





# Cost-effectiveness analysis of Baby-Friendly Hospital Initiative in promotion of breast-feeding and reduction of late neonatal infant mortality in Brazil

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## Abstract

**Objective:** To analyse the cost-effectiveness of Baby-Friendly Hospital Initiative (BFHI) in promoting breast-feeding during the first hour of life (BFFHL) and reducing late neonatal mortality.

**Design:** Cost-effectiveness economic assessment from the health system perspective, preceded by a prospective cohort of mother–baby followed from birth to 6 months of life. The direct costs associated with two health outcomes were analysed: intermediate end point (BFFHL) and final end point (reduction in late neonatal mortality).

**Setting:** Study was carried out in six hospitals in the city of São Paulo (Brazil), three being Baby-Friendly Hospitals (BFH) and three non-BFH.

**Participants:** Mothers with 24 h postpartum, over 18 years old, single fetus and breast-feeding at the time of the interview were included. Poisson regressions adjusted for maternal age and level of education were estimated to identify factors related to BFFHL and late neonatal mortality. Sensitivity analysis was performed to ensure robustness of the economic assessment.

**Results:** Cost-effectiveness analysis showed that BFHI was highly cost-effective in raising BFFHL by 32.0% at lower cost in comparison with non-BFHI. In addition, BFHI was cost-effective in reducing late neonatal mortality rate by 13.0% from all causes and by 13.1% of infant mortality rate from infections.

**Conclusions:** The cost-effectiveness of the BFHI in promoting breast-feeding and reducing neonatal mortality rates justifies the investments required for its expansion within the Brazilian health system.

**Keywords**  
Breast-feeding  
Neonatal mortality  
Baby-friendly  
Cost-benefit analysis  
Brazil

Breast-feeding ensures food and nutrition in early life years with long-term benefits on health throughout individuals' lifetime. In addition, its benefits are extensive amidst infants and mothers from high-, medium- and low-income population groups. It is considered a health investment with lasting effects in physical, cognitive and social development of infants, usually resulting in improvements of intergenerational formation of human capital<sup>(1,2)</sup>.

Policies designed to protect, promote and support breast-feeding are considered strategies that favour enduring health, social and economic benefits within national health systems<sup>(1–3)</sup>; thus, it is important to assess its short-term costs and effectiveness to ensure the

sustainability of programmes independently of political contexts. The Baby Friendly Hospital Initiative (BFHI) was established by the WHO and the UNICEF to incentivise breast-feeding by reorienting practices and childbirth routines within health facilities, following the Ten Steps to Successful Breastfeeding<sup>(4,5)</sup>.

There is significant evidence on the role of BFHI for breast-feeding promotion<sup>(4–9)</sup>; however, unfortunately, estimates point that only 10.0% of births occur in BFHI facilities worldwide<sup>(4)</sup>. The prevalent low BFHI coverage results from diverse barriers lead to scale up the initiative within different countries, especially challenges related to large-scale implementation due to lack of cost estimates

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at the national level<sup>(10)</sup>, criticism on the effects of the ‘Ten Steps’ and lack of policy guidance for implementation. To tackle the challenges posed in BFHI, a recent review of the ‘Ten Steps’ was published by the WHO including supplemental material to comprise implementation guidelines to support governments towards scaling up the strategy<sup>(4,5,9)</sup>.

In Brazil, the BFHI was adopted as a public policy within the health system since 1992; yet the current coverage is only 23.4% of births in BFHI facilities nationwide<sup>(7,11)</sup>, indicating the relevance of addressing the programme implementation challenges. A recent analysis conducted in Brazil indicated that BFHI is effective in reducing infant mortality by promoting breast-feeding<sup>(12)</sup>; nevertheless, there is still a gap in the literature regarding the costs associated with adoption of BFHI (i.e., whether effects outweigh financial resources applied in its implementation and maintenance).

The BFHI accreditation in Brazil follows the adherence of the Ten Steps to Successful Breastfeeding and additional criteria. These include the compliance to the Brazilian Standard for the Trading of Marketing of Food for Infants and Early Childhood, Pacifiers, Baby Bottles and Nipple Shields, the global Woman-Friendly Care criterion and the assurance of free access and/or stay of an accompanying person with the newborn 24 h/d<sup>(11)</sup>. In 2014, the Ministry of Health reformulated the criteria to enable hospitals to get the BFHI accreditation, excluding the mandatory criterion on low rate of caesarean sections and including financial incentives based on higher reimbursements for adherence of public hospitals to best practices during birth, thus encouraging vaginal delivery. Hospitals accredited as BFHI receive a monthly financial transfer from the federal government.

Both WHO<sup>(13)</sup> and the Brazilian Ministry of Health<sup>(14)</sup> recommend that economic assessments should be performed in order to incorporate innovative practices and protocols in health services. Scientific evidence on the cost and effectiveness of health interventions should support decision-making processes in order to promote the optimisation of resources for health systems<sup>(2)</sup>. Therefore, the aim of the study was to perform an economic assessment of BFHI in promoting breast-feeding and reducing neonatal mortality in Brazil, using cost-effectiveness analysis to indicate the costs and the effects that justify investments for maintenance and scale-up of the BFHI.

