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ORIGINAL ARTICLE

An economic evaluation on sub-optimal breastfeeding in Hong Kong: Infant health outcomes and costs

Lai Ling Hui[1,2] | Emily Liao[1] | Karene Hoi Ting Yeung[2] | Carlos K. H. Wong[3,4,5] | Tharani Loganathan[6] | Edmund Anthony S. Nelson[2,7]

[1]Department of Food Science and Nutrition, The Hong Kong Polytechnic University, Hong Kong, China

[2]Department of Paediatrics, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong, China

[3]Department of Pharmacology and Pharmacy, LKS Faculty of Medicine, The University of Hong Kong, Hong Kong, China

[4]Department of Family Medicine and Primary Care, School of Clinical Medicine, LKS Faculty of Medicine, The University of Hong Kong, Hong Kong, China

[5]Laboratory of Data Discovery for Health (D24H), Hong Kong Science and Technology Park, Hong Kong, China

[6]Centre for Epidemiology and Evidence-based Practice, Department of Social and Preventive Medicine, University of Malaya, Kuala Lumpur, Malaysia

[7]School of Medicine, The Chinese University of Hong Kong, Shenzhen, China

Correspondence
Lai Ling Hui, Department of Food Science and Nutrition, TU315, 3/F, Core T, Hong Kong Polytechnic University, Hung Hum, Kowloon, Hong Kong, China.
Email: llhui@polyu.edu.hk

Edmund Anthony S. Nelson, School of Medicine, The Chinese University of Hong Kong Shenzhen, Guangdong 518172, China.
Email: tonynelson@cuhk.edu.cn

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Abstract

Aim: This study estimated the healthcare cost savings for the government due to the prevention of gastroenteritis (GE) infections and lower respiratory tract infections (LRTI) in the first year of life, attributed to an increase in the exclusive breastfeeding rate at 4 months in Hong Kong.

Methods: The model used the best available data inputs, with uncertainty considered using probabilistic sensitivity analysis. We additionally assessed the impact of neonatal jaundice (NNJ) on the economic benefits of increasing exclusive breastfeeding rates.

Results: During 2010–2019, five admissions for GE and three admissions for LRTI per 1000 births would have been prevented in the first year of life if the exclusive breastfeeding rate at 4 months increased from the actual levels (~15–30%) to 50%, resulting in annual healthcare cost savings of USD1.05 (95% CI 1.03–1.07) million/year. The cost saving would reach USD1.89 (95% CI 1.86–1.92) million/year if the exclusive breastfeeding rate at 4 months increase to 70%. However, if higher NNJ admissions during 7–90 days related to more exclusive breastfeeding are considered, the cost saving would reduce by 60%.

Conclusion: Our findings can guide policymakers in allocating budget and resources for breastfeeding promotion in Hong Kong. The prevention of unnecessary NNJ admissions would maximise the economic benefits of exclusive breastfeeding at 4 months.

KEYWORDS
breastfeeding, cost saving, economic evaluations, hospital admission, neonatal jaundice

Abbreviations: EBF, exclusive breastfeeding; GE, gastroenteritis; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; LRTI, lower respiratory tract infection; NNJ, neonatal jaundice.

1 | BACKGROUND

The health benefits of breastfeeding for children are well-established. Yet, exclusive breastfeeding (EBF) during the first 6 months of infancy and continued breastfeeding for up to 2 years and beyond, as recommended by the World Health Organisation, is not the norm in many places, including Hong Kong. During the 1980–90s, Hong Kong had one of the lowest breastfeeding rates in the world.[1] Efforts have been made to improve breastfeeding support in hospitals,[2] including a policy change in 2006 to stop hospitals from accepting free infant formula, and breastfeeding rates at hospital discharge increased from 19% in 1992 to higher than 80% since 2011.[3] However, EBF rates at 4 and 6 months were still low (respectively 29% and 26% in 2018).[4] The large gap in attaining optimal breastfeeding practices highlights the need to further enhance policy to protect, promote and support breastfeeding.

