Potential cost-savings of breastfeeding promotion to prevent breast cancer: a Monte Carlo simulation

Lai Ling Hui[1,2*], Emily Liao[1], Jin Xiao Lian[3], Ching So[3], Ting Ting Wu[4], Carlos K. H. Wong[4,5,6], Tharani Loganathan[7] and Edmund Anthony S. Nelson[2,8*]

Abstract

Background Breastfeeding protects mothers against breast cancer. Our study aimed to estimate the healthcare cost-savings resulting from a reduction in breast cancer attributed to an increase in the breastfeeding rate in Hong Kong.

Methods This is an economic evaluation. We constructed an individual-based Monte Carlo method to simulate with probabilistic sensitivity analysis the development of breast cancer over a woman's lifetime in a hypothetical birth cohort aged 20 years in 2018 ($n = 33500$) using best available data mainly from government statistics. We predicted the cases of, and deaths due to breast cancer in the base case (with the actual breastfeeding rate in 2018) and two hypothetical optimal scenarios (90% exclusive breastfeeding for six months or cumulative exclusive/partial breastfeeding for at least 12 months). The healthcare cost-savings, the number of deaths averted and the increase in disability-adjusted life years (DALYs) due to the prevention of breast cancer attributed to a higher breastfeeding rate were then deduced, assuming an annual discount rate of 3%.

Results Increasing the proportion of parous women breastfeeding *exclusively* for six months from 26 to 90% averted 266 (95% CI 259, 273) or ~10% of all-stage breast cancer cases, 18 deaths (95% CI 17, 19) and 399 DALYs (95% CI 381, 416), over the lifetime of each annual cohort of women in Hong Kong. The lifetime medical costs that could be saved would be ~USD3 million using 2018 prices. However cost-savings were 5-times less in another scenario where the cumulative partial/exclusive breastfeeding for 12 months in parous women is increased to 90% due to its weaker protection against breast cancer compared to exclusive breastfeeding.

Conclusions Promoting and protecting breastfeeding could lead to cost-savings for treating breast cancer in Hong Kong. Our analysis can inform the annual healthcare budget that could be allocated to promote exclusive breastfeeding for six months.

Keywords Breastfeeding, Breast cancer, Economic evaluation, The monte carlo method, Cost-savings, DALYs

*Correspondence:
Lai Ling Hui
connie.hui@polyu.edu.hk
Edmund Anthony S. Nelson
tonynelson@cuhk.edu.cn
Full list of author information is available at the end of the article

Hui *et al. International Breastfeeding Journal*   (2025) 20:10

Page 2 of 8

Background

Hong Kong is a densely populated special administrative region of China with over 7 million residents, the majority of whom are Chinese. In the past three decades, Hong Kong has experienced a three-fold increase in breast cancer incidence which imposes a huge burden on not only families but also the governmental healthcare system because the majority of breast cancers are treated in the heavily subsidised public system. The breast cancer crude incidence per 100,000 females increased from 39.4 in 1990 to 116.6 in 2019, constituting 27% of all new cancers in women [1]. Hong Kong's age-standardised rate (per 100,000 females) of breast cancer incidence rate in 2020 (73.5) was much higher than the world average (47.8), and it was approaching the highest rates (> 80) observed in Australia/New Zealand, Western Europe and Northern America [2].

Breastfeeding protects mothers against breast cancer [3]. Given that breastfeeding, and particularly exclusive breastfeeding, is still not the norm in many places, including Hong Kong, promotion of breastfeeding could reduce future breast cancer incidence and its related healthcare costs. Treatment costs of breast cancer that could be saved by increased breastfeeding rates have been estimated in different settings. This calculation is also known as economic evaluation of breastfeeding. In the UK, it was estimated that £21 million (2009–2010 value), over the lifetime of a cohort of first-time mothers in 2009, could be saved as a result of reduced treatment costs for maternal breast cancer [4]. In Mexico, US$71.27 million (2012 value) direct healthcare treatment costs for breast cancer could be avoided for a cohort of 1.116 million Mexican women aged 15 years in 2012 [5]. A US study reported total medical costs of $118 million (2014 value) for treating breast cancer could be saved for the cohort of US women aged 15 years in 2002 over their lifetime [6]. The results from economic evaluations of breastfeeding are highly setting specific due to differences in epidemiology of breast cancer and financing of healthcare.