## Methodology

### Study design

Study conducted with data from a prospective cohort including mother–infant pairs selected in six hospitals in São Paulo (Brazil) from 2016 to 2018 and monitored from birth to 6 months of life. Then, the researchers performed a cost-effectiveness analysis based on the direct costs

estimation of hospitals that adopt the BFHI (Baby-Friendly Hospitals, BFH), and its effectiveness in promoting breast-feeding and reducing late neonatal mortality, compared with hospitals that do not adopt the BFHI (non-BFH), according to the Brazilian government perspective (i.e., costs and health outcomes that are relevant to the public health system).

### Sample

The hospitals included in the intervention group (BFH) were selected from the BFH that met all of the BFHI criteria in the previous year, according to the online self-monitoring of the Brazilian Ministry of Health. The three hospitals with the highest number of specialised beds (gynaecology, obstetrics, neonatal ICU and neonatology) were included, thus representing 25% of the hospitals participating in the initiative in São Paulo. Then, three non-BFH were selected to compose the paired control group. The hospitals included in the control group were selected according to the main similar characteristics in relation to the hospitals in the intervention group (geographic location, state or municipal management and number of beds), to allow the comparison between two health strategies (BFH and non-BFH) for economic evaluation.

Sample size of mother–infant pairs was estimated with 95% CI, 80% test power and +28% effect on exclusive breast-feeding among BFHI-born children following estimates from previous studies<sup>(15,16)</sup>, resulting in minimum sample size of 686 mother–infant pairs.

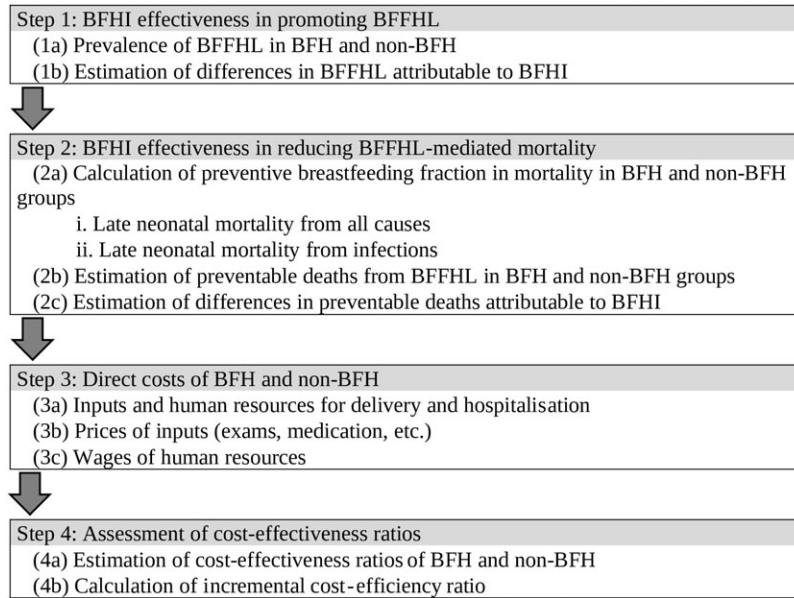
The procedure for the selection of mother–infant pairs at each hospital was based on stratified proportional probability, taking into account the number of deliveries and the proportion of caesarean sections in each hospital, according to the estimated sample size. The sample was expanded by 41% to compensate for possible losses from follow-up, resulting in 969 mothers who were initially included in the cohort.

The inclusion criteria were interview occurring >24 h postpartum, mother with 18 years or older, single fetus and breast-feeding at the time of the interview. The exclusion criterion was delivery outside the hospital. Mothers who met the inclusion criteria were invited to participate in the study at each hospital; all mothers who agreed, read and signed the informed consent form were included in the study until the sample size was obtained.

### Data collection

Data collection included four data sources: (i) structured interview with mothers, (ii) institutional protocols, (iii) medical records and (iv) interview with healthcare professionals.

First, structured interviews were conducted with mothers enrolled at the hospitals to investigate:



**Fig. 1** Description of the analytical steps to estimate the reduction in breast-feeding-mediated late neonatal mortality in the first hour of life promoted by the Baby-Friendly Hospital Initiative (BFHI), São Paulo city, 2018. BFFHL, breast-feeding in the first hour of life; BFH, Baby-Friendly Hospital; non-BFH, non-Baby-Friendly Hospital

1. Birth and birth routines related to BFHI (i.e., type of delivery, breast-feeding support in the delivery room, skin-to-skin contact and breast-feeding in the first hour);
2. Child characteristics (i.e., birth weight, gestational age, gender);
3. Maternal characteristics (i.e., age, per capita income, education, intention to breastfeed, colour and marital status).

Then, institutional protocols were obtained at the hospitals in order to define standard procedures and protocols during pre-delivery, delivery and postpartum until discharge, according to the health professional category.

Next, an in-depth analysis was conducted in the medical records of a subsample consisting of 14 % of the mothers in order to identify in detail the resources and supplies used in each procedure. Considering that health procedures follow protocols using combinations of inputs and generally use similar proportions of certain inputs in similar circumstances<sup>(17)</sup>, the researchers initially established a subsample of 10 % of the medical records to gather information to estimate the typical direct costs of birth within each hospital. However, given the increase in the sample of mothers interviewed (+41 %), the subsample of medical records was proportionately increased to 14 %. Due to requirements of comprehensive information from pre-delivery to post-delivery discharge to perform micro-costing, the study analysed the medical records to extract the amounts and the types of examinations, supplies, medications, human resources and length of stay of the mother–infant pairs.

