets were structured, cleaned and formatted to easily link data from the FiNaL Study.

## Statistical Analysis

Descriptive statistics, either frequencies for categorical variables or means (SD) for continuous variables were presented to compare baseline maternal characteristics and HSU outcomes associated with IFM. Both univariate and multivariate generalized linear modelling was used to compare HSU, direct medical costs, and maternal and child characteristics between the exposure of IFM. Kruskal-Wallis (KW) Tests were used to compare medians of continuous variables, and chi square tests were used to compare proportions of binary and categorical variables. KW tests were selected as it does not require the groups to be normally distributed and is more stable to outliers.

The total itemized cost of billable claims for visits to each healthcare professional were summed using the claims provided by the NLCHI. Means (SD), medians (interquartile ranges), min and max and total costs associated with each healthcare professional for the total group and by IFM were calculated. Costs were converted to 2015 Canadian dollars, as all resource intensity weights (RIW) provided by the NLCHI and cost per standard hospital stay (CSHS) used were for the 2015 fiscal year. The average cost of an ER visit for the EH regional health authority was provided by the NLCHI and calculated using the average of the 2014/2015 and 2015/2016 fiscal years.

Due to the skewed HSU costs, both base case and robustness analyses were performed in the multivariate analysis. As a base case analysis generalized linear modelling (GLM) was used, following a gamma distribution and a log link function. The robustness check used GLM following an inverse gaussian distribution and a reciprocal function, following findings from the modified park test and box cox tests. Due to the size of the sample, variables with counts less than 10 (i.e. smoking status, education, income, age and marital status) were not included in the final model. Both the final models included IFM, residence, parity and delivery type as independent variables as they were significantly

associated with IFM, and total costs associated with HSU as the dependent variable. Statistical analysis was conducted using SPSS (IBM 25) software [24].

## Results

The FiNaL Study enrolled 1,283 expectant mothers in the third trimester living in the province of NL. From those participants, 51% ( $n = 658$ ) participated in the first postnatal survey (1–3 months postnatal, phase 2) and 43% ( $n = 554$ ) completed the second postnatal survey (6–12 months, phase 3). During phase 3 of the FiNaL Study, 362 (65.4%) mothers eligible for the HSU study were enrolled. Mothers residing in the Eastern Health region of NL who have already taken part in phase 3 of the FiNaL Study, phase 3 were invited to participate in this study and consented by providing their infants medical care plan number for the data linkage. Of them, 242 (67%) mothers consented to take part in the HSU study and returned their questionnaires on healthcare service use during the infant's first year of life, and 160 (44%) mothers provided their infants medical care plan number to be linked for the analysis. The participant recruiting process is illustrated in *Figure 1*.

The patient population consisted of births in the Eastern Health region of NL between 2012 and 2014. Maternal characteristics are reported in *Table 1*. The majority of mothers were Caucasian (95.6%), 26 years of age or older (95%), partnered (97.5%), living in a household with income greater than \$30,000 CAN (98.1%) and had a post-secondary education (97.5%). Based on those who did not take part in our HSU, those that were living in the Eastern Health Region and consented were more likely to be older, partnered, with higher levels of education and higher household incomes, residing in urban NL. IFM was categorized as exclusively breastfed, mixed fed or exclusively formula fed. At one month 67% were exclusively breastfeeding, 20% were mixed feeding, and 13% were exclusively formula feeding. Mean birth weight was 3523.5g (SD 455.8), with the majority of infants (80%) born the appropriate size for gestational age. There were no differences when examining gender, and appropriateness of size for gestational age (appropriate, small, or large) between groups of IFM,  $p > 0.05$ .

