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**Practices, Predictors and Consequences of Expressed Breast  
Milk Feeding in Healthy Full-term Infants**

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1 **ABSTRACT**

2 **Objective:** To investigate the prevalence and predictors of expressed breast milk feeding in  
3 healthy full-term infants and its association with total duration of breast milk feeding.

4 **Design:** Prospective cohort study.

5 **Setting:** In-patient postnatal units of four public hospitals in Hong Kong.

6 **Subjects:** A total of 2450 mother–infant pairs were recruited in 2006–2007 and 2011–2012  
7 and followed up prospectively for 12 months or until breast milk feeding had stopped.

8 **Results:** Across the first 6 months postpartum, rates of exclusive expressed breast milk  
9 feeding ranged from 5.1% to 8.0% in 2006–2007 and from 18.0% to 19.8% in 2011–2012.

10 Factors associated with higher rates of exclusive expressed breast milk feeding, include  
11 supplementation with infant formula, lack of previous breast milk feeding experience, having  
12 a planned cesarean section delivery, and returning to work postpartum. Exclusive expressed  
13 breast milk feeding was associated with an increased risk of early breast milk feeding  
14 cessation when compared with direct feeding at the breast. The hazard ratios (HR) ranged  
15 from 1.25 (95% CI: 1.04, 1.51) to 1.91 (95% CI: 1.34, 2.73) across the first 6 months.

16 **Conclusions:** Mothers of healthy term infants should be encouraged and supported to feed  
17 directly at the breast. Exclusive expressed breast milk feeding should be recommended only  
18 when medically necessary and not as a substitute for feeding directly at the breast. Further  
19 research is required to explore mothers' reasons for exclusive expressed breast milk feeding  
20 and to identify the health outcomes associated with this practice.

21

22 **Keywords:** breast milk, expression, pumping, breastfeeding, Chinese

## 23 INTRODUCTION

24 Human milk provides optimal nutritional benefits for infants' growth and development<sup>(1-3)</sup>.  
25 The majority of breast milk feeding studies have focused on the initiation, duration, or  
26 exclusivity of breast milk feeding<sup>(4, 5)</sup>. Notably, the delivery mode of breast milk (direct  
27 feeding at the breast, expressed breast milk feeding, or a combination) has been substantially  
28 less investigated. The World Health Organization (WHO) recommends that new mothers are  
29 taught the skill of hand expression during the postpartum hospital stay<sup>(6)</sup>, especially in cases  
30 of preterm delivery, low birth weight infants, or infants who were unable to feed at the  
31 breast<sup>(7-8)</sup>. In addition to hand expression, breast pumps provide an alternate way for mothers  
32 to express breast milk, with exclusive expression more feasible because of substantial  
33 developments in breast pump technology after the mid-20<sup>th</sup> century<sup>(9)</sup>. When compared with  
34 direct feeding at the breast, expressed breast milk feeding provides an alternative method to  
35 provide breast milk during periods of maternal–infant separation<sup>(10)</sup>, when there is a need to  
36 store extra milk<sup>(11)</sup>, to manage breast milk feeding difficulties<sup>(12)</sup>, and to facilitate maternal  
37 independence<sup>(13, 14)</sup>. Conversely, potential contamination of expressed breast milk<sup>(15)</sup>, loss or  
38 depletion of nutritional components<sup>(15, 16)</sup>, the additional handling required in the process of  
39 expression<sup>(17)</sup>, breast pain or nipple trauma<sup>(18-20)</sup>, and lack of mother–infant skin-to-skin  
40 contact and bonding<sup>(21)</sup> have been identified as disadvantages of feeding with expressed breast  
41 milk or the expression process.

42 Researchers in high-income countries have documented a growing trend in expressed  
43 breast milk feeding among healthy term babies<sup>(22)</sup>. Findings from the Infant Feeding Practices  
44 Study (IFPS) II in the United States showed that 85% of mothers had expressed breast milk at  
45 some point, 68% expressed within the first 2 weeks after birth, and 25% did so on a regular  
46 basis<sup>(10)</sup>. An Australian study found that 98% of mothers had expressed breast milk at least  
47 once<sup>(11)</sup>. Only two studies, however, have measured expressed breast milk feeding rates over  
48 time. One study in Australia reported that over a 10-year period from 1992–1993 to 2002–  
49 2003, rates of any expressed breast milk feeding within the first 6 weeks increased from 38%  
50 to 69%<sup>(12)</sup>. Another study in Singapore reported an increase in exclusive expressed breast milk  
51 feeding from 9% in 2000–2001 to 18% in 2006–2008<sup>(23)</sup>.