Lastly, health professionals involved in the protocols (e.g., doctor, nurse, nursing technician, anaesthetist and

neonatologist) were interviewed as for the frequency and average time spent for each procedure to establish the adherence to protocols. The BFHI supervisors were also interviewed in order to obtain the costs of inputs used and the time spent by health professionals (according to their categories) on breast-feeding clinical management education during the previous year. The information was collected by trained researchers, then coded and typed into single data set.

**Data analysis**

The analysis was conducted in four steps (Fig. 1), according to details described in the following sections, including data sources used and statistical tests performed. Statistical analysis was conducted using Stata software version 13.1.

*Baby-Friendly Hospital Initiative effectiveness in promoting breast-feeding during the first hour of life*

The effectiveness of BFHI to promote breast-feeding in the first hour of life (BFFHL) (intermediate outcome) was assessed using information from mothers’ interviews. Intervention and control groups were compared based on  $\chi^2$  test for comparison of proportions and the Mann–Whitney test for comparison of means. In sequence,  $\chi^2$  test was used to verify associations between explanatory variables and BFFHL, and variables with  $P < 0.20$  were eligible for inclusion in the final model. Bivariate analysis using robust Poisson regression (i.e., crude prevalence ratio,  $PR_c$ ) was conducted. Maternal age and education, and variables with  $PR_c < 0.10$  were included in the final model, generating adjusted prevalence ratios ( $PR_{adj}$ ). Children

born in BFH facility showed higher prevalence of BFFHL; therefore, there was positive difference in the prevalence of BFFHL between BFH and non-BFH groups, representing the increment promoted by the BFHI.

*Baby-Friendly Hospital Initiative effectiveness in reducing breast-feeding in the first hour of life-mediated mortality*

The number of late neonatal deaths from all causes and from infections potentially avoided due to BFFHL in both groups was estimated using preventive fraction (PF), to obtain the differences in mortality rates (final outcome). The PF is defined as the proportion of morbidity and mortality cases avoided by exposure to protection factors and corresponds to the proportion of morbidity and mortality that would occur if there was no intervention conducted in the population<sup>(18,19)</sup>, described by Miettinen<sup>(20)</sup> and used in similar studies<sup>(21,22)</sup>. PF was calculated according to the following equation<sup>(21)</sup>:

$$PF_x = P_x \times (1 - RR),$$

where  $P_x$  is the prevalence of protective exposure (breast-feeding) in the sample, and  $RR$  is the relative risk on protective effect of breast-feeding in children from 7 to 27 d of life with BFFHL in comparison with children without BFFHL, obtained from Debes *et al.*<sup>(23)</sup>. The estimated number of late neonatal deaths avoided (cases averted = CA) by BFFHL in São Paulo city during 2016 was obtained using the following equation<sup>(21)</sup>:

$$CA = \sum \frac{N_x}{1 - PF_x} - N_x,$$

where  $N_x$  is the number of cases observed in the municipality of São Paulo in 2016<sup>(24)</sup> and  $PF_x$  is the preventive fraction of the mortality indicator.

*Direct costs of Baby-Friendly Hospitals and non-Baby-Friendly Hospitals*

The direct costs were calculated using micro-costing technique according to the type of delivery (vaginal delivery (VD) and caesarean delivery (CS)) and length of stay (2, 3–4 and  $\geq 5$  d), resulting in six cost categories (VD2, VD3, VD5, CS2, CS3 and CS5). The following cost items were considered in the costs calculation: human resources, examinations, supplies, medications and BFHI training.

Human resource costs were estimated using the hourly wage and the time spent by each health professional on the mother–infant pairs. The annual workload and the number of participants were considered to estimate costs related to BFHI training, using the hourly wages according to health professional categories, including the trainers. The annual cost of training was divided by the number of annual deliveries in each BFH.

The estimated mean direct costs of the subsample (14%) were considered representative of the direct costs of other mothers within each hospital sample, according to the groups of mothers with similar type of delivery and length of stay. Thus, the mean direct costs per hospital were estimated and included details of mean direct costs per type of delivery and length of stay.

Direct costs were estimated up to June 2018, using official inflation rates in Brazil, published by the Brazilian Institute for Geography and Statistics, and converted into US dollars, applying the official exchange rates available at the Brazilian Central Bank at reference period.

*Assessment of cost-effectiveness ratios*

The cost-effectiveness ratios (CER) of BFH and non-BFH were calculated by dividing direct costs of births within each group by its effectiveness. Incremental cost-effectiveness ratio (ICER) was also estimated referring to the differences in direct costs between the two groups divided by the differences in health outcomes, using the following equation<sup>(14)</sup>:

$$ICER = \frac{C_{BFH} - C_{nBFH}}{E_{BFH} - E_{nBFH}},$$

where  $C_{BFH}$  is the direct costs of BFH intervention group,  $C_{nBFH}$  is the direct costs of non-BFH comparison group,  $E_{BFH}$  is the effectiveness of BFH intervention group and  $E_{nBFH}$  is the effectiveness of non-BFH comparison group.