**Table 1. Maternal Characteristics (Frequency, n (%))**

<b>MATERNAL CHARACTERISTICS</b>	<b>PN1 Survey (N = 554)</b>	<b>No MCP (N= 394)</b>	<b>HSU [Admin] (N = 160)</b>	<b>P value*</b>
<b>Infant Feeding Mode</b>				
<b>EBF at 1 month</b>	291 (52.5%)	201 (51.0%)	107 (66.9%)	<b>0.003</b>
<b>Mixed Fed</b>	165 (29.8%)	116 (29.4%)	32 (20.0%)	
<b>EFF</b>	98 (17.7%)	77 (19.5%)	21 (13.1%)	
<b>Mother's Age (&gt; 26 years)</b>	494 (89.2%)	344 (86.8%)	152 (95.0%)	<b>0.005</b>
<b>Marital Status (Married/Partnered)</b>	518 (93.7%)	362 (92.1%)	156 (97.5%)	<b>0.018</b>
<b>Education Level (Post-Secondary)</b>	510 (92.1%)	354 (89.8%)	156 (97.5%)	<b>0.003</b>
<b>Household Income (&gt; 30,000 CAN\$)</b>	520 (93.9%)	363 (92.1%)	157 (98.1%)	<b>0.008</b>
<b>Parity (Primiparous)</b>	316 (57.2%)	218 (55.6%)	98 (61.3%)	0.224
<b>Type of Delivery (Vaginal)</b>	403 (73.0%)	286 (73.0%)	117 (73.1%)	0.968
<b>Smoking Status (Current)</b>	18 (3.20%)	16 (4.1%)	2 (1.30%)	0.091
<b>Dwelling Area (Urban)</b>	253 (45.7%)	136 (44.9%)	117 (73.1%)	<b>0.0000</b>
<b>Ethnicity: Caucasian</b>	514 (94.5%)	362 (94.0%)	151 (95.6%)	0.478
<b>Ethnicity: Other (i.e., Asian, Aboriginal, Afro-Canadian)</b>	30 (5.5%)	23 (5.9%)	7 (4.4%)	

\*P Value compares those that took part in the HSU study (n=160) to those that did not (n=394)

## Common infections during infancy

In their first year of life, 81.6% of infants ( $n = 133$ ) had at least one type of infection; 29% (29) an upper respiratory tract infection, 22% (22) an ear infection, 20% (21) had the common cold, 12% (12) had thrush, and 13% (13) diagnosed with atopic dermatitis. In descending order, the highest frequency of billable claims was: no specific illness diagnosed at the visit ( $n = 591$ , 41.2%), signs and symptoms not otherwise diagnosed as an infection or disease ( $n = 225$ , 15.7%), upper respiratory tract infection ( $n = 92$ , 6.4%), otitis media ( $n = 61$ , 4.3%), common cold ( $n = 49$ , 3.4%), disorders of eyes and ears ( $n = 46$ , 3.2%), thrush ( $n = 46$ , 3.2%), and atopic dermatitis ( $n = 37$ , 2.6%).

## Healthcare Service Use

Table 2 presents the frequency of healthcare provider visits for the total sample and by IFM. The majority (96.8%) of infants were seen by a family doctor ( $n = 151$ ) within their first year of life, irrespective of feeding mode. Over half (59%) of the infants ( $n = 92$ ) were seen by a specialist, which included visits to pediatricians, pediatric cardiologists, dermatologists, otolaryngologists, diagnostic radiologists and plastic surgeons. MF and EFF infants has a higher percentage of specialist visits (65.6% and 65.0%, respectively), while 55.8% of EBF infants visited a specialist during the first year.

	<b>Total (n=159)</b>	<b>EBF (n = 106)</b>	<b>Mixed (n= 32)</b>	<b>Formula (n=21)</b>
<b>Hospitalization (n=159)</b>	12 (7.5)	3 (2.8)	5 (15.2)	4 (19.0)
	<b>Total (n=160)</b>	<b>EBF (n = 107)</b>	<b>Mixed (n= 32)</b>	<b>Formula (n=21)</b>
<b>ER Visit (n=160)</b>	83 (51.9)	57 (53.3)	18 (56.3)	8 (38.1)
	<b>Total (n = 156)</b>	<b>EBF (n = 104)</b>	<b>Mixed (n= 32)</b>	<b>Formula (n=20)</b>
<b>Family Doctor (n=156)</b>	151 (96.8)	100 (96.2)	32 (100.0)	19 (95.0)
<b>Any Specialist (n=156)</b>	92 (59.0)	58 (55.8)	21 (65.6)	13 (65.0)
<b>Pediatrician</b>	21 (13.5)	15 (14.4)	4 (12.5)	2 (10.0)
<b>Pediatric Cardiologist</b>	8 (5.1)	5 (4.8)	2 (6.3)	1 (5.0)
<b>Dermatologist</b>	11 (7.1)	4 (3.8)	3 (9.4)	4 (20.0)
<b>Diagnostic Radiologist</b>	68 (43.6)	42 (40.4)	17 (53.1)	9 (45.0)
<b>Plastic Surgeon</b>	2 (1.3)	0 (0.0)	1 (3.1)	1 (5.0)
<b>Otolaryngologist (ENT)</b>	9 (5.8)	6 (5.8)	2 (6.3)	1 (5.0)