The breastfeeding rate has been suboptimal in Hong Kong, despite an improvement in recent decades compared to the 1980s when only respectively 7.6% and 3.9% infants were breastfed at one and three months [7]. According to the biennial breastfeeding survey conducted by the Hong Kong Department of Health [8], the exclusive breastfeeding rate reached 32% at one month and 26% at six months in 2018, with an any (exclusive/partial) breastfeeding rate of 46.5% at six months. There was, however, a small decline in exclusive breastfeeding rates in the recent two surveys conducted during and after the COVID-19 pandemic (2020 and 2022). Although trends in breastfeeding rates and breast cancer incidence are likely driven by a range of factors, suboptimal breastfeeding rates and high breast cancer incidence in Hong Kong offers opportunities to optimise resource allocation decisions to maximize population health among women and children by investing in strategies to protect and support breastfeeding.

We recently investigated the immediate healthcare cost-savings to the government due to the prevention of gastroenteritis infections and lower respiratory tract infections of the infants during their first year of life [9]. Here we assessed the longer-term healthcare costs for breast cancer treatment that could be saved by an increase in the breastfeeding rate. These data can inform decisions on the efficient utilization of healthcare resources in Hong Kong because the majority of the cancers are treated in the public system.

Methods

Perspective

We aimed to estimate costs for breast cancer treatment due to suboptimal breastfeeding from a healthcare provider or a government perspective in Hong Kong. We only focused on direct medical cost to the government so as to inform investment of healthcare resources. As such our evaluation did not consider individual costs and societal costs, such as loss of productivity due to absence from work.

The model

An individual-based Monte Carlo method (Fig. 1) adopted from previous studies [6, 10] was constructed to simulate the development of breast cancer over a woman's lifetime in a hypothetical birth cohort aged 20 years in 2018 ($n = 33500$), with which we predicted the cases and deaths of breast cancer in the base case (with actual breastfeeding rate of 26% in 2018) and two hypothetical optimal scenarios (scenario 1: 90% parous women exclusively/partially breastfeed for at least 12 months or scenario 2: 90% parous women exclusively breastfeed for six months). Monte Carlo methods are a computational technique that uses repeated random sampling of input parameters to predict probability of outcomes. In this present economic evaluation, the outcome was incidence of breast cancer and the input parameters for simulation were best available data mainly from the government statistics. (Table 1) The fertility rates of Hong Kong women and mortality rates were obtained from the Hong Kong Census and Statistics Department. Rates of exclusive and partial breastfeeding were obtained from biennial breastfeeding surveys in Hong Kong conducted by the Department of Health. Incidence rates of different breast cancer stages and surviving rates of each stage of breast cancer were obtained from Hong Kong Cancer Registry operated by the Hospital Authority. Medical costs for treating breast cancer in Hong Kong were obtained from a local cost study [11]. Disability weights were obtained from
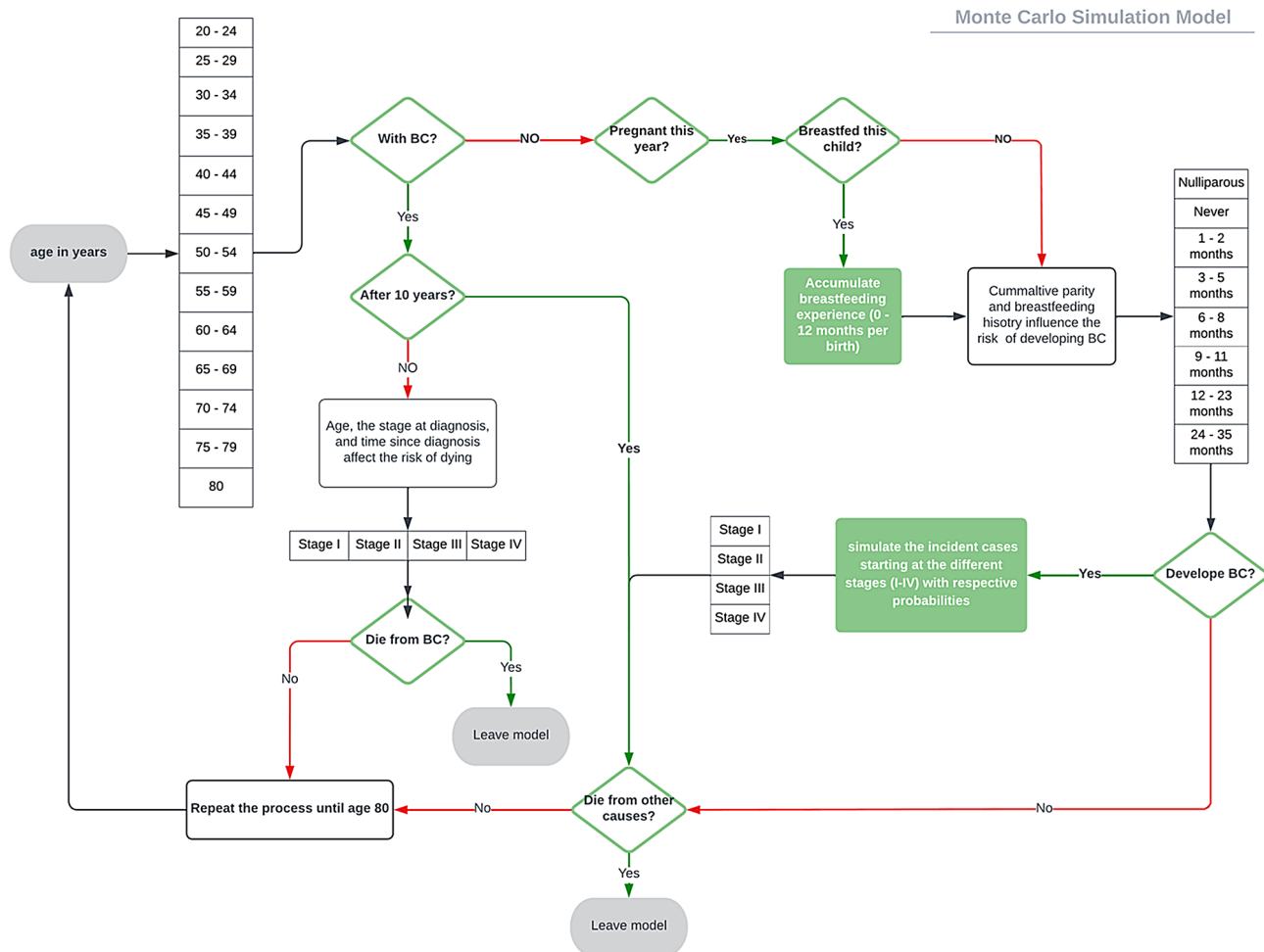
Fig. 1 Diagram of simulation model. Adapted from: Bartick et al., Cost analysis of maternal disease associated with suboptimal breastfeeding. *Obstet Gynecol*. 2013;122(1):111–119. https://doi.org/10.1097/AOG.0b013e318297a047 Bartick et al., Suboptimal breastfeeding in the United States: Maternal and pediatric health outcomes and costs *Matern Child Nutr*. 2017;13(1):e12366. https://doi.org/10.1111/mcn.12366