Breastfeeding benefits the health of both children and mothers. Increasing breastfeeding rates, both exclusive and any breastfeeding, will reduce government healthcare costs for treating the paediatric and maternal diseases prevented by breastfeeding. From a governmental policy perspective, an economic evaluation of the healthcare costs attributable to suboptimal breastfeeding can guide budget allocation for breastfeeding promotion to maximise population health. The cost savings due to a reduction in hospital admissions for high disease-burden paediatric conditions in infancy, such as gastroenteritis (GE) infections and lower respiratory tract infections (LRTI), would be particularly impactful.[5]

Economic evaluations have shown that increased breastfeeding rates are cost-saving in a range of different settings, including the USA,[6–8] Mexico,[9] Europe,[10–12] Australia[13] and Southeast Asia.[14] The estimates are setting- and model- specific due to the differences in healthcare systems, healthcare costs, health-seeking behaviours, baseline breastfeeding rates and population structure. Although the incidence of neonatal jaundice (NNJ) increases with an increase in EBF rate, none of the previous economic evaluations considered it when estimating cost savings for an increase in breastfeeding rates.[15]

Here, we carried out an economic evaluation to assess paediatric hospital admissions averted and healthcare cost that would be saved due to an increase in the EBF rate at 4 months. We also additionally assessed the counterimpact of NNJ, the risk of which particularly increases with EBF, on the economic benefits of breastfeeding promotion.

2 | METHODS

We aimed to calculate the potential governmental cost saving attributed to a reduction in hospitalizations for GE and LRTI in the first year of life in Hong Kong if EBF rates at 4 months had been higher during 2010–2019, with and without considering the impact of NNJ.

Key notes

- None of the previous economic evaluations of breastfeeding considered the costs of treating neonatal jaundice.
- Our data showed that the cost savings to the government attributed to an increase in exclusive breastfeeding could be reduced by 60% due to more neonatal jaundice admissions associated with exclusive breastfeeding.
- The present economic evaluation suggests that preventing unnecessary neonatal jaundice admissions would maximise the immediate economic benefits of exclusive breastfeeding in Hong Kong.

2.1 | Perspective

This economic evaluation focused on governmental cost attributed to hospitalisations in the first year of life to implicate government budgeting for breastfeeding promotion. We did not consider societal costs associated with not breastfeeding.

2.2 | Hospital admissions, bed days and costs per bed day

There are eight public hospitals and 13 private hospitals in Hong Kong, providing in-patient hospital care for GE, LRTI and NNJ. The present analysis only considered the costs of admissions in public hospitals, which provide the majority of in-patient paediatric services and are heavily subsidised by the government. The average cost per bed day in the general paediatric wards in all public hospitals in each year during 2010–2019 was provided by the finance department in Prince of Wales Hospital.

The number of admissions due to GE, LRTI and NNJ and number of bed days per admission were obtained from aggregated in-patient discharge data capturing all admissions in public hospitals during 2010–2019 from the Hong Kong Hospital Authority. Admissions due to GE, LRTI and NNJ were identified using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) code (Table S1). We used the primary diagnosis of admission to avoid double counting (i.e., an infant suffering from both GE and LRTI during the same admission) and to eliminate nosocomial infection-related admissions. We assumed all admissions were to general paediatric beds, i.e., not to the more costly beds in neonatal or paediatric intensive care units.

2.3 | Time horizon and discount rate

We considered the protection from breastfeeding against GE and LRTI in the first year of life and its impact on NNJ in the first 3 months of life. We estimated costs for treating NNJ during 0–6, 7–30 and 31–90 days, as physiological NNJ during the first week of life could be unrelated to feeding mode, and prolonged jaundice is typically investigated after 2–4 weeks of age.[16,17]

A 0% discount rate was used for the cost in the first year of life. All costs are presented in 2020 price levels, and the inpatient costs per case were adjusted using the Consumer Price Index published by the Hong Kong Census and Statistics Department.

2.4 | Breastfeeding rate

Exclusive breastfeeding rates were obtained from Hong Kong biennial breastfeeding surveys and individual studies. We chose the EBF rate at 4 months as a measure of optimal scenarios after considering the local context. First, a previous local study[18] provided the evidence on the protection of EBF at 3 months against GE, and several meta-analyses showed protection was stronger with longer breastfeeding. Second, reliable data on EBF rates at 4 months in Hong Kong are available. Third, the statutory maternity leave in Hong Kong is 14 weeks, making the promotion of EBF for 4 months more achievable compared to 6 months.