There were 12 infants hospitalized at least once during the first year of life. The length of stay (LOS) for these hospital admissions ranged from 1–7 days. Total LOS (in days) across the first year of life including time spent in hospital during the first days of life can be found in *Supplementary Material*. Most commonly, hospital admissions were related to respiratory complications (i.e., upper respiratory tract infection, croup, asthma) (see *Supplementary Material*). EBF infants had fewer hospital admissions (2.8%) than that of MF (15.2%) and EFF (19.0%),  $p < 0.05$ .

Half of infants ( $n = 83$ , 51.9%) were brought to the ER at least once during the first year of life. More MF infants had ER visits (56.3%) than that of EBF (53.3%) and EFF infants (38.1%). MF and EBF infants had significantly more ER visits when compared to EFF infants,  $p < 0.01$ . Triage levels for unique ER visits are outlined in *Supplementary Material*, where 43.6% were non-urgent or less urgent cases, 35.1% were urgent cases, 3.6% were emergent cases, and 17.6% had no identified triage level in the database.

## Cost Associated

The direct healthcare expenditures of 160 healthy full-term infants during their first year of life amounted to \$315,235.56. When considering costs associated with HSU post discharge from birth, the expenditures equated to \$127,373.41. The highest percentage spent on HSU was for hospital admissions, 37.6%, (\$47,867.56), where overall costs per infant ranged from \$1430.60–\$12,664.22 when examining hospitalizations post birth, and \$900.35–\$14,329.37 when including the cost of birth. This was followed by visits to the family doctor and specialists which were 30.1%, (\$38,271.88) and 13.7% (\$17,254.3) respectively, where costs per infant ranged from \$6.40 (a single diagnostic test)–\$2065.68 (a combination of visits). Costs to the ER made up 18.8% (\$23,805.5), and costs per infant ranged from \$147.86–\$1478.6 (*Table 3*). There were no differences between infant feeding groups when comparing physician services or ER visits,  $p > 0.05$ , while EFF infants had higher expenses for hospital admissions than other feeding groups (MF, EBF),  $p = 0.010$ .

<b>Table 3. Total Costs Associated with each Healthcare Provider, By Infant Feeding Mode</b>					
	<u><b>Total (n = 156).</b></u>	<u><b>EBF (n = 104).</b></u>	<u><b>Mixed (n= 32).</b></u>	<u><b>Formula (n=20).</b></u>	<u><b>P Value</b></u>
<b>Hospitalizations (n=159)</b>	\$47,867.56	\$5,132.90	\$24,823.42	\$17,911.24	0.141
<b>Hospitalizations (n=159) (Including Birth)</b>	\$235,883.92	\$128,434.74	\$64,126.26	\$43,322.92	<b>0.015</b>
<b>Emergency Room (n=160)</b>	\$23,805.50	\$16,264.60	\$4,731.52	\$2,809.34	0.672
<b>Family Doctor &amp; Specialist (n=156)</b>	\$55,546.18	\$36,465.19	\$10,949.68	\$8131.31	0.972
<b>Total Costs:</b>	\$127,373.41	\$58,345.41	\$40,255.41	\$28,851.89	
<b>Total Costs (Including birth):</b>	\$315,235.56	\$181,164.53	\$79,807.46	\$54,263.57	
*P Value compares all three groups of Infant Feeding Mode					

EFF infants had higher average spending associated with all hospitalizations (including birth), as well as family doctor and specialist visits, \$2063 and \$406 respectively. While MF infants had higher average spending associated with hospital admissions post birth (\$4964), and EBF infants, had higher average spending associated with visits to the ER (\$152) during their first year of life (*Table 4*).