Global Burden of Disease Study 2017 [12]. We adopted the relative risks of breast cancer by duration of any (exclusive or partial) breastfeeding and exclusive breastfeeding summarised in a recent meta-analysis on 65 studies [13] as local studies on the associations between breastfeeding and breast cancer are lacking.

In base case and each scenario, we simulated a cohort of Hong Kong women aged 20 years old in 2018. The proportion of parous women in each year was simulated according to 20 to 49 year-old age-specific fertility rates in Hong Kong in 2018 in which total number of births was 53,700. The maximum parity was set at two because average fertility rate was as low as 1.1–1.3 during 2010–2019. For each simulated woman, the risk of developing breast cancer in each year from age 20 to 80 years was simulated based on her age, cumulative lifetime breastfeeding history and age-specific incidence rates of breast cancer in 2018. The case-fatality was simulated based on the age, stage at diagnosis and ten-year survival rates

extrapolated from the stage-specific relative 1-to-5-year survival rates from the Hong Kong Cancer Registry, but not their breastfeeding history. The mortality of women without breast cancer was simulated using the age-specific death rates among females in Hong Kong. We assumed steady-state rates of disease incidence, disease survival, fertility, and the cost of treatment. We did not consider transitions between stages as early diagnosed breast cancers are mainly treated and we set out to provide a conservative estimate. Deaths for women surviving beyond 10 years from diagnosis were considered unrelated to breast cancer.

Cost and DALYs estimation

We calculated the treatment cost and DALYs associated with breast cancer in each scenario of breastfeeding rate using stage-specific aggregated one-time treatment costs reported in a local study [11] and DALYs information from the Global Burden of Disease Study [12], at an

Table 1 Input parameters for economic evaluation of the prevention of breast cancer through the promotion of breastfeeding in Hong Kong