Regarding the avoided deaths (final outcome), the cost-effectiveness was estimated using decision tree modelling<sup>(14)</sup> (see Appendix 1 in the online supplementary material). CER and ICER were calculated considering probabilities of tree branches modelled according to the following parameters: delivery (born in BFH or non-BFH), type of delivery (vaginal or caesarean birth), BFFHL (yes or no), average gross cost per type of delivery and the probability of death. Thus, the final assessment was based on cost per death avoided, considering costs within each group in relation to probabilities in decision tree branches.

The probabilities of late neonatal deaths in infants breastfed or not in the first hour of life were estimated using the equation proposed by Bartick & Reinhold<sup>(25)</sup>.

$$X = \frac{S}{(B \times R + 1 - B)},$$

where  $X$  is the probability of death in non-breastfed infants,  $X \times R$  is the probability of death in breastfed infants,  $B$  is the current prevalence of breast-feeding,  $R$  is the risk rate in favour of breast-feeding<sup>(23)</sup> and  $S$  is the general incidence of all-cause late neonatal mortality rate in the population (2.25 deaths per 1000 live births in São Paulo municipality in 2016)<sup>(24)</sup>.

**Table 1** Characterisation of the individuals in the sample, according to groups, São Paulo city, 2018

Characteristics	BFH		Non-BFH		P*
	n	%	n	%	
<b>Delivery routines</b>					
Type of delivery (n)	375		267		0.365
Vaginal		62.1		66.7	
Caesarean		36.3		32.6	
Skin-to-skin contact	375		267		0.000
Yes		32.3		3.4	
No		67.7		96.6	
BFFHL	375		267		0.000
Yes		66.7		50.6	
No		33.3		49.5	
<b>Maternal characteristics</b>					
Intention to breastfeed	369		265		0.000
Yes		53.7		67.5	
No		46.3		32.5	
Skin colour	362		259		0.026
Black		24.6		17.4	
Brown		33.4		49.4	
White		42.0		33.2	
Living with partner	369		266		0.000
Yes		85.4		69.5	
No		14.6		30.5	

BFH, Baby-Friendly Hospital; non-BFH, non-Baby-Friendly Hospital; BFFHL, breast-feeding in the first hour of life.

\* $\chi^2$  test comparing intervention and control groups.

Univariate sensitivity analysis was performed for the intermediate outcome (BFHHL) and final outcome (avoided deaths) in order to verify robustness of CER and ICER according to parameter variations<sup>(14)</sup>.

**Table 2** Proportion of non-breastfed infants in the first hour of life (nBFFHL), crude prevalence ratios ( $PR_c$ ) and prevalence ratios adjusted ( $PR_{adj}$ ) according to selected variables, São Paulo city, 2018

Variables	n	nBFFHL (%)	P*	$PR_c$		$PR_{adj}$	
				OR	95 % CI	OR	95 % CI
<b>Groups</b>							
BFH	375	33.3	0.000	1		1	
Non-BFH	267	49.4		1.48	1.16, 1.89	1.41	1.02, 1.96
<b>Delivery routines</b>							
Type of delivery							
Vaginal	419	28.2	0.000	1		1	
Caesarean	223	62.3		2.21	1.73, 2.83	2.05	1.48, 2.85
Skin-to-skin							
Yes	130	13.1	0.000	1		1	
No	512	46.9		3.58	2.19, 5.86	3.93	1.90, 8.17
<b>Maternal characteristics</b>							
Skin colour							
Black	134	42.5	0.780	–		–	
Brown	249	39.0					
White	238	39.5					
Living with partner							
Yes	500	38.8	0.235	–		–	
No	135	44.4					
Intention to breastfeed							
Yes	377	37.7	0.092	1		–	
No	257	44.4		1.18	0.92, 1.51		

BFH, Baby-Friendly Hospital; non-BFH, non-Baby-Friendly Hospital.

\* $\chi^2$  test comparing intervention and control groups.

Regarding intermediate outcome scenarios, estimations were performed adopting changes ( $\pm 10\%$ ) in the following parameters: cost per delivery, length of stay, human resources, medications, inputs, tests and effectiveness (BFFHL). Referring to final outcome scenarios, sensitivity analysis was based on variations ( $\pm 10\%$ ) of parameters included in decision tree branches (group, average cost, type of delivery and effectiveness (deaths avoided)). The results of the sensitivity analysis are shown in dispersion diagrams and tornado diagrams, thus providing analyses of several parameters at the same time. This method allows visualising the magnitude of the impact on the ICER of each of the simulated scenarios with the variation in costs or final outcomes.

## Results

### Baby-Friendly Hospital Initiative effectiveness

The sample used for the cost-effectiveness analysis consisted of 642 mother–infant pairs who reported the length of stay: 58.3% in the BFH group and 41.7% in the non-BFH group (see Appendix 2 in the online supplementary material). The variables related to the mother (age, education and work), the child (gestational age, birth weight and type of delivery) and per capita income were similar between both groups. Table 1 presents the sample characteristics that showed significant differences between the BFH and non-BFH groups.

Regarding the delivery routines, skin-to-skin contact and BFFHL were more prevalent in the BFH group. In relation to maternal characteristics, the non-BFH group had more mothers who were intending to breastfeed, black and did not live with their partner, compared with the BFH group. However, these maternal variables did not influence BFFHL, as shown in Table 2. Variables associated with non-breastfed infants in the first hour of life in the adjusted model were born in a non-BFH hospital, by caesarean section and not having skin-to-skin contact (Table 2).