2.5 | Economic modelling

We adopted a seven-step framework (Figure 1) that has been employed in previous similar economic evaluations on breastfeeding.[6,11,19,20] The input parameters are summarised in Table 1.

For each year, the base-case scenario represented the government expenditure on hospital admissions for selected diseases based on the actual number of hospital admissions, length of stay and bed costs with the actual breastfeeding rate in that year in Hong Kong, and three *hypothetical* optimal scenarios representing situations with, respectively, the EBF rate at 4 months increased from the base-case during 2010–2019 to 50%, 70% and 90%.

For each of the base-case and *hypothetical* optimal scenarios, we estimated the breastfed population and the non-breastfed population from the incidence of the diseases (assuming a child is admitted only once for the same condition) and the risk ratio in favour of breastfeeding abstracted from the literature, using the equations shown in Box 1 in Appendix S1.

The number of admissions averted due to an increase in breastfeeding rate (i.e., the healthcare cost attributable to sub-optimal breastfeeding) was the difference between *the base-case scenario* and each *hypothetical optimal scenario*. The governmental cost savings were obtained by multiplying the averted admissions by the

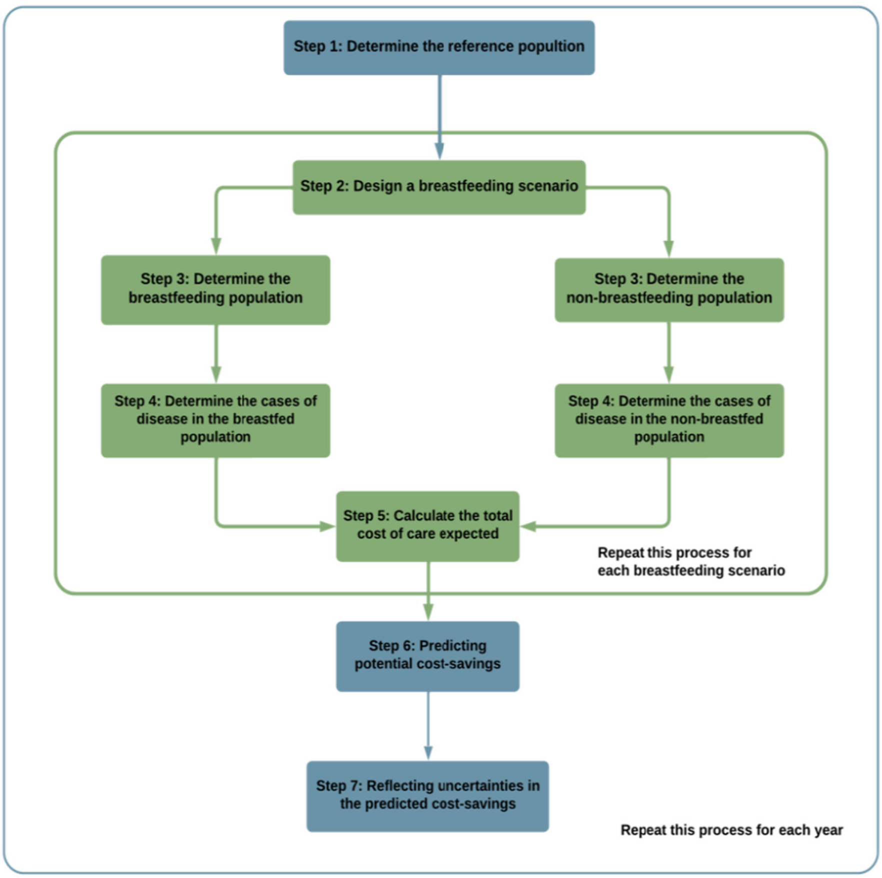

FIGURE 1 Schematic diagram and input parameters of the economic model.

TABLE 1 Input parameters[a] and source of data.