Input parameter	Point estimate	Uncertainty range	Distribution	Source of data and Remarks
Age-specific fertility rates of 20-49-year-old females in 2018	NA	NA	NA	Hong Kong Census and Statistics Department
All-cause age-specific mortality rates in 2018	NA	NA	NA	Hong Kong Census and Statistics Department
Age-specific female invasive breast cancer incidence rate in 2018	NA	NA	NA	Hong Kong Cancer Registry, Hospital Authority [1] (Supplementary Table S1)
Female invasive breast cancer stage distribution in 2018				
I	0.62	-	Dirichlet	Hong Kong Cancer Registry, Hospital Authority [1]
II	0.16			
III	0.13			
IV	0.09			
Aggregated medical treatment costs (per case, $US 2017 level)				
Stage I	$27,683	($20,762-$34,604)	Uniform	Leung et al., 2021 [11]
Stage II	$31,831	($23,873-$39,789)		
Stage III	$38,374	($28,781-$47,968)		
Stage IV	$83,217	($62,413-$104,021)		
Terminal Care	$27,208	($20,271-$33,785)		
5-year survival probability for female invasive breast cancer Stages 1–4				
Stage I	0.993	NA	NA	Hong Kong Cancer Registry, Hospital Authority [1] (Supplementary Table S2)
Stage II	0.946			
Stage III	0.762			
Stage IV	0.298			
Disability weight				
Diagnosis and primary therapy phase	0.288	(0.193, 0.399)	Triangular	Global Burden of Disease study 2017 [12]
Controlled phase	0.049	(0.031, 0.072)		
Metastatic phase	0.451	(0.307, 0.600)		
*Relative risk of breast cancer by duration of any breastfeeding (for Scenario 1)				
Never	1	-	Triangular	Unar-Munguía 2017 [13]
1–2 months	0.9	(0.86, 0.93)		
3–5 months	0.85	(0.82, 0.89)		
6–8 months	0.86	(0.82, 0.91)		
9–11 months	0.87	(0.82, 0.91)		
12–23 months	0.86	(0.82, 0.9)		
24–35 months	0.81	(0.76, 0.85)		
*Relative risk of breast cancer in flavour of exclusive breastfeeding for 6 months (for Scenario 2)				
No	1	-	Triangular	Unar-Munguía 2017 [13]
Yes	0.72	(0.58, 0.90)		
Duration of any (exclusive/partial) breastfeeding in a woman's lifetime (base case or scenario 1)				
Months	76.6%	(74.8%, 78.4%)	Triangular	Breastfeeding survey 2018, Department of Health [8] (Supplementary Table S3)
At 2 months	66.4%	(64.4%, 68.4%)		
At 4 months	55.7%	(53.6%, 57.5%)		
At 6 months	46.5%	(44.4%, 48.6%)		
At 12 months	26.1%	(24.3%, 27.9%)		
Proportion of 6-month-old infants exclusive breastfed in Hong Kong in 2018 (Base case for scenario 2)	26%	(24.50%, 28.10%)	Triangular	Breastfeeding survey 2018, Department of Health [8]

annual discount rate of 3%. Costs were converted to US dollars based on the exchange rate in 2018 (1 USD = 7.8 HKD). The terminal care cost would be applied when the death due to breast cancer occurred in the simulation. We assumed all the diagnosed breast cancer cases would receive treatment. We also assumed treatment cost in public sector, which is heavily subsidised by the government is the same as private hospitals, where more expensive treatment options are maybe available.

For DALYs calculation, the number of years lived with disability (YLD) and the number of years of life lost (YLL) were deduced with the formula in the DALY calculator for R. The information to calculate YLL and YLD, including age of onset and duration of disease, were derived from the simulation of the disease outcome for each woman. Survivors beyond ten years were considered cured [12]. Two sequelae (diagnosis and primary therapy, and controlled phase) were assumed for cases that were cured, and four sequelae (diagnosis and primary therapy; controlled phase; metastatic phase; terminal phase) were assumed for those that did not survive beyond ten years. Age-weighting was not applied.

Sensitivity analysis and validation

The simulated outcomes were based on 500 iterations each with parameters including relative risks, age-specific incidence of breast cancer, aggregated treatment costs, and disability weights randomly generated from specified distributions. (Table 1) The results from probabilistic sensitivity analysis were validated by comparing deduced incidence rates from the model for the base case with the actual rates. We also carried out deterministic sensitivity analysis to assess the main cost drivers (by changing one parameter at a time) and the most/least cost-saving simulations (by changing parameters at the same time to achieve most/least cost-saving scenario).

Programming was performed using Python and R statistical software version 4.1.0 (Vienna, Austria; R Core Team, 2021).