52 Studies examining the relationship between expressed breast milk feeding and total  
53 duration of breast milk feeding are also limited, and their conclusions are conflicting.  
54 Although some researchers have reported no significant associations between expressed  
55 breast milk feeding and the total duration of breast milk feeding<sup>(24)</sup>, others have shown both  
56 negative<sup>(25-28)</sup> and positive relationships<sup>(29, 30)</sup>. Schwartz et al.<sup>(31)</sup> found that expressed breast

57 milk feeding within the first 3 weeks postpartum was associated with early breast milk  
58 feeding cessation, whereas expressed breast milk feeding between 4 and 12 weeks postpartum  
59 predicted a lower risk of stopping breast milk feeding. Given the limited research on the  
60 practices and consequences of expressed breast milk feeding in healthy term infants, the aims  
61 of this study were: to describe and compare the prevalence of expressed breast milk feeding in  
62 healthy full-term infants at two time points (2006–2007 and 2011–2012); to identify the  
63 factors associated with expressed breast milk feeding; and to examine the association between  
64 expressed breast milk feeding at different time points and subsequent duration of any and  
65 exclusive breast milk feeding.

## 66 **METHODS**

### 67 **Participants and Setting**

68 This multi-center prospective cohort study examined the association between  
69 sociodemographic factors and breast milk feeding. Study methods have been reported in more  
70 detail elsewhere<sup>(32, 33)</sup>. In brief, two cohorts of mother–infant pairs were recruited during their  
71 postpartum hospitalization from the obstetric units of four geographically distributed public  
72 hospitals in Hong Kong. Hong Kong has eight public and ten private hospitals that deliver  
73 obstetric care, with public hospitals accounting for 67.8% of all births to Hong Kong  
74 mothers<sup>(34)</sup>. In Hong Kong, about 75% of women of childbearing age are employed full-  
75 time<sup>(35)</sup>. The maximum maternity leave in Hong Kong is 10 weeks and at least 2 weeks must  
76 be taken before the expected date of delivery<sup>(36)</sup>. Over 80% of employed mothers return to  
77 work within 10 weeks postpartum, and more than one-half work 45 hours or more per  
78 week<sup>(37)</sup>. Childcare is generally provided in the home by family members or foreign domestic  
79 helpers employed by the family<sup>(37)</sup> and workplace based childcare is very rare. Cohort 1  
80 included 1417 mother–infant pairs recruited in 2006–2007, and Cohort 2 included 1287  
81 mother–infant pairs recruited in 2011–2012. Participants were Cantonese-speaking, Hong  
82 Kong Chinese mothers who had just given birth to healthy, full-term infants with no serious  
83 obstetric or birth complications and who were intending to breastfeed their infants.

### 84 **Data Collection**

85 Sociodemographic characteristics were collected by maternal self-report during postpartum  
86 hospitalization. Pregnancy and birth data were collected from participants by two trained  
87 research nurses for each study cohort. Breast milk feeding status was assessed by maternal  
88 self-report through telephone follow-up at 1, 2, 3, 6, 9, and 12 months postpartum or until  
89 breast milk feeding had stopped, whichever occurred first. Breast milk feeding patterns were  
90 classified as exclusive, predominant, or partial according to widely accepted definitions<sup>(38, 39)</sup>.

91 Infants who were still receiving breast milk at 1, 2, 3, and 6 months were also asked about the  
92 number of direct feedings at the breast and the number of expressed breast milk feedings  
93 during the previous 24 hours<sup>(39)</sup>. We did not collect data on the source of the expressed breast  
94 milk (i.e., infant's mother, wet nurse, or breast milk bank). However, wet nursing is not  
95 commonly practiced in Hong Kong, and there are no established milk banks. Thus, we have  
96 assumed that the expressed breast milk was the participant's milk. For infants who had  
97 stopped receiving breast milk during the follow-up, weaning data—including the duration of  
98 breast milk feeding in weeks—were reported by participants in the interview after their  
99 infants had stopped receiving breast milk. No further data were collected after this point. **Both**  
100 **cohorts were recruited from the same hospitals using the same study protocols, inclusion**  
101 **criteria, questionnaires, and data collection procedures.**