Table 3 shows the number of late neonatal deaths avoided by BFFHL in both groups, estimated by the PF. The increase in BFFHL promoted by the BFHI resulted in a reduction of forty-nine all-cause deaths and fourteen more deaths from infections, equivalent to potential reduction of 13 and 13.1%, respectively, in late neonatal mortality from all causes and from infections in São Paulo city during 2016 (Table 3).

### Direct costs of Baby-Friendly Hospital Initiative

The costs with human resources represented the highest proportion of the overall direct costs of births (68.8%), followed by exams (11.6%), medication (11.0%) and other inputs (8.0%). Direct costs related to BFHI training accounted only for 0.58% of average cost of deliveries in hospitals participating in the initiative. Mean direct cost

of births in the BFH group was significantly lower for both vaginal and caesarean delivery (Table 4).

On average, vaginal delivery had approximately 45% lower direct costs compared with caesarean section. Costs increased proportionally according to length of stay. BFFHL was associated with a shorter length of stay, resulting in a higher prevalence of vaginal delivery with up to 2 d of hospitalisation (RP = 1.89; 95% CI 1.31, 2.70), in comparison with children who were not breastfed in the first hour of life. Consequently, the results pointed to a shorter length of stay in BFH for vaginal delivery ( $P=0.010$ ). Being born in BFH increased the prevalence of vaginal delivery with 2 d of hospitalisation (PR = 1.47; 95% CI 1.05, 2.06). On the other hand, being born in non-BFH quadrupled the prevalence of vaginal delivery with  $\geq 5$  d of hospitalisation (RP = 3.96; 95% CI 1.99, 7.87).

### Baby-Friendly Hospital Initiative cost-effectiveness

Figure 2 presents the cost-effectiveness diagrams for BFFHL and late neonatal deaths avoided, showing alternative scenarios resulting from changes in key parameters of costs and effectiveness that may result in deviations from the deterministic scenario.

Considering the intermediate outcome (BFFHL), the BFHI presented 76.2% of the alternative cases resulting from parameter variations in the quadrant IV (dominance),

**Table 3** Estimates of deaths averted in intervention group (Baby-Friendly Hospital, BFH) and comparison group (non-Baby-Friendly Hospital, non-BFH), according to mortality indicators, São Paulo city, 2018

Indicators	Cases in São Paulo* (2016)	BFH		Non-BFH		BFH difference	Infant mortality reduction (%)
		PF	Cases avoided	PF	Cases avoided		
Late neonatal mortality rate	377	0.2948	158	0.2244	109	49	13.0
Late neonatal mortality rate due to infections	107	0.3015	46	0.2295	32	14	13.1

PF, preventive fraction.

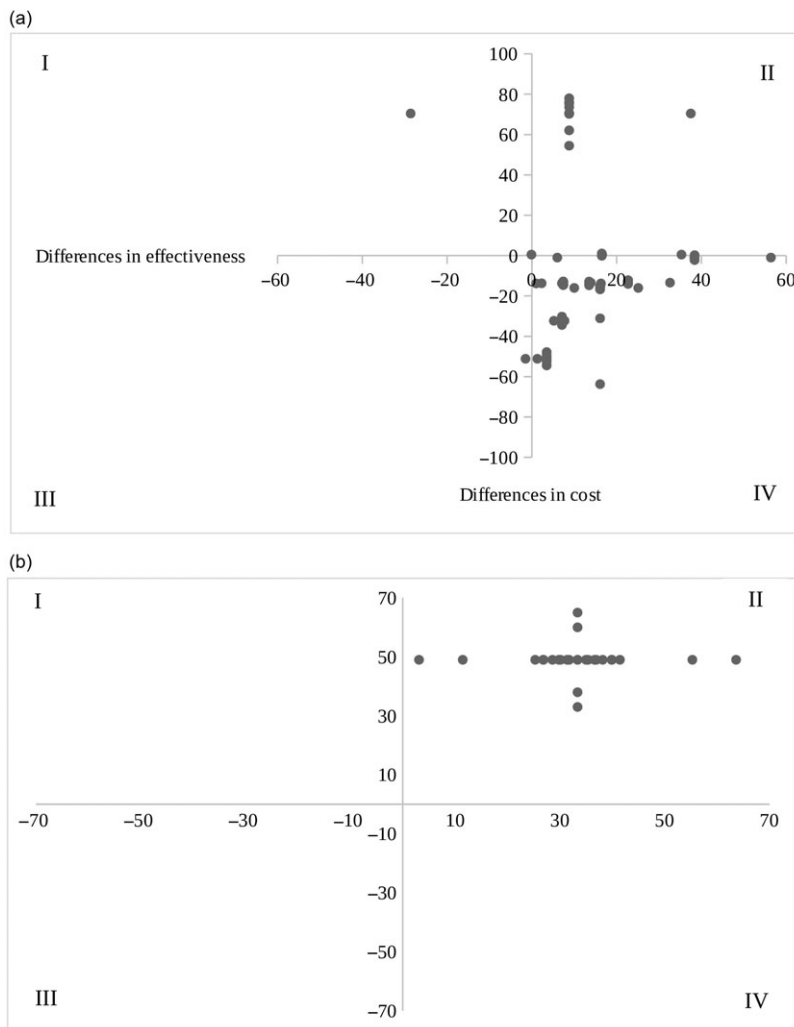
\*Source: Department of Informatics of the Brazilian Unified Health System (<http://tabnet.datasus.gov.br/cgi/tabcgi.exe?sih/cnv/nrsp.def>).