**Table 4. Mean (SD), Median (IQR), Min & Max of the Total Costs Associated with each Healthcare Provider, By Infant Feeding Mode**

<u>Hospitalizations</u>	<u>Total (n = 156).</u>	<u>EBF (n = 104).</u>	<u>Mixed (n= 32).</u>	<u>Formula (n=20).</u>	<u>P Value</u>
MEAN (SD)	3988.96 (3188.99)	1710.97 (122.67)	4964.68 (4415.57)	4477.81 (2046.37)	0.141
MEDIAN (IQR)	3040.90 (3778.43)	1781.79 (213.48)	3805.69 (6037.35)	4580.27 (3728.46)	
MIN - MAX	1430.60 - 12,664.22	1569.31 - 1781.79	1430.60 - 12,664.22	2402.84 - 6347.87	
<u>Hospitalizations</u> (including birth)	<u>Total (n = 156).</u>	<u>EBF (n = 104).</u>	<u>Mixed (n= 32).</u>	<u>Formula (n=20).</u>	-
MEAN (SD)	1483.55 (1434.19)	1211.65 (492.40)	2003.95 (2519.00)	2062.99 (1990.91)	0.015
MEDIAN (IQR)	1202.99 (530.25)	900.35 (481.70)	1382.06 (706.16)	1382.06 (851.18)	
MIN - MAX	900.35 - 14,329.37	900.35 - 3791.20	900.35 - 14,329.37	900.35 - 7501.69	
<u>Emergency Room Visits</u>	<u>Total (n = 156).</u>	<u>EBF (n = 104).</u>	<u>Mixed (n= 32).</u>	<u>Formula (n=20).</u>	-
MEAN (SD)	148.78 (220.31)	152.00 (214.42)	147.86 (246.27)	133.77 (218.83)	0.672
MEDIAN (IQR)	147.86 (147.86)	147.86 (295.72)	147.86 (147.86)	147.86 (221.79)	
MIN - MAX	147.86 -1478.6	147.86 -1478.6	147.86 -1330.74	147.86 - 739.30	
<u>Family Doctor &amp; Specialist Visits</u>	<u>Total (n = 156).</u>	<u>EBF (n = 104).</u>	<u>Mixed (n= 32).</u>	<u>Formula (n=20).</u>	-
MEAN (SD)	356.07 (288.42)	350.63 (266.23)	342.18 (254.37)	406.57 (430.91)	0.972
MEDIAN (IQR)	300.12 (307.85)	296.73 (339.74)	291.40 (307.30)	301.92 (194.61)	
MIN - MAX	6.40 - 2065.68	6.40 - 1678.90	25.63 - 1244.26	54.14 - 2065.68	

\*P Value compares all three groups of Infant Feeding Mode

Table 5 outlines HSU spending during quartiles of the first year of life. Apart from the costs of hospitalizations during the first days of life, when examining HSU after discharge, the highest percentage of healthcare spending remained within an infant’s first three months of life (44.0%, \$56,054).

<b>Table 5. Number of visits and Total Costs Associated with each Healthcare Provider (Quartiles of The Infant’s First Year of Life)</b>						
	<b>Hospital Admissions</b>	<b>ER Visits</b>	<b>Family Doctor Visits</b>	<b>Specialists Visits</b>	<b>COSTS</b>	<b>COSTS (including birth)</b>
<b>0-3m</b>	8	61	486	152	\$56,054.651	\$243,923.62
<b>4-6m</b>	3	32	255	66	\$23,594.20	\$23,594.20
<b>7-9m</b>	2	36	226	51	\$19,058.12	\$19,058.12
<b>0-12m</b>	1	32	150	38	\$28,659.62	\$28,659.62
					\$127,366.60	\$315,235.56

## Multivariate Analysis

Both generalized linear regression models are presented in Table 6. IFM remained a predictor of total costs associated with HSU during an infant’s first year of life, after adjustment for residence (urban vs. rural areas), delivery type (vaginal vs. caesarean section), and parity (primiparous vs. multiparous). With EBF to 1 month as our reference category, both MF and EFF were significant predictors of higher total HSU costs. No other factors were significantly associated with total costs.