### 102 **Variable Descriptions**

103 The term “breastfeeding” has been used to describe the feeding of breast milk to infants by  
104 any and all means<sup>(38, 39)</sup>. Thus, confusion may arise when we try to distinguish between  
105 different modes of breast milk delivery. **In this paper, we have used the term “breast milk**  
106 **feeding” to describe all breast milk feedings received by the infant or the generic act of**  
107 **feeding breast milk, irrespective of the delivery mode of breast milk. “Exclusive breast milk**  
108 **feeding” was defined as infant receiving only breast milk with no other liquids or breast milk**  
109 **substitutes (other than vitamins or medications).** Additionally, we have used the term  
110 “expressed breast milk feeding” to denote breast milk received by infants as a result of  
111 expression either using manual expression or a breast pump and the term “direct feeding at  
112 the breast” to describe the feedings that were given directly from the breast.

113 At 1, 2, 3, and 6 months postpartum, we computed the proportion of expressed breast  
114 milk feedings among all breast milk feedings received by the infant in the preceding 24 hours.  
115 Expressed breast milk feedings were recoded as four levels: 0%, >0–50%, >50–99%, and  
116 100%. Exclusive expressed breast milk feeding was defined as the infant receiving expressed  
117 milk for all breast milk feeds (100%). Breast milk feeding duration was defined as the total  
118 number of weeks the infant received any breast milk. Sociodemographic variables were  
119 measured to assess their association with expressed breast milk feeding and also served as  
120 confounding variables in the adjusted regression models. These variables included: the study  
121 cohort, proportion of total milk diet that was infant formula (0%, >0–50%, >50–99%),  
122 maternal age, maternal education level, monthly family income, length of residence in Hong  
123 Kong, intention to exclusively breastfeed, participant breastfed as a child, previous breast  
124 milk feeding experience, husband's infant feeding preference, delivery type, and mother

125 returning to work. Length of residence in Hong Kong was assessed as many Hong Kong  
126 mothers have migrated from Mainland China where breast milk feeding rates in most regions  
127 are higher than in Hong Kong<sup>(40)</sup>. Previous research has shown differences in breast milk  
128 feeding duration between Hong Kong born and Mainland Chinese born mothers<sup>(32)</sup>.

### 129 Data Analysis

130 Descriptive statistics were used to describe the characteristics of study participants and  
131 practices of expressed breast milk feeding at 1, 2, 3, and 6 months postpartum. Unadjusted  
132 and adjusted logistic regression models were performed to identify factors associated with  
133 exclusive expressed breast milk feeding across the first 6 months postpartum. The Hosmer–  
134 Lemeshow goodness of fit test<sup>(41)</sup> was used to assess the adequacy of the logistic models, and  
135 the variance inflation factor (VIF)<sup>(42)</sup> was used to assess for multicollinearity. We also  
136 employed interaction terms between the predictor variables and the study cohort in all  
137 adjusted regression models. Kaplan–Meier survival curves and log-rank tests (trend) were  
138 performed to explore the association between the different levels of expressed breast milk  
139 feeding at the selected time points and the total duration of breast milk feeding<sup>(43)</sup>. We used  
140 unadjusted and adjusted Cox proportional hazards models to evaluate the extent to which  
141 expressed breast milk feeding influenced subsequent duration of any and exclusive breast  
142 milk feeding<sup>(44)</sup>. Breast milk feeding duration in participants with partial follow-up (n=72)  
143 was censored at the last contact. To assess whether the association between expressed breast  
144 milk feeding and cessation of breast milk feeding varied between infants who were  
145 exclusively breastfed and those who were not, interaction terms between the predictor  
146 variables and supplementation with infant formula (0%, >0–50%, >50–99%) were tested in  
147 the adjusted regression models. All data analysis was conducted using Stata version 13.1  
148 statistical software (Stata Corp, College Station, TX)<sup>(45)</sup>, and a 0.05 nominal level of  
149 significance was used throughout the statistical analysis.