Input parameter	Point estimate	Uncertainty range	Distribution[b]	Source of data	Remarks
Number of births/year	52 900–95 500	N.A.	N.A.	Census and Statistics Department	Yearly figure in Figure 2A and Table S2
Rate of exclusive breastfeeding at 4 months (%)	14.8–30.7%	Table S3	PERT-Beta	Hong Kong breastfeeding survey and Lam 2014	Yearly figure in Figure 2B and Table S3
Relative risks					
GE-related hospital admissions	0.39	95% CI (0.18, 0.85)	PERT-Beta	Quigley et al.[22]	
LRTI-related hospital admissions	0.7	95% CI (0.49, 0.98)		Quigley et al.[22]	
NNJ related hospital admissions	3.39	95% CI (2.03, 5.68)		Leung et al.[15]	
Hospital admissions (per 100 000 birth)					
GE during 0–12 months	2062–3454	N.A.	N.A.	Hong Kong Hospital Authority	Yearly figure in Figure 2C and Table S4 ICD9 in Table S1
LRTI during 0–12 months	2513–4676	N.A.	N.A.		
NNJ		N.A.	N.A.		
0–6 days	9487–13 748	N.A.	N.A.		
7–30 days	4648–5966	N.A.	N.A.		
31–90 days	1285–3557	N.A.	N.A.		
Length of stay per admission[c,d] *(day)*					
GE	2.05–2.46	Q1: 1.32–1.66; Q3: 3.12–3.82	PERT-Beta	Hong Kong Hospital Authority	Yearly figure in Table S5
LRTI	2.98–3.57	Q1: 1.99–2.50; Q3: 4.51–5.14			
NNJ					
0–6 days	1.00–1.88	Q1: 0.13–0.79; Q3: 2.75–3.71			
7–30 days	0.13–0.17	Q1: 0.08–0.96; Q3: 0.96–1.00			
31–90 days	0.08–0.38	Q1: 0.04–0.21; Q3: 0.13–0.88			
Cost data (US$, 2020 price)					
Cost per hospital bed per day	720–977	N.A.	N.A.	Hong Kong Hospital Authority	Yearly figure in Table S6

Abbreviations: GE, gastroenteritis; LRTI, lower respiratory tract infection; NNJ, neonatal jaundice.

[a]Refer to Supplementary materials for input parameters in yearly value.

[b]Distribution in probabilistic sensitivity analysis.

[c]Q1 first quartile/25th percentile; Q3 third quartile/75th percentile.

[d]Length of stay (in days) per admission was calculated by the total hours of stay divided by 24. Aggregated data on average length of stay per admission was provided by the Hong Kong Hospital Authority.

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year-specific average length of stay and the year-specific average cost of a bed day.

2.6 | Probabilistic sensitivity analyses

The probabilistic sensitivity analysis was conducted to test the uncertainty of various parameters, including relative risks, actual breastfeeding rate, the cost of a bed day, the incidence of GE, LRTI and NNJ, and length of stay, with specified probabilistic distributions shown in Table 1.

2.7 | Deterministic sensitivity analyses

For the predicted cost savings for GE/LRTI, we also performed one-way analyses to assess the influence of different parameters (relative risks, length of stay, cost for public hospital admission and actual EBF rate) and presented the difference compared with estimates obtained from the base-case simulation when mean values of all parameters were used. Multi-way analyses were performed to show the results in the most cost-saving (best) case and the least cost-saving (worst) case simulations for the selected EBF rate.

3 | RESULTS

3.1 | Number of births, public hospital use and hospital expenditure during 2010–2019

The annual number of births in Hong Kong decreased from ~88 000–92 000 in 2010–2012 to about 50 000–60 000 in 2013–2019 (Figure 2A). The significant drop in births was due to a policy change in 2013 to stop women resident in mainland China from coming to Hong Kong to deliver unless their husbands were Hong Kong residents. EBF rates at 4 months increased from 19% in 2012 to above 26% since 2016. (Figure 2B).