**Table 4** Distribution of direct costs of deliveries in intervention group (Baby-Friendly Hospital, BFH) and comparison group (non-Baby-Friendly Hospital, non-BFH), according to cost categories (mean), São Paulo city, 2018

Cost categories	Total sample (\$US)	BFH (\$US)	Non-BFH (\$v)	$P^*$
Overall cost	259.44	252.78	268.78	0.001
Vaginal delivery	223.19	217.84	231.23	0.000
VD2	200.71	200.40	201.36	0.421
VD3	227.89	221.81	235.57	0.001
VD5	280.05	335.99	265.53	0.000
Caesarean section	326.80	314.20	346.49	0.000
CS2	276.79	272.01	285.71	0.015
CS3	338.70	316.29	367.40	0.000
CS5	371.98	372.15	371.64	0.893

BFH, Baby-Friendly Hospital; non-BFH, non-Baby-Friendly Hospital; VD2, vaginal delivery with up to 2 d of hospitalisation; VD3, vaginal delivery with 3–4 d of hospitalisation; VD5, vaginal delivery with 5 or more days of hospitalisation; CS2, caesarean section with up to 2 d of hospitalisation; CS3, caesarean section with 3–4 d of hospitalisation; CS5, caesarean section with  $\geq 5$  d of hospitalisation.

\*Mann–Whitney test for comparison of means between groups.



**Fig. 2** Cost-effectiveness dispersion diagrams of breast-feeding during the first hour of life (a) and neonatal deaths avoided (b), São Paulo city, 2018. ●, deterministic scenario; ●, parameter variations; I: Quadrant I; II: Quadrant II; III: Quadrant III; IV: Quadrant IV

which means that changes in initial conditions may result in lower cost and greater effectiveness for 76.2 % of the situations (Fig. 2(a)).

Referring to the final outcome (late neonatal deaths avoided), all simulated scenarios due to variations in parameters were included in quadrant II, which means that changes in costs and/or outcomes may generate slightly higher costs associated with greater effectiveness in relation to the deterministic scenario (Fig. 2(b)).

**Incremental cost-effectiveness ratio**

ICER in the intermediate outcome was negative, indicating that BFH was dominant compared with non-BFH promoting a 16.1-percentage point increase in BFFHL prevalence (+31.8 %) at a lower cost (Table 5). Regarding avoided infant deaths, positive ICER indicated a slightly higher cost in the BFH group, with a \$US 0.68 increase in costs for prevented deaths (Table 5).

The ICER in the final outcome was positive because the final cost obtained by summing the decision tree parameters probabilities was influenced by the higher probability of being born in BFH (BFH 0.58 and non-BFH 0.42) and higher probability of caesarean delivery in the BFH group (BFH 0.36 and non-BFH 0.33), according to decision tree in Appendix 2 in the online supplementary material.

The sensitivity analysis represented the changes in ICER due to variations in costs and end points, according to categories for promotion of BFFHL and reduction in late neonatal mortality (Fig. 3).

The length of hospitalisation, especially combined with caesarean section delivery, was the parameter with the highest influence in ICER for BFFHL (Fig. 3(a)), in comparison with changes in other parameters determining ICER. The results of univariate sensitivity analysis for reduction in neonatal mortality (Fig. 3(b)) indicated that variations in the probability of being born in the BFH or non-BFH group would be the parameter with the greatest influence

**Table 5** Cost-effectiveness ratio (CER) and incremental cost-effectiveness ratio (ICER) of breast-feeding in the first hour of life (BFFHL) and neonatal mortality, according to cost categories, São Paulo city, 2018

BFFHL						
Groups	Cost (\$US)	Incremental cost (\$US)	Effectiveness BFFHL (%)	Incremental effectiveness	CER (\$US/pp)*	ICER
BFH	252.79	-15.99	66.7	16.1	3.79	-0.99 (dominant)
Non-BFH	268.78		50.6		5.31	
VDBFH	217.84	-13.39	81.6	22.7	2.67	-0.59 (dominant)
VDnBFH	231.23		58.9		3.93	
CSBFH	314.20	-32.29	40.4	7.1	7.78	-4.55 (dominant)
CSnBFH	346.49		33.3		10.41	