### 150 RESULTS

151 In total, 2704 (Cohort 1=1417; Cohort 2=1287) mother–infant pairs were eligible for analysis.  
152 We excluded 18 participants (Cohort 1=8; Cohort 2=10) who subsequently did not meet the  
153 study eligibility criteria, two participants (Cohort 1) without demographic data, 124  
154 participants (Cohort 1=87; Cohort 2=37) with whom there was no contact after hospitalization,  
155 and 110 participants (Cohort 1=66; Cohort 2=44) with missing values related the primary  
156 variables. A total 2450 mother–infant pairs (Cohort 1=1254; Cohort 2=1196) were included in  
157 the final analysis. Of the 2450 participants, 2.9% (n=72) had partial follow-up, with 0.9%  
158 (n=22) lost to follow-up after 1 month, 0.6% (n=14) lost to follow-up after 2 months, 0.5%

159 (n=13) lost to follow-up after 3 months, 0.5% (n=12) lost to follow-up after 6 months, and  
160 0.4% (n=11) lost to follow-up after 9 months. Characteristics of participants are presented in  
161 Table 1. Among all of the participants, about 40% had obtained a university degree, and  
162 almost 70% returned to work postpartum. Approximately one-half of the participants'  
163 husbands supported exclusive breast milk feeding, and over one-third had no specific infant  
164 feeding preference.

165 Of the 2450 participants, 64.7 % (n=1584) fed their infants with breast milk for at  
166 least 1 month, 51.0% (n=1249) for at least 2 months, 41.9% (n=1027) for at least 3 months,  
167 and 29.0% (n=710) for at least 6 months or longer. Figure 1 shows the levels of expressed  
168 breast milk feeding over the first 6 months by study cohort. The proportion of exclusive  
169 expressed breast milk feeding ranged from 5.1% to 8.0% across the first 6 months in Cohort 1,  
170 whereas the rates ranged from 18.0% to 19.8% in Cohort 2. Rates of exclusive direct feeding  
171 at the breast ranged from 62.2% to 71.4% in Cohort 1 and from 52.4% to 58.1% in Cohort 2.  
172 In cohort 1 across the first 6 months, 28.6% to 37.8% of participants still breast milk feeding  
173 were giving some amount of expressed milk. In cohort 2, the proportions ranged from 41.9%  
174 to 47.6%.

175 In the unadjusted analysis (Table 2), exclusive expressed breast milk feeding was  
176 associated with a number of variables including: study cohort, infant formula supplementation,  
177 maternal age, maternal education, family income, length of residence in Hong Kong,  
178 participant breastfed as a child, previous breast milk feeding experience, husband's infant  
179 feeding preference, delivery type, and returning to work postpartum. The fully adjusted odds  
180 ratios of exclusive expressed breast milk feeding are presented in Table 3. When compared  
181 with participants in Cohort 1, infants in the Cohort 2 were approximately three times more  
182 likely to be fed only with expressed breast milk at all time points. Proportion of infant  
183 formula supplementation, having a planned cesarean section delivery, and returning to work  
184 postpartum were all significantly associated with exclusive expressed breast milk feeding.  
185 Conversely, participants with previous breast milk feeding experience were less likely to feed  
186 exclusively with expressed breast milk. Results of the Hosmer–Lemeshow goodness of fit  
187 tests for the adjusted logistic models ranged from 0.21 to 0.92, indicating that the models  
188 were good fits for the data. VIF values also indicate a low degree of multicollinearity. There  
189 were no significant interactions between the study cohort and the independent variables in all  
190 adjusted logistic regression models ( $P>0.05$ ).

191 Results from Kaplan–Meier survival analysis and log-rank tests (trend) showed the  
192 effect of different levels of expressed breast milk feeding on the duration of breast milk



193 feeding (Figure 2). Across the first 6 months, when compared with exclusive direct feeding at  
194 the breast, exclusive expressed breast milk feeding was consistently associated with the  
195 highest risk of early breast milk feeding cessation. The results of the unadjusted and fully  
196 adjusted Cox proportional hazards models show that exclusive expressed breast milk feeding  
197 was associated with an increased risk of early breast milk feeding cessation when compared  
198 with direct feeding at the breast (Table 4). The hazards ratios ranged from 1.25 (95% CI: 1.14,  
199 1.51) to 1.91 (95% CI: 1.34, 2.73) across the first 6 months. The unadjusted Cox proportional  
200 hazards analysis on exclusive breast milk feeding showed that exclusive expressed breast milk  
201 feeding was associated with a higher risk of stopping exclusive breast milk feeding with the  
202 hazards ratios ranging from 1.32 (95% CI: 1.05, 1.66) to 1.79 (95% CI: 1.54, 2.09) (Results  
203 not shown). However, these associations were no longer statistically significant after  
204 adjustment for confounding variables. There were no significant interactions between infant  
205 formula supplementation and different levels of expressed breast milk feeding in all adjusted  
206 Cox proportional hazards models ( $P>0.05$ ).