The average yearly number of admissions of infants aged 0–12 months in public hospitals due to GE/LRTI was 1862/year and 2340/year, respectively, during 2010–2019. (Figure 2C) Infants

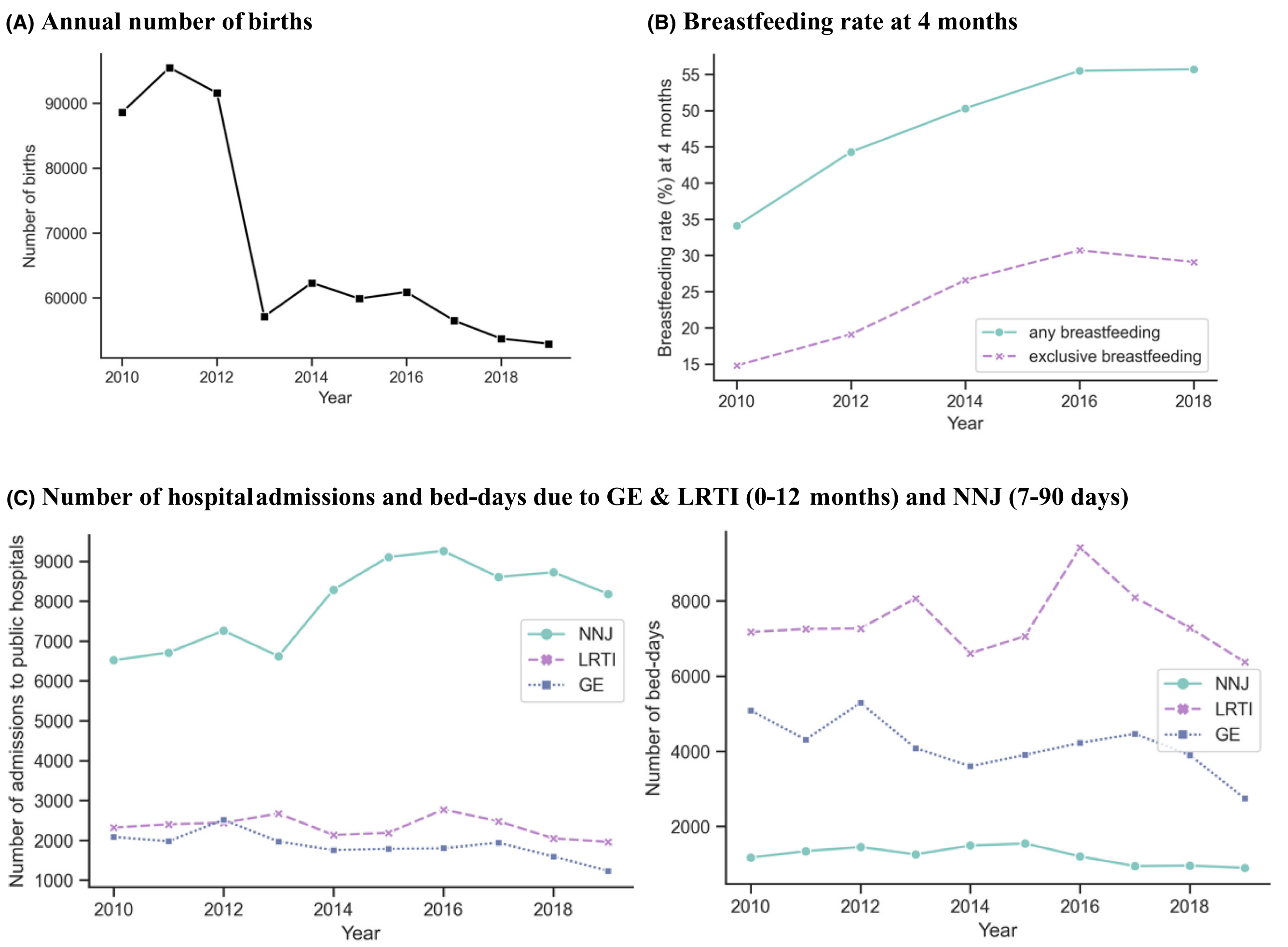

FIGURE 2 Secular trends in 2020–2019 of (A) number of births, (B) breastfeeding rates and (C) yearly number of hospital admissions and bed days for GE, LRTI and NNJ.

admitted had slightly longer hospital stays for LRTI (2.98–3.57 days/admission) than for GE (2.05–2 46 days/admission). Compared to GE/LRTI, there were more admissions due to NNJ (11 352/year for infants aged 0–6 days; 7927/year for infants aged 7–90 days), but the average length of stay was shorter (1.0–1.9 days/admission and 0.1–0.2 day/admission, respectively).