**Table 6. Generalized Linear Modelling of Total Healthcare Costs During The Infant's First Year of Life**

	Base Case Analysis			Robustness Analysis		
	Coefficient (SE)	95% CI	P Value	Coefficient (SE)	95% CI	P Value
<b>Constant</b>	7.408 (0.889)	7.234 - 7.582	0.000	1774.81 (159.48)	1462.24 - 2087.38	0.000
<b>Infant Feeding Mode</b>	0.383 (0.118)	0.152 - 0.615	0.001			0.009
<b>EFF</b>	0.408 (0.099)	0.212 - 0.603	0.000	806.30 (309.37)	199.94 - 1412.66	0.001
<b>MF</b>	(Referent)	.	.	858.26 (254.29)	359.80 - 1356.67	.
<b>EBF</b>	(Referent)	.	.	(Referent)	.	.
<b>Residence</b>						
<b>Rural Area</b>	0.124 (0.090)	-0.52 - 0.301	0.167	138.103 (158.248)	-172.06 - 448.26	0.383
<b>Urban Area</b>	(Referent)	.	.	(Referent)	.	.
<b>Parity</b>	0.061 (0.080)	-0.096 - 0.218	0.444			0.844
<b>Multiparous</b>	(Referent)	.	.	-27.842 (141.727)	-305.62 - 249.94	.
<b>Primiparous</b>	(Referent)	.	.	(Referent)	.	.
<b>Delivery Type</b>	-0.042 (0.088)	-0.214 - 0.130	0.629			0360
<b>Vaginal</b>	(Referent)	.	.	-148.298 (162.125)	-466.06 - 169.46	.
<b>Caesarean Section</b>	(Referent)	.	.	(Referent)	.	.

\*EFF (Exclusive Formula Feeding), MF (Mixed Feeding), EBF (Exclusive Breastfeeding). Base Case Analysis (Gamma Distribution with log link function) and Robustness Analysis (Inverse Gaussian Distribution with Reciprocal function)

## Discussion

In the present study, 160 mother-infant dyads were enrolled in a data linkage to examine the impact of IFM on HSU and related costs during the first year of life. Overall, the majority of infants were seen by family doctors, specialists and the ER at least once during their first year. Cumulative HSU cost in the first year of life for all healthy full-term infants in one provincial region in Canada was \$315, 235.56, including cost of birth. The highest percentage spent on HSU was for hospital admissions, followed by family doctor, ER and specialist visits. Higher HSU costs were associated with EFF infants when examining hospitalizations (birth and admissions), and significant differences were found between IFM when examining the total costs associated with HSU during the first year of life.

Compared to previous studies in other countries, our findings are consistent when examining HSU costs associated with IFM. Studies have shown that infants who had early exposure to formula experienced higher volumes of visits to family doctors, infectious episodes and hospital admissions [25-29]. These studies reveal how infants that are predominantly or exclusively breastfed have a lower risk of common childhood infections, and therefore experience fewer healthcare professional visits and consults. Similarly, our study found differences when comparing IFM, where EFF infants had higher average spending associated with hospital admissions, family doctor and specialist visits, and both MF and EFF infants were predictive of higher total HSU costs. The WHO recommends EBF for 6 months for full health benefits, and our study demonstrates that even EBF to 1 month can have a significant impact on reducing the economic burden to the health systems in terms of HSU and direct costs.

Previous research in Canada on the protective effects of breastfeeding in infants has shown substantial benefits against childhood diseases [13,14] and that breastfeeding promotion programs could be a critical intervention. Estimation of healthcare services use, and related cost is necessary for developing cost-effective interventions to improve breastfeeding rates. This information could help policymakers regarding the development of educational policies and development of breastfeeding support programs. Further research is needed to determine the cost of services utilized in the first year of life extrapolated provincially and how this relates to IFM as this information provides empirical data around the impact of not breastfeeding. Other countries have shown the impact of educational campaigns, training programs, and laws and regulations around the use of breastmilk substitutes and its impact on improving breastfeeding rates [30]. An integrated provincial breastfeeding program should have the key components that include training programs, communications for health promotion at a population level, political will and legislation, advocacy, evaluation research and appropriate funding to achieve desired rates of breastfeeding.