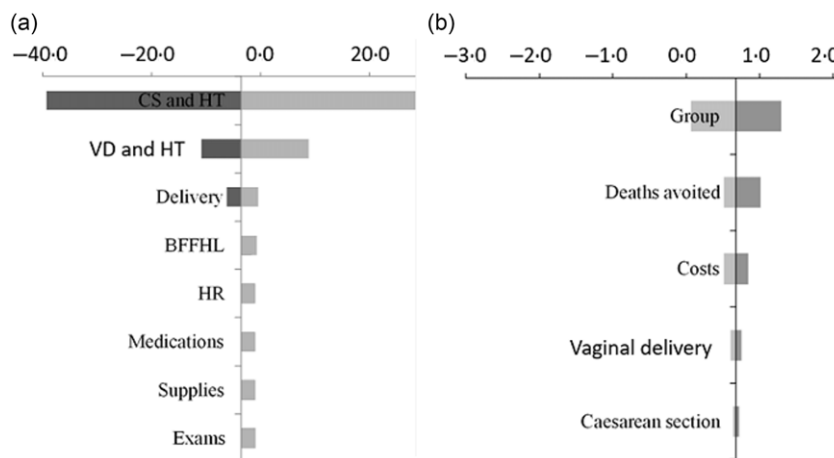
  

Late neonatal mortality rate						
Groups	Cost (\$US)	Incremental cost (\$US)	Avoided cases	Incremental effectiveness	CER (\$US/ac)†	ICER
BFH	146.47	33.38	158	49	0.93	0.68 (cost-effective)
Non-BFH	113.09		109		1.04	

BFH, Baby-Friendly Hospital; non-BFH, non-Baby-Friendly Hospital; VDBFH, vaginal delivery in the BFH group; VDnBFH, vaginal delivery in the non-BFH group; CSBFH, caesarean section in the BFH group; CSnBFH, caesarean section in the non-BFH group.

\*\$US/pp = cost per percentage points.

†\$US/ac = cost per avoided cases.



**Fig. 3** Tornado diagrams with variations of incremental cost-effectiveness ratio due to cost parameters of breast-feeding in the first hour of life (BFFHL) and avoided cases of late neonatal mortality from all causes, São Paulo city, 2018. CS and HT, variation in length of stay for caesarean section deliveries; VD and HT, variation in length of stay for vaginal deliveries; delivery, variation in the prevalence of type of delivery; HR, variation of costs due to human resources; group, cost-effectiveness variation as a function of birth probability in the Baby-Friendly Hospitals (BFH) and non-BFH groups

on the ICER, followed by variations in effectiveness. However, considering the scenarios projected, variations in ICER reached the maximum amount of \$US 1.30 per death avoided, showing that cost-effectiveness ratios estimated in the intervention were robust to changes in costs and outcomes.

**Discussion**

The study showed evidence of the effectiveness of the BFHI in increasing the prevalence of BFFHL by

approximately 32%. This result corroborates global evidence that the BFHI is one of the most effective interventions to improve the prevalence of BFFHL<sup>(6,8,26)</sup>. Other studies in Brazil have also supported this effect, such as the study by Carvalho *et al.*<sup>(27)</sup>, which reported that the BFHI doubled the prevalence of BFFHL and the study by Venancio *et al.*<sup>(15)</sup>, which analysed a nationally representative sample and found that the BFHI increased the BFFHL by 9%; the impact, although minor, is significant. The data reinforce the importance of this strategy, considering the potential of the BFFHL in reducing neonatal mortality<sup>(23,28,29)</sup>.





The reduction of neonatal mortality rate as the result of BFFHL promotion by the BFHI is consistent with evidence from other studies that early initiation of breast-feeding is among the most effective interventions to reduce neonatal mortality<sup>(23,28–31)</sup>. Therefore, it is important to foster investments in public policies that promote adherence to early breast-feeding initiation, such as the BFHI. Corroborating the findings, Silva *et al.*<sup>(12)</sup>, analysing data from the National Survey on Breastfeeding in Brazil, found that BFHI was effective in increasing the BFFHL by 11.7% and potentially contributing to reduction of 4.2% of late neonatal deaths in Brazil. The increase in BFFHL was higher in the current study, with greater effect in mortality rate reduction. This evidence allows to infer that higher effectiveness of the BFHI in raising the prevalence of BFFHL represents larger proportion of children's lives saved. The late neonatal mortality rate in Brazil was reduced from 5.4 in 1990 to 2.2 per 1000 live births in 2015<sup>(32)</sup>. There were 167 276 live births registered in São Paulo municipality during 2016, and late neonatal mortality rate was 2.25 per thousand<sup>(24)</sup>. Considering that the neonatal component corresponds to 70% of infant mortality in Brazil, infections being the second leading cause of death<sup>(32)</sup>, especially in late neonatal period<sup>(28)</sup>, the potential of BFHI in reducing neonatal mortality confirms its relevance as public policy to promote child survival.

Direct cost of deliveries in the BFH group was significantly lower compared with non-BFHI. Since the breast-feeding in the first hour was associated with a shorter length of stay and lower costs, this difference may be partly attributed to the increase in the BFFHL promoted by the BFHI. Thus, considering the effectiveness of BFHI for promotion of breast-feeding in the first hour, the wide adoption of the initiative in Brazilian hospitals may provide benefits to the population and also to the national health system.

Furthermore, the direct costs involved in the development and promotion of BFHI through the assignment of one health professional responsible for monitoring the initiative and annual training of health professionals' teams were included in the estimation of costs within the study, comprising approximately 0.6% of direct costs per birth in a BFH. Nevertheless, the births in a BFH remained lower than in a non-BFH, which did not include these additional costs. This suggests that the direct costs of maintaining BFHI would not be a barrier to promoting breast-feeding at the hospital level.