Results

In the cohort of 33,500 women aged 20 years in 2018 (with an actual exclusive breastfeeding rate of 26% at six months), our model simulated 2550–2570 cases of breast cancer developed in their lifetime. The simulated stage-specific incidence rates in base case were congruent with the actual age-specific incidence rates from Hong Kong cancer registry.(Supplementary Table S4) Increasing the proportion of parous women with a cumulative (exclusive/partial) breastfeeding duration of at least 12 months from current levels to 90%, i.e. optimal scenario 1, averted 59 (95% CI 54, 62) cases of breast cancer, from which 3 (95% CI 3,5) premature deaths and 84 DALYs (95% CI 70, 100) could be prevented. In optimal scenario 2 when 90% of parous women breastfeed exclusively for six months, 266 (95% CI 259,273) or about 10% of all-stage breast cancer cases, 18 death (95% CI 17,19) and 399 DALYs (95% CI 381, 416) could be averted. (Table 2)
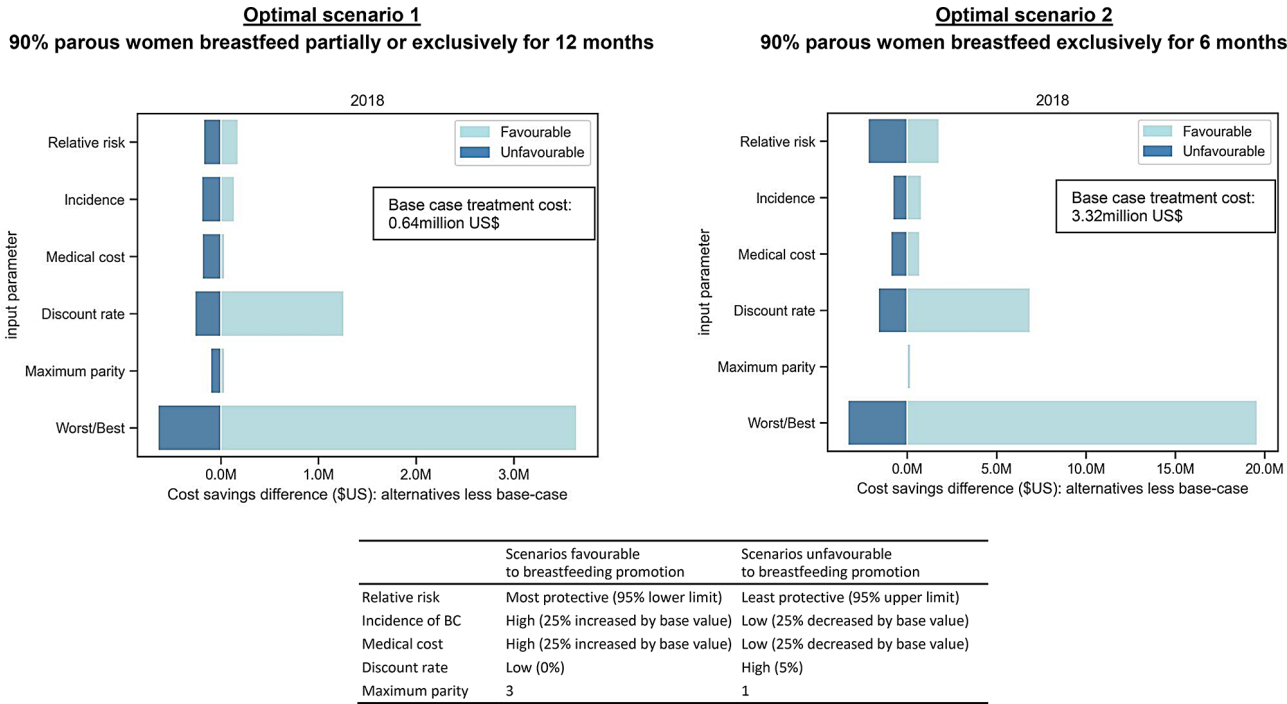
Using 2018 prices with 3% discount rate, the total lifetime medical treatment costs for breast cancer that could be saved in the lifetime of the women in the simulated cohort would be about US$ 0.65 (95% CI 0.60, 0.70) million when 90% parous women have cumulative (exclusive/partial) breastfeeding for 12 months. The saving was estimated to be US$3.07 (2.98, 3.15) million when 90% parous women exclusively breastfeed for six months. (Table 2)

Table 2 Cases and deaths of breast cancer averted & lifetime costs (million US$) of breast cancer saved by optimal scenario 1 (90% parous women breastfeed partially or exclusively for 12 months) & optimal scenario 2 (90% parous women breastfeed exclusively for 6 months) for a cohort of 33,500 Hong Kong women aged 20 years in 2018