Hospitalisation for GE, LRTI (0–12 months) and NNJ (0–3 months) contributed to approximately 2.8%, 5.1% and 11.5% of total bed days of infants aged 0–12 months in public hospitals during 2010–2019, respectively. The annual cost for these hospitalizations for GE (USD 3.38 million/year) and LRTI (USD 6.08 million/year) in the first year of life was much lower than that for NNJ hospitalisation in the first 3 months of life (USD15.8 million/year), of which 90% was attributed to admissions in the first 6 days of life.

3.2 | Economic evaluation of breastfeeding promotion

Table 2 and Figure S1 show the number of admissions due to GE, LRTI and NNJ that could be changed and the governmental cost that could be saved/increased each year during 2010–2019 attributed to higher EBF rates (50%, 70% or 90%) from the probabilistic sensitivity analyses.

Potential cost savings for GE and LRTI

Increasing the EBF rate at 4 months from those in 2010–2019 (15–30%) to 50% or above would reduce admissions for treating GE and LRTI by at least 198/year and 141/year, respectively (Figure S1A). The predicted annual cost savings/year due to reducing hospitalisation for GE/LRTI in the first year of life would have been USD1.05 (95% CI 1.03–1.07) million if the EBF rates at 4 months increase to 50% (Table 2 and Figure S1B). The cost savings would be USD 1.89 (95% CI 1.86–1.92) million or more if EBF rates at 4 months increased to 70%.

The deterministic sensitivity analyses suggested that cost savings were most sensitive to the relative risk of GE and LTRI associated with breastfeeding (Figure S2). When the EBF rate at 4 months reaches 50%, annual cost savings from avoiding GE and LTRI would range from USD 0.2 million if breastfeeding is least protective (i.e., upper bound of relative risk) to USD 2.2 million if breastfeeding is most protective. In the worse-case scenario, where the actual breastfeeding rate and relative risk of GE and LRTI are at the upper bounds and length of stay and hospital cost are at lower bounds, achieving EBF at 4 months to 50% would still be cost saving (USD 0.1 million).

3.2.1 | The impact of NNJ on cost savings for GE and LRTI

If the increase in NNJ admissions during 7–90 days is considered, cost savings would be reduced ~60% to USD0.4 (95% CI 0.36–0.45)

TABLE 2 Average annual estimated costs (Million US$, 2020 price) for hospitalizations for GE, LRTI and NNJ and potential cost saving associated with increasing exclusive breastfeeding rate at 4 months in Hong Kong during 2010–2019 by probabilistic sensitivity analyses.

	Average annual costs/savings in Million US$, 2020 price (95% CI)													
	GE (0–12 months)		LRTI (0–12 months)		NNJ (0–90 days)		NNJ (0–6 days)		NNJ (7–90 days)		GE + LRTI (0–12 months)		GE + LRTI (0–12 m) + NNJ (7–90 days)	
Current costs[a]	3.38	(3.36, 3.41)	6.08	(6.04, 6.12)	15.18	(15.0, 15.4)	13.6	(13.4, 13.8)	1.58	(1.55, 1.61)	9.46	(9.41, 9.51)	11.0	(11.0, 11.2)
Cost savings[b]														
Exclusive breastfeeding rate														
50% at 4 months	0.58	(0.57, 0.59)	0.47	(0.46, 0.48)	−2.60	(−2.67, −2.53)	−1.96	(−2.02, −1.90)	−0.64	(−0.66, −0.61)	1.05	(1.03, 1.07)	0.40	(0.36, 0.45)
70% at 4 months	1.03	(1.02, 1.05)	0.86	(0.84, 0.87)	−4.62	(−4.74, −4.50)	−3.50	(−3.61, −3.39)	−1.12	(−1.16, −1.08)	1.89	(1.86, 1.92)	0.75	(0.68, 0.82)
90% at 4 months	1.47	(1.44, 1.50)	1.24	(1.21, 1.27)	−6.64	(−6.81, −6.48)	−5.06	(−5.21, −4.90)	−1.59	(−1.65, −1.53)	2.71	(2.66, 2.75)	1.13	(1.03, 1.23)

Abbreviations: GE, gastroenteritis; LRTI, lower respiratory tract infection; NNJ, neonatal jaundice.