## **Strengths and Limitations**

There are a number of strengths of the current study. To our knowledge, this is the first time estimates of the cost of HSU by IFM of a sample of full term healthy infants living in Canada have been conducted. Our ability to link maternal and child data allowed us to examine the specific characteristics that are associated with higher HSU costs among infant's (i.e., mother's parity, type of delivery and residence), and control for these covariates in our multivariate analysis. The administrative database allowed for the calculation of individual level data and the direct costs associated with HSU through the claims of family doctors and specialists. Linking the databases to information collected in the FiNaL Study allowed for the examination of maternal and infant characteristics and their association with IFM. Compared with respondents who were included in the analyses, those who were excluded because residence or missing data were younger, less educated, rural residents and living in lower-income households. Evidence showed that those characteristics of mothers were associated with a shorter period of exclusive breastfeeding in Canada [31]. This might have led to an underestimation of the disease incidence and frequency of healthcare usage.

Our results are based on a relatively small sample size, however the socio-demographic characteristics of the HSU study respondents were similar with those of the participants of the FiNaL Study, a province wide study on over 1200 expectant mothers. Further analysis of the results showed no difference between the non-responding eligible mothers and the participants of this study. The FiNaL Study had a selection bias of higher education and household income mothers and the participants of this study are representative of those mothers in the province of NL. Notably, due to challenges with collecting exposure data on feeding mode and its duration, our exclusive breastfeeding rate was considered valid and reliable for the first month only. The data on exposure were self-reported by mothers and therefore could result in misclassification. Based on the health insurance claims in the province of NL, the administrative databases can only collect information on fee for service physicians. Therefore there are a proportion of family doctors and pediatricians that are salaried that we would not have healthcare service use on. The Newfoundland and Labrador Medical Association (NLMA) membership statistics concluded that for our province as a whole, 55% of physicians are fee for service, while others are salaried or receive alternative payment plans which would not be picked up in our database [Personal Communication 2019, NLMA]. Membership statistics for the Eastern Health Region were not available to compare the proportion of fee for service or salaried physicians. Based on these provincial rates, our final results would be an underestimation of the true costs associated with healthcare service use. In addition, although we used a health systems perspective to examine the costs, not all costs were included in our analysis, such as the costs of medications.

## Conclusion

In one region of Canada, exclusive formula and mixed feeding were found to be significant predictors of the total costs associated with HSU during the first year of life. Due to human and economic burden associated with no breastfeeding, policies and programs that support and encourage breastfeeding should be a priority for governments and regional health authorities.

## List Of Abbreviations

BFRWG, Breastfeeding Research Working Group; CMG, Case Mix Group; CSHS, Cost of a Standard Hospital Stay; EBF, Exclusively Breastfed; EFF, Exclusively Formula Fed; ER, Emergency Room; FiNaL Study, Feeding Infants in Newfoundland and Labrador; HSU, Healthcare Service Use; IFM, Infant Feeding Mode, KW, Kruskal-Wallis; LBS, Live Birth System; PDAD, Provincial Discharge Abstract Database; FFS, Medical Care Plan Fee-for-Service Physician Claims; MF, Mixed Fed; NLCHI, Newfoundland and Labrador Centre for Health Information; NL SUPPORT, Newfoundland and Labrador Support for People and Patient Oriented Research Trials Unit; TPMI, Translational Personalised Medicine Initiative; RIW, Resource Intensity Weight; UNICEF, United Nation's International Children's Emergency Fund; WHO, World Health Organization

## Declarations

## **Ethics Approval & Consent to Participate**

The study received ethical approval from the Provincial Human Research Ethics Authority (HREA)

# 2017.226

## **Consent for Publication**

Not applicable

## **Availability of Data & Materials**

The administrative data that support the findings of this study are available from the Newfoundland and Labrador Centre for Health Information (NLCHI) but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the NLCHI.