	Cases		Deaths		DALYs		Lifetime costs+	
	Base^/Optimal	Averted (95% CI)	Base^/Optimal	Averted (95% CI)	Base^/Optimal	Averted (95% CI)	Base^/Optimal	Averted (95% CI)
Scenario 1 (90% parous women breastfeed partially or exclusively for 12 months)								
Stage I	1594/1558	36(33, 39)	85/83	2 (1, 2)	2078/2036	42 (32, 52)	15.49/15.16	0.34 (0.3, 0.37)
Stage II	411/403	9(7, 10)	24/24	0 (0, 1)	567/556	11 (6, 16)	4.01/3.93	0.08 (0.07, 1)
Stage III	334/325	9(7, 10)	23/22	0 (0, 1)	506/495	10 (5, 16)	3.72/3.63	0.09 (0.08, 0.11)
Stage IV	232/227	5(4, 6)	44/42	1 (1, 2)	755/734	21 (14, 28)	6.79/6.65	0.14 (0.10, 0.17)
Total	2571/2513	59(54, 62)	176/173	3 (3, 5)	3908/3834	84 (70, 100)	30.02/29.37	0.65 (0.60, 0.70)
Scenario 2 (90% parous women breastfeed exclusively for 6 months)								
Stage I	1584/1419	164 (159, 169)	85/76	9 (8, 9)	2077/1865	212 (201, 223)	15.39/13.81	1.58 (1.53, 1.63)
Stage II	411/367	44 (42, 46)	24/21	3 (2, 3)	570/508	62 (57, 67)	3.99/3.58	0.43 (0.41, 0.45)
Stage III	332/298	35 (33, 36)	23/20	2 (2, 3)	510/455	55 (49, 60)	3.71/3.32	0.38 (0.36, 0.4)
Stage IV	229/206	23 (22, 24)	43/39	4 (3, 4)	740/670	70 (62, 77)	6.74/6.07	0.68 (0.64, 0.71)
Total	2556/2290	266 (259, 273)	174/158	18 (17, 19)	3897/3498	399 (381, 416)	29.83/26.78	3.07 (2.98, 3.15)

^Base: Actual breastfeeding rate in 2018 was used in baseline

+2018 prices with 3% discount rate

Optimal scenario 1
90% parous women breastfeed partially or exclusively for 12 months

Optimal scenario 2
90% parous women breastfeed exclusively for 6 months

	Scenarios favourable to breastfeeding promotion	Scenarios unfavourable to breastfeeding promotion
Relative risk	Most protective (95% lower limit)	Least protective (95% upper limit)
Incidence of BC	High (25% increased by base value)	Low (25% decreased by base value)
Medical cost	High (25% increased by base value)	Low (25% decreased by base value)
Discount rate	Low (0%)	High (5%)
Maximum parity	3	1

Fig. 2 Tornado diagram for deterministic sensitivity analyses of cost-savings (million US$) in optimal scenario 1 (90% parous women breastfeed partially or exclusively for 12 months) & optimal scenario 2 (90% parous women breastfeed exclusively for 6 months), 2018 prices with 3% discount rate

The deterministic sensitivity analyses suggest the cost-savings would be made should the optimal breastfeeding rates for both scenarios be achieved for all individual scenarios and marginally for the worst-case scenario (Fig. 2). Discount rates have the largest impact on the estimated cost-savings over a lifetime. The relative risk of breast cancer in favour of breastfeeding was more important when exclusive breastfeeding was considered (optimal scenario 2) compared to any (i.e. exclusive/partial) breastfeeding rate (optimal scenario 1), due to the wider confidence intervals of the relative risk.

We compared the economic evaluations with optimal scenario 1 with similar economic evaluations in the UK, the US, and Mexico assuming a change in the duration of cumulative (exclusive/partial) breastfeeding duration in the optimal scenario. Cases averted per 100,000 women were 392 for Mexico (when 95% of parous women breastfeed for 24 months), 252 for the US (when 90% of mothers breastfeed each infant exclusively for six months, with continuing breastfeeding through 12 months postpartum) and 176 for Hong Kong (when 90% of parous women exclusively/partially breastfeed for 12 months).

Discussion

Our findings suggested that increasing the exclusive breastfeeding rate at six months from the current rate (about 26%) to 90% in Hong Kong could avert 266 cases of breast cancer and save US$3 million (2018 price) attributed to the prevention of breast cancer over the lifetime of each annual cohort of 33,500 women. There would also be 16 premature deaths prevented and 399 DALYs averted. The benefits of having 90% parous women with cumulative exclusive/partial breastfeeding duration of 12 months were about 5 times less. Prioritising the exclusivity in breastfeeding promotion could avert more cases of breast cancer and lead to more governmental healthcare cost-saving in Hong Kong where the majority of breast cancers are treated in public settings and heavily subsidised.