## 207 DISCUSSION

208 This study is one of only a few studies that have examined the rates of expressed breast milk  
209 feeding over time<sup>(12,23)</sup>. We found a substantial increase in the rates of exclusive expressed  
210 breast milk feeding among healthy full-term infants between 2006–2007 and 2011–2012. At 1  
211 month postpartum, the rates of exclusive expressed breast milk feeding increased from 6.8%  
212 in Cohort 1 to 18.8% in Cohort 2. At 2 months postpartum, one-fifth of infants in Cohort 2  
213 who were still breast milk feeding were fed with exclusive expressed breast milk. We  
214 identified risk factors associated with exclusive expressed breast milk feeding, including  
215 supplementation with infant formula, lack of previous breast milk feeding experience, having  
216 a planned cesarean section, and returning to work postpartum. Our findings suggest that when  
217 compared with feeding solely at the breast, exclusive expressed breast milk feeding was  
218 associated with shorter duration of breast milk feeding across the first 6 months.

219 Despite the growing trend of breast milk expression, antenatal breast milk feeding  
220 education has not sufficiently addressed this issue<sup>(46)</sup>. Therefore, new mothers may believe  
221 there is no difference between expressed breast milk feeding and direct feeding at the breast  
222 and thus may express more liberally than necessary<sup>(47)</sup>. While some amount of expressed  
223 breast milk feeding may be necessary for healthy full-term infants to remedy short-term breast  
224 milk feeding problems, providing only expressed breast milk feedings may negatively impact  
225 the establishment of direct feeding at the breast<sup>(30)</sup>.

226 Returning to work has been identified as a common reason for healthy term infants to  
227 receive expressed breast milk<sup>(10, 11, 48, 49)</sup>. Globally, an increasing number of women have  
228 become involved in the labor market over the past several decades<sup>(35, 50, 51)</sup>. With the short  
229 maternity leave in Hong Kong and the long working hours, mothers may find it challenging to  
230 continue breast milk feeding when they are separated from their infants because of work<sup>(37)</sup>.  
231 Advances in breast pump technology have enabled mothers to effectively express breast milk  
232 at work so that they can continue breast milk feeding while employed<sup>(9, 11)</sup>. However,  
233 maternal employment is also identified as the main reason mothers provide only expressed  
234 breast milk<sup>(48)</sup>. In this study, when compared with participants not returning to work, mothers  
235 returning to employment postpartum were twice as likely to feed their infants only expressed  
236 breast milk. While exclusive expressed breast milk feeding was negatively associated with  
237 breast milk feeding duration, at 2 months postpartum, when most Hong Kong mothers return  
238 to work<sup>(36, 37)</sup>, >0–50% expressed breast milk feeding was associated with a lower, but not  
239 statistically significant, risk of breast milk feeding cessation. Fein et al.<sup>(48)</sup> found that an infant  
240 feeding strategy that combined expressed breast milk feeding and direct feeding at the breast  
241 was more effective in prolonging breast milk feeding duration when compared with expressed  
242 breast milk feeding only. In most workplaces in Hong Kong, it is currently not an option for  
243 women to bring their infants for direct breast milk feeding, and childcare is often provided by  
244 a family member or domestic helper in the home while mothers are at work<sup>(37)</sup>. Employers  
245 should be encouraged, or even mandated, to provide a friendly work environment that allows  
246 mothers to express breast milk during their work hours<sup>(48)</sup>. Furthermore, reduced working  
247 hours, especially in the early postpartum period, would allow mothers more time to maintain  
248 direct breast milk feeding<sup>(37)</sup>.

249 We also found that lower household income was associated with lower likelihood of  
250 exclusive expressed breast milk feeding. This may be because lower income women are less  
251 likely to be employed full-time and therefore do not need to exclusively express breast milk.  
252 Another possible reason may be that mothers with lower income are less likely to own an  
253 electric breast pump, which is commonly used in exclusive expressed breast milk feeding<sup>(10)</sup>.  
254 In Hong Kong there are no subsidies provided by the government or employers for purchasing  
255 breast pumps and although high quality pumps are available to rent from commercial  
256 companies, they are highly sought after and must be booked well in advance.