[a]Total number of hospital admissions multiplied by the average length of stay/admission and the cost for each bed day.

[b]Negative values indicate costing more (instead of cost saved).

million and USD0.75 (95% CI 0.68–0.82) million if EBF rates at 4 months increase to 50% and 70%, respectively. (Table 2) If the increase in NNJ admissions in the first 6 days of life is also considered, an increase in the EBF rate would cost at least USD1.56 (95% CI 1.49–1.62) million due to more admissions for NNJ in all scenarios.

When breastfeeding is most protective against GE and LRTI, increasing the EBF rate at 4 months to 50% will cause more healthcare costs unless hospitalizations for NNJ during 0–3 months are reduced by at least 25%.

4 | DISCUSSION

4.1 | Summary of findings

Our economic evaluation, based on conservative assumptions, suggested that increasing the EBF rate at 4 months in Hong Kong from 15–30% to 50% could have saved governmental healthcare costs of at least 1 million USD per year during 2010–2019 by reducing public hospital use for treating GE and LRTI in the first year of life. Such cost savings could reach 1.89 million USD when EBF rates at 4 months increase to 70%. For the first time, we demonstrated that about 60% of such healthcare cost savings could be offset by the increase in hospitalisation for NNJ during 7–90 days postpartum due to more exclusively breastfed infants. These findings give important information to guide healthcare expenditure to maximise the health of Hong Kong children and, with the review of NNJ management policy, to maximise economic benefits from breastfeeding promotion.

4.2 | Uncertainties in the models

Our economic evaluation used the best available data and probabilistic sensitivity analyses to consider uncertainties of input parameters. As expected, the cost saving attributed to reducing hospital admissions for GE/LRTI was most sensitive to protection effect of EBF, as shown in deterministic sensitivity analyses. The protection of EBF for 4 months against GE/LRTI was not available from published meta-analyses[5] or local studies. The only local data was from a 1997 birth cohort,[21] which showed that children exclusively breastfed for 3 months (~6%) had fewer hospital admissions due to GE/LRTI in the first 6 months, but the protection against LRTI did not reach statistical significance.[18] Therefore, we chose the most suitable protection effect of EBF at 4 months reported in a UK birth cohort,[22] despite its larger CIs than those from meta-analyses. Nevertheless, our sensitivity analysis confirmed that increasing the EBF rate to 50% is still cost-saving even when assuming the protection is at the lower bound for GE and LRTI or when no protection against LRTI is considered. Furthermore, we assumed no benefit from partial breastfeeding or EBF for 3 months or less, and we did not include costs of intensive care, general outpatient clinics and accident and emergency visits. We also used primary diagnosis, instead of any diagnosis, in counting hospital use. Therefore, the potential total governmental cost savings attributed to the reduction of GE and LRTI due to a higher EBF rate should be higher; and our predicted cost saving is realistic.

4.3 | Comparison with other studies

We set out to perform economic evaluations focusing on paediatric diseases in early infancy for rapid monetary return. We also excluded severe but rarer conditions protected by breastfeeding, e.g., necrotizing enterocolitis, and milder conditions requiring few hospitalizations in our setting, e.g., otitis media. Therefore, the economic benefits of breastfeeding estimated here cannot be directly compared with those conducted in elsewhere, including more diseases in infants, older children and mothers. Our estimated annual cost savings per 1000 births attributed to preventing GE and LTRI also differed from the UK,[11] Spain[12] and the US,[7] due to differences in model assumptions, healthcare systems, healthcare costs and baseline breastfeeding rates in different settings.