A study conducted by Oliveira<sup>(33)</sup> in Rio de Janeiro investigated the costs of delivery within a BFH in Brazil and, when assessing the direct costs of childbirth in a birth centre, the authors projected that if all deliveries occurred in a BFHI facility, there would be an annual saving of approximately \$ 630 000 for childbirth. There is lack of cost estimates referring to BFHI in the literature worldwide. A systematic review recently published<sup>(10)</sup> on costs for implementation and enhancement of interventions for breast-feeding identified only five studies focusing on

BFHI. Only two studies, both performed in the USA, compared the costs of births in BFH and non-BFH<sup>(34,35)</sup>.

Dellifraire *et al.*<sup>(34)</sup> noted that the BFHI had a slightly higher cost (1.6–5.0%) than other hospitals; however, the difference was not statistically significant. When analysing hospital data from twenty US states, Allen *et al.*<sup>(35)</sup> found an increase in costs according to the number of BFHI steps completed (also not statistically significant).

The cost-effectiveness analysis of the BFHI for promotion of BFFHL indicated a negative ICER, showing that the BFHI was dominant in relation to non-BFH, that is, highly cost-effective with important results for mothers who went through caesarean delivery, even considering additional costs for annual health professionals training, according to initiative's recommendations. The shorter length of stay (2 d) and absence of complications were situations with higher cost-effectiveness ratios (in favour of BFHI), while the prolonged length of stay of the mother and/or child increased the costs and reduced cost-effectiveness. Similarly, results from a systematic review performed by Renfrey *et al.*<sup>(36)</sup> showed evidence that trained health professionals' support in hospitals was potentially cost-saving for promotion of breast-feeding, increasing the quality-adjusted life years.

Contrary to BFFHL, the cost-effectiveness ratio for neonatal mortality had a positive ICER through estimation of costs in comparison with outcomes probabilities within decision tree modelling. The costs were influenced by a higher probability of being born within BFH in combination with a higher probability of caesarean delivery in the BFH, according to information obtained in the cohort. Compared with similar costs prevailing in other branches of the decision tree, the cost-effectiveness ratio resulted in slightly higher costs and positive ICER within the BFH group. Therefore, scenarios involving equal probability of birth in BFH and non-BFH with equal probability of caesarean section in both groups showed a negative ICER.

It is important to highlight that the effectiveness was also higher within the BFH group, including potential scenarios in sensitivity analysis located in quadrant II, which involves decision-making based on cost-effectiveness ratios thresholds. Considering the absence of threshold for health interventions established in Brazil and the low ICER obtained (\$US 0.68 per neonatal death avoided), the BFHI provides extensive social benefits in costs in relation to other health programmes.

Additionally, direct costs established in the current study considered only the payers' perspective (Brazilian government), that is, the inclusion of potential future hospitalisation costs due to health problems associated with late neonatal mortality in the absence of early breast-feeding could impose supplementary costs in the non-BFH group, resulting in further economic advantages to the initiative. Evidence in recent studies shows that breast-feeding potentially prevents 623 000 premature deaths of children and 20 000 premature deaths of women worldwide<sup>(1)</sup>,



highlighting the burden imposed by the absence of breast-feeding and early weaning in health systems and societies<sup>(1,2,25)</sup>.

There was lack of evidence regarding cost-effectiveness studies related to the BFHI in the literature review performed, and the existing information on cost-effectiveness was related only to general breast-feeding promotion activities in three countries (Brazil, Honduras and Mexico)<sup>(37)</sup>. Horton *et al.*<sup>(37)</sup> estimated morbidity and mortality cases avoided due to diarrhoea and respiratory infections and disability-adjusted life years, concluding that the cost-effectiveness ratio of the programmes evaluated was comparable with gains in death cases avoided due to immunisations, vitamin A supplementation and short-term treatment of tuberculosis<sup>(38)</sup>.

The main limitation of the study refers to sample representativeness, since it encompasses only population using public hospitals. On the other hand, most BFHI in Brazil are public hospitals, that is, the methodological criteria used for sample selection encompassed major part of the target group. It is important to highlight the originality of the study in conducting a prospective cohort to perform a cost-effectiveness analysis of BFHI in promoting early breast-feeding and reducing neonatal mortality. Given the unavailability of information to compare the cost-effectiveness analysis, future investigations should focus on collecting long-term longitudinal data on costs and impacts on health outcomes referring to BFHI implementation. This should be studied especially considering indirect and societal costs due to early weaning, and benefits attributable to breast-feeding in the prevention of diseases and reduction of future health care costs.

## Conclusion

The study provides the first cost-effectiveness analysis of the BFHI, conducted in Brazil in prospective cohort of mothers to present data on cost-effectiveness of breast-feeding outcomes, particularly in the promotion of adherence in the first hour of life and in the reduction of late neonatal mortality rates. The results showed dominance of the initiative in deterministic and sensitivity analysis scenarios for early promotion of breast-feeding and also its cost-effective results in the reduction of late neonatal mortality rates. The evidence represents an advance in economic assessment of public health programmes that require low level of expenditures for investments in its expansion and sustainability, resulting in health, social and economic gains in short, medium and long term. Based on findings of the current study, considering estimate of deaths avoided by BFHI between 7 and 28 d after birth (forty-nine deaths averted), late neonatal mortality rate could be reduced to approximately 1.96 per thousand in the municipality during 2016 due to

adoption of BFHI in all hospitals, representing a reduction of 13 % in this infant mortality rate component.

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## Supplementary material

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