257 Our study also found that participants with previous breast milk feeding experience  
258 were less likely to feed exclusively with expressed breast milk, which is consistent with a  
259 previous study<sup>(10)</sup>. Mothers without breast milk feeding experience often lack confidence in

260 their ability to breastfeed<sup>(52, 53)</sup>, and may be more concerned about an over- or under-supply of  
261 breast milk, a frequently cited reason for expression<sup>(10, 11, 13, 54)</sup>. Other researchers have also  
262 reported that cesarean section was associated with higher rates of expressed breast milk  
263 feeding, likely because of the delayed onset of lactation when compared with vaginal  
264 delivery<sup>(10, 12)</sup>. However, we found that participants who had a planned cesarean section were  
265 more likely to feed their infants with only expressed breast milk, whereas participants who  
266 had an emergency (unplanned) cesarean section were not more likely to do so. Another study  
267 in this population found that women undergoing a planned cesarean section were less likely to  
268 initiate breast milk feeding when compared with mothers who had an emergency cesarean or  
269 who delivered vaginally<sup>(55)</sup>. In Hong Kong public hospitals, elective cesarean sections are not  
270 permitted and all planned operative births are medically indicated. Therefore, it is unlikely  
271 that participants with a planned cesarean birth were substantially different from those who  
272 experienced an emergency cesarean section, except that they knew in advance they would  
273 have an operative delivery. Thus, these women may prepare in advance to feed their infant  
274 with expressed breast milk after birth and may not even attempt direct breast milk feeding.  
275 Existing research, however, had rarely distinguished between these two types of cesarean  
276 birth when assessing the relationship between delivery type and expressed breast milk  
277 feeding<sup>(10, 12)</sup>.

278 Our findings suggest that supplementation with infant formula was associated with an  
279 increased likelihood of exclusive expressed breast milk feeding. Infants supplemented with  
280 formula, especially if the supplements are given using a bottle, are more likely to experience  
281 nipple confusion and problems with direct feeding at the breast<sup>(56)</sup>. Thus, to maintain breast  
282 milk feeding, mothers may be more likely to provide expressed breast milk. Another possible  
283 explanation is that both early formula supplementation and exclusive expressed breast milk  
284 feeding are consequences of breast milk feeding infants who experience difficulty in latching  
285 and sucking<sup>(10-12, 57)</sup>. Either way, mothers who experience difficulties in establishing breast  
286 milk feeding require adequate support and guidance, especially if they need to transition from  
287 a bottle to direct feeding at the breast.

288 The previous conflicting research findings on the association between expressed breast  
289 milk feeding and breast milk feeding duration<sup>(24, 25, 29-31)</sup> may have resulted from variations in  
290 study designs and sample size or the measurement of expressed breast milk feeding using a  
291 single yes/no variable without distinguishing between different levels of the expressed breast  
292 milk feeding<sup>(24, 29-31)</sup>. Consistent with another recent study<sup>(28)</sup>, we found that exclusive  
293 expressed breast milk feeding was negatively associated with the total duration of breast milk

294 feeding whereas other levels of expressed breast milk feeding were not. Existing evidence  
295 suggests that, apart from the extra time and work involved with producing and handling  
296 expressed breast milk<sup>(17)</sup> and possible nipple confusion<sup>(56)</sup>, expression can cause breast pain,  
297 nipple trauma, and mastitis<sup>(11, 58, 59)</sup>, which may contribute to early discontinuation of breast  
298 milk feeding. Also, exclusive expressed breast milk feeding is associated with a lack of skin-  
299 to-skin contact and bonding when compared with direct feeding at the breast<sup>(21)</sup>. Although  
300 expressed breast milk feeding provides greater nutritional benefits than infant formula, bottle-  
301 feeding may diminish the positive effects of direct breast milk feeding on the infant's  
302 respiratory system. Expressed breast milk is usually fed with a bottle, which can cause a  
303 shorter duration of sucking, a higher rate of swallowing, more frequent ventilator  
304 interruptions, and a lower oxygen saturation<sup>(60)</sup>. The negative pressure before milk ejection in  
305 direct breast milk feeding is approximately three times higher than the pressure developed  
306 during bottle-feeding<sup>(61)</sup>. As a result, bottle-feeding reduces the lung function (lung volume  
307 and flow rate) of infants<sup>(62)</sup>, which is associated with a higher risk of asthma at 10 years of  
308 age<sup>(63)</sup>. In addition to the negative effect on the respiratory system, bottle-feeding, irrespective  
309 of the type of milk, is also associated with a compromised ability to self-regulate milk  
310 intake<sup>(64)</sup>, rapid weight gain<sup>(65)</sup>, and oral diseases<sup>(66)</sup>.