4.4 | NNJ in economic evaluation of breastfeeding

For the first time, we quantified the potential negative impact of NNJ on the economic benefits of breastfeeding. Some costs potentially saved by more breastfeeding could be offset by the increase in prolonged or breastmilk NNJ, as proxied by admissions for NNJ for infants aged 7–90 days. Such NNJ is a prolongation of unconjugated hyperbilirubinemia usually after the third week of life and up to 3 months in healthy exclusively breastfed infants. Breastmilk jaundice is not a disease but rather a normal and harmless developmental phenomenon observed even in optimally exclusively breastfed infants who are thriving well. This explains the short hospital stay (about 3–5 h) for NNJ during 7–90 days of age, suggesting that infants were admitted for NNJ monitoring instead of treatments requiring longer stays.

On the other hand, our analysis showed that the government may pay more healthcare costs for all excess NNJ admissions *from birth* attributable to increased breastfeeding. The major cause of NNJ in the first week of life is termed physiological jaundice, caused by insufficient uptake and conjugation of bilirubin due to developmental hepatic immaturity and/or excess intestinal reabsorption of bilirubin, i.e., enterohepatic circulation. Although not all breastfed infants developed physiological jaundice, the prevalence of physiological jaundice increases with the EBF rate, and its economic impact could be huge in Hong Kong. As such, preventing unnecessary admissions for NNJ will maximise both the health benefits and economic benefits of breastfeeding in the Hong Kong and similar settings.

4.5 | Public health implications – how much and what to invest

Our economic evaluation found that increasing EBF rates at 4 months from the actual rate to 50% could save government cost of

1 million US$ per year due to prevention of GE and LRTI in the first year of life, informing policymakers of a potential budget for breastfeeding promotion in Hong Kong. We also show the importance of optimising NNJ management in maximising the economic benefits of breastfeeding.

Not all breastfeeding promotion interventions are effective,[19,23] implicating the need to identify cultural and setting-specific strategies. Most Hong Kong mothers intend to breastfeed,[24] but more than half stop breastfeeding before they had wished,[25] and only ~30% managed EBF for 1 month. Investing in breastfeeding support in the first month should be prioritised not only because the majority who did not sustain breastfeeding to 4 months gave up during this period, but also for the prevention of "insufficient breastfeeding jaundice"[17] or "sub-optimal intake jaundice".[16] Equally important is the continued investment in established evidence-based strategies, including implementing Baby Friendly Hospital Initiative policies in all birthing hospitals, strengthening breastfeeding support after discharge, implementing paid maternity leave[26] and strengthening the implementation of the International Code of Marketing of Breastmilk Substitutes to protect mothers from unethical marketing of infant formula[27,28] to enable mothers to make informed choices about infant feeding.[29]

4.6 | Limitations

Some limitations require consideration. First, we assumed a child was admitted only once for GE or LRTI in the first year of life. However, if a child is admitted more than once with GE or LRTI, it would likely have little impact on the estimations of cost savings since it could be argued that the protective effect of breastfeeding would apply to all admissions. Second, we assumed the protective effect of breastfeeding using data from the United Kingdom. The effect size of the protection from breastfeeding of different durations and exclusivity in Hong Kong would improve the estimates for cost saving. Finally, although the bed cost was obtained from the local Hospital Authority and is highly reliable, the cost estimates can be strengthened by healthcare cost of paediatric/neonatal intensive care units, out-patient clinics and accident and emergency units.

5 | CONCLUSION

This study conservatively estimated that increasing EBF at 4 months from the current rate to 50% in Hong Kong could have saved one US million per year during 2010–2019, attributed to treating GE and LRTI in the first year of life in government hospitals. At least 60% monetary benefits could be offset by the potential increase in NNJ prevalence attributed to more breastfed infants, implicating the importance of policy changes in managing NNJ while promoting breastfeeding to maximise child health in Hong Kong and similar Asian settings with high rates of NNJ.

AUTHOR CONTRIBUTIONS

Hui drafted the initial manuscript, conceptualised and designed the study, reviewed and revised the manuscript. Yeung, Wong and Loganathan critically reviewed manuscript and contributed to the interpretation of data. Liao carried out the data analysis. Nelson conceptualised and designed the study, reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest relevant to this article to disclose.

ETHICS STATEMENT

This study was approved by the Joint Chinese University of Hong Kong-New Territories East Cluster Clinical Research Ethics Committee (CREC reference number 2019.616).

ORCID

Carlos K. H. Wong https://orcid.org/0000-0002-6895-6071

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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