We carefully considered uncertainties of inputs, including protection of breastfeeding against breast cancer, disability weight, breastfeeding rate, treatment cost per case and breast cancer stage distribution using probabilistic sensitivity analyses in the present economic evaluations. However there are some caveats in the model that require considerations. First we assumed age-specific incidences of breast cancer to be static despite the breast cancer incidence has been on a rising trend. Second we assumed there was no disease progression from earlier stages to metastasis, i.e. stages III and IV cancers, with higher case-fatalities. Thirdly we assumed treatment costs in the public sector to be the same as private hospitals, although some treatment in private settings may be more expensive than public hospitals. These assumptions made our economic evaluation more conservative which may underestimate the cost-saving. The actual cost-saving is likely to be higher.

Similar economic evaluations in both high-income settings (the UK [4] and the US [6]) and a lower income setting (Mexico [5]) reported that an increase in proportion of women practicing any (i.e. exclusive/partial) breastfeeding is cost-saving for breast cancer treatment. The cases averted and the cost saved in each setting being dependent on the epidemiology of breast cancer (such as age-specific disease incidence and survival rate), detection rate of early breast cancer, fertility rate, breastfeeding status and assumed protection of breastfeeding. In Hong Kong, the fertility rate has been always under 1.4/woman since 1991 [14]. According to data collected from the Cancer Registry during 2010–2017, the majority of breast cancer was diagnosed at stage I (56%) or stage II (14%) and the five-year survival rate on average was as high as 84% overall or > 95% for women diagnosed with stage I and stage II breast cancers [15]. The smaller number of breast cancer cases averted per 100,000 women in Hong Kong than those in the US and Mexico may be partly attributed to the much lower fertility rate, the early detection rate and the high survival rate of early breast cancer in Hong Kong.

Our findings suggested that increasing the exclusive breastfeeding to six months could lead to substantial cost-savings for treating breast cancer in Hong Kong, in addition to alleviating suffering for women and their families. Promoting, protecting and supporting breastfeeding, especially exclusive breastfeeding, is an early lifestyle-related intervention for preventing breast cancer, in addition to prevention of obesity, reduction of alcohol consumption and increase in physical activity [16]. This is particularly important in Hong Kong as falling rates of exclusive and partial breastfeeding during the first six months were observed during the COVID-19 pandemic. The exclusive breastfeeding rates at four and six months dropped to 21.8% and 18.2% in 2022 respectively, potentially due to a reduction in access to breastfeeding support and antenatal education on breastfeeding due to the pandemic [8]. Violations of the International Code of Marketing of Breastmilk Substitutes especially in the social media are widespread in Hong Kong [17] as in many places [18]. While all public birthing hospitals in Hong Kong are accredited as Baby-friendly health facilities, the majority of the private birthing hospitals in Hong Kong do not intend to seek accreditation. Evidence-based strategies, including "The Ten Steps" of the Baby-Friendly Hospital Initiative [19] and the International Code of Marketing of Breastmilk Substitutes [20, 21] can protect exclusive breastfeeding from unnecessary and uninformed choice of infant formula supplementation in Hong Kong. Investing public money to strengthen these strategies will not only bring health benefits to the mothers and babies but also potential monetary return to the government in Hong Kong and therefore should be enthusiastically supported.

Conclusion
Promoting and protecting breastfeeding could lead to cost-savings for treating breast cancer in Hong Kong. Healthcare resources can be directed to breastfeeding promotion as an early lifestyle-related intervention for breast cancer, focusing on promoting exclusive breastfeeding for six months as recommended by the World Health Organization.

Supplementary Information
The online version contains supplementary material available at https://doi.org/10.1186/s13006-024-00689-y.

Supplementary Material 1: Table S1 Age-specific female invasive breast cancer (per 100,000 women) in 2018. Table S2 Death rate of general population and age- and stage-specific survival rate of breast cancer. Table S3 of any breastfeeding in a woman's lifetime (base case) deduced from the proportion of infants at different ages (1, 2, 4, 6 and 12 months) who were "partially breastfed" or "exclusively breastfed". Table S4 Comparison of deduced incidence rate of female breast cancer from simulation with actual data.

Author contributions
Hui LL drafted the initial manuscript, conceptualized and designed the study, reviewed and revised the manuscriptLIAN JX, SO C, WU TT, WONG CKH and LOGANATHAN T critically reviewed manuscript and contributed to the interpretation of data. Liao E carried out the data analysis. Nelson EAS conceptualized 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.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethical approval
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).

Clinical trial number
Not applicable.

Consent to participate
Not applicable. This study only used summary statistics as such individual consent was not required.