311 Researchers have raised awareness about the increasing trend of expressed breast milk  
312 feeding<sup>(67, 68)</sup>, especially exclusive expressed breast milk feeding. On one hand, the increase in  
313 expressed breast milk feeding may be because more mothers are choosing expressed breast  
314 milk over infant formula. In that context, this is a positive trend as expressed breast milk can  
315 provide infants with the superior nutritional benefits when compared with infant formula<sup>(3)</sup>.  
316 Conversely, the increase in expressed breast milk feeding may be because new mothers are  
317 unaware of the benefits of direct breast milk feeding, and that expressed breast milk feeding  
318 may be correlated with some negative health outcomes<sup>(3, 62, 65)</sup>. **Unfortunately, no qualitative**  
319 **data on the reasons for and experiences with expressed breast milk feeding were collected.**  
320 **Further studies would be helpful to explore the reasons why mothers are increasingly**  
321 **expressing breast milk.** It is also necessary to conduct studies to identify the health risks of  
322 expressed breast milk feeding when compared with direct breast milk feeding. Furthermore,  
323 researchers have recommended that in addition to the existing methods of classifying breast  
324 milk feeding status as exclusive or non-exclusive, infant feeding studies should also  
325 categorize breast milk feeding according to the mode of breast milk delivery<sup>(69-71)</sup>.

326 To our knowledge, this study is one of only a few studies to describe the prevalence of  
327 expressed breast milk feeding over time and to examine its association with breast milk

328 feeding duration. A large number of participants were followed prospectively for up to 12  
329 months, with low dropout and loss to follow-up (4.6%). This study also has some limitations.  
330 First, it was not population-based. It is also possible that mothers with less positive breast  
331 milk feeding attitudes chose not to participate. We do not have data on those who refused to  
332 participate, and participants in our sample have higher levels of maternal education and  
333 family income when compared with all mothers who initiate breastfeeding<sup>(55)</sup>. Other  
334 population-based surveys suggest however, that the breast milk feeding patterns reported in  
335 our study are similar to those in the larger population<sup>(72)</sup>. Second, breast milk feeding duration  
336 was self-reported by participants and may be affected by recall bias. Such bias, however, is  
337 likely to be minimal as we followed participants on a regular and frequent basis after hospital  
338 discharge and studies have reported that mothers accurately report breast milk feeding  
339 duration many years later<sup>(73, 74)</sup>. Third, we did not measure the method of breast milk  
340 expression (i.e., hand expression, manual pump, or electric pump). However, a Cochrane  
341 review found no significant difference in breast milk volume between manual and electric  
342 pumps, whereas hand expression did produce less milk than an electric pump<sup>(75)</sup>. Furthermore,  
343 mothers who exclusively express their breast milk are more likely to use electric breast pumps  
344<sup>(10)</sup>. Fourth, at the follow-up intervals, we recorded the proportion of total feedings given—not  
345 the total volume of feeding. Thus, some misclassification bias may have been caused among  
346 those infants receiving both expressed breast milk feeding and direct feeding at the breast.  
347 However, such misclassification bias would be unlikely to affect the interpretation of the  
348 results as infants who were fed with exclusive expressed breast milk, and those who were  
349 receiving all breast milk directly at the breast would not be subject to misclassification.  
350 Finally, at the follow-up intervals we assessed infant feeding status by asking the mother to  
351 report the feeding patterns on the day before the follow-up<sup>(76)</sup>. Thus, it is possible that the  
352 feeding pattern reported did not reflect the usual infant feeding pattern of the infant.

### 353 **Conclusions**

354 An increasing number of healthy full-term infants are given expressed breast milk. Exclusive  
355 expressed breast milk feeding is associated with a significantly higher risk of early breast milk  
356 feeding cessation when compared with feeding directly at the breast. Thus, in both clinical  
357 practice and research, it is necessary to collect data on the mode of breast milk delivery.  
358 Mothers who feed their infants with expressed breast milk should be encouraged to feed  
359 directly at the breast as much as possible to prolong the total duration of breast milk feeding  
360 and to maximize the health benefits of breast milk feeding. Further