The prospective cohort (FiNaL Study) datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## **Competing Interests**

The authors declare that they have no competing interests

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## **Authors' Contributions**

LT and LN conceived the study concept. AT was responsible for analysis of data with input from LT, ZG and HVN. AT wrote the initial draft with critical revisions by LT. All authors reviewed the manuscript. All authors were involved in interpretation of the data. All authors approved the manuscript. Work previously completed on the FiNaL Study was done by SC, WM, BH, NG, LN and LT.

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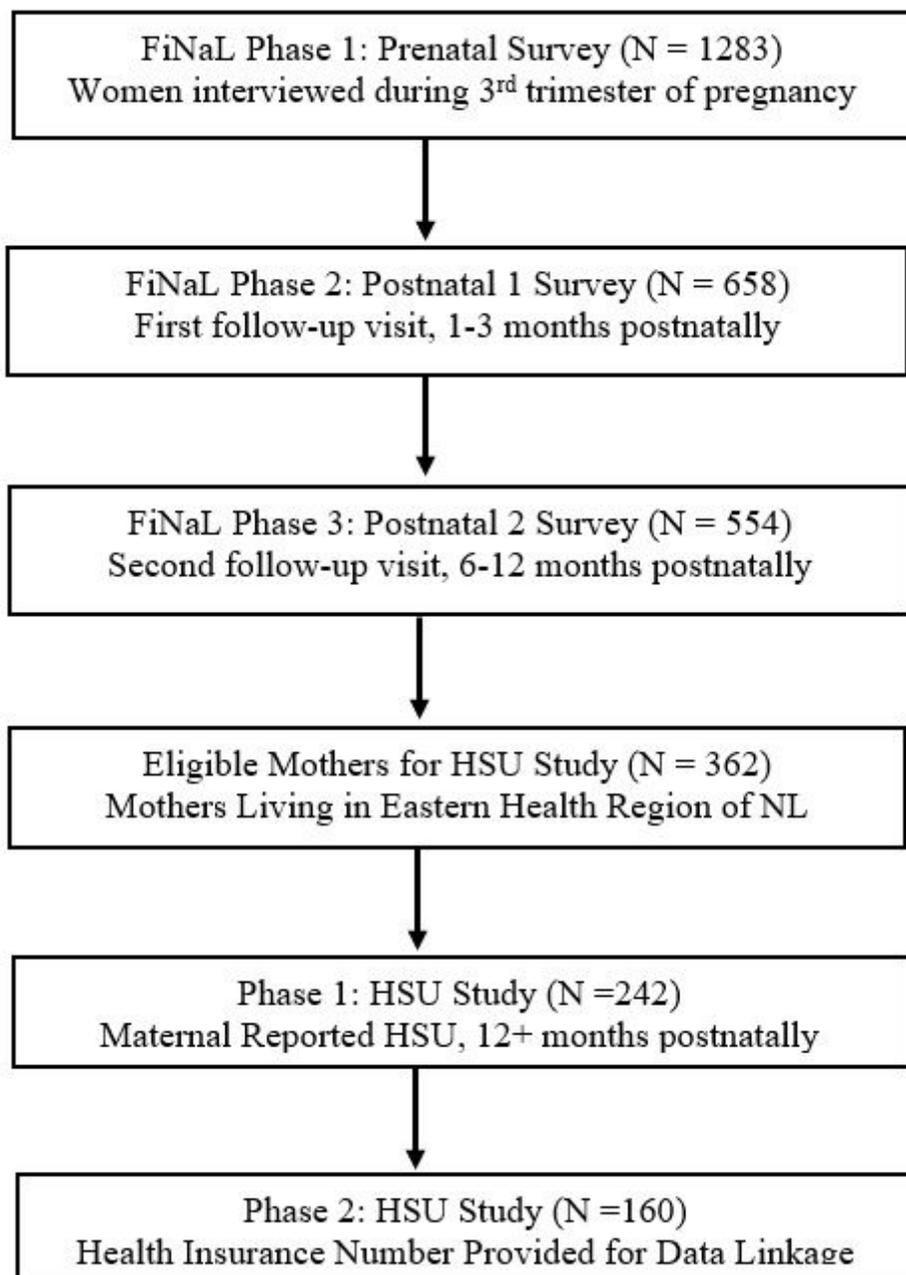
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## Figures



**Figure 1**

Flowchart of participant recruitment process.

## Supplementary Files

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