Consent for publish
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[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]School of Optometry, The Hong Kong Polytechnic University, 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]Department of Pharmacology and Pharmacy, LKS Faculty of Medicine, The University of Hong Kong, Hong Kong, China
[6]Laboratory of Data Discovery for Health (D24H), Hong Kong Science and Technology Park, Hong Kong, China
[7]Centre for Epidemiology and Evidence-based Practice, Department of Social and Preventive Medicine, University of Malaya, Kuala Lumpur, Malaysia
[8]School of Medicine, The Chinese University of Hong Kong, Shenzhen, Guangdong, China

References
1. Female breast cancer in 2019. [https://www3.ha.org.hk/cancereg/pdf/factsheet/2019/breast_2019.pdf]
2. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2021;71(3):209–49.
3. Chowdhury R, Sinha B, Sankar MJ, Taneja S, Bhandari N, Rollins N, Bahl R, Martines J. Breastfeeding and maternal health outcomes: a systematic review and meta-analysis. Acta Paediatr. 2015;104(467):96–113.
4. Pokhrel S, Quigley MA, Fox-Rushby J, McCormick F, Williams A, Trueman P, Dodds R, Renfrew MJ. Potential economic impacts from improving breastfeeding rates in the UK. Arch Disease Child. 2015;100(4):334–40.
5. Unar-Munguia M, Stern D, Colchero MA, Gonzalez de Cosio T. The burden of suboptimal breastfeeding in Mexico: maternal health outcomes and costs. Matern Child Nutr 2018:e12661.
6. Bartick MC, Schwarz EB, Green BD, Jegier BJ, Reinhold AG, Colaizy TT, Bogen DL, Schaefer AJ, Stuebe AM. Suboptimal breastfeeding in the United States: maternal and pediatric health outcomes and costs. Matern Child Nutr. 2017;13(1):e12366.
7. Leung GM, Ho LM, Lam TH. Breastfeeding rates in Hong Kong: a comparison of the 1987 and 1997 birth cohorts. Birth. 2002;29(3):162–8.
8. Hong Kong Breastfeeding Survey. 2023 [https://www.fhs.gov.hk/english/reports/files/BF_survey_2023.pdf]
9. Hui LL, Liao E, Yeung KHT, Wong CKH, Loganathan T, Nelson EAS. An economic evaluation on sub-optimal breastfeeding in Hong Kong: infant health outcomes and costs. Acta Paediatr 2024,30 Aug (Online ahead of print).
10. Bartick MC, Stuebe AM, Schwarz EB, Luongo C, Reinhold AG, Foster EM. Cost analysis of maternal disease associated with suboptimal breastfeeding. Obstet Gynecol. 2013;122(1):111–9.
11. Leung K, Wu JT, Wong IO, Shu XO, Zheng W, Wen W, Khoo US, Ngan R, Kwong A, Leung GM. Using risk stratification to optimize mammography screening in Chinese women. JNCI Cancer Spectr. 2021;5(4):pkab060.
12. GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the global burden of Disease Study 2017. Lancet. 2018;392(10159):1789–858.
13. Unar-Munguia M, Torres-Mejia G, Colchero MA, Gonzalez de Cosio T. Breastfeeding mode and risk of breast cancer: a dose-response meta-analysis. J Hum Lact. 2017;33(2):422–34.
14. Hong Kong Monthly Digest of statistics. Fertility trend in Hong Kong, 1991 to 2021. In.; 2023.
15. Female Breast Cancer in. 2021 [https://www3.ha.org.hk/cancereg/pdf/factsheet/2021/breast_2021.pdf]
16. Diet N, Activity P, Cancer B. 2017. [https://www.wcrf.org/wp-content/uploads/2021/02/Breast-cancer-report.pdf]
17. Ng WCY, Yeung KHT, Hui LL, Chow KM, Lau EYY, Nelson. E.A.S. Examining digital marketing strategies of formula companies and influencers to promote commercial milk formula in Hong Kong: a content analysis. Matern Child Nutr. 2025. (in press).
18. Rollins N, Piwoz E, Baker P, Kingston G, Mabaso KM, McCoy D, Ribeiro Neves PA, Perez-Escamilla R, Richter L, Russ K, et al. Marketing of commercial milk formula: a system to capture parents, communities, science, and policy. Lancet. 2023;401(10375):486–502.
19. Implementation guidance. protecting, promoting and supporting breastfeeding in facilities providing maternity and newborn services - the revised Baby-friendly Hospital Initiative. In. Geneva: World Health Organization; 2018.
20. International Code of Marketing of Breast-milk Substitutes. In. Geneva, World Health Organization 1981.
21. The International Code of Marketing of Breast-milk Substititutes. Frequently asked questions (2017 updates) in. Geneva, Switzerland. World Health Organization; 2017.

Publisher's note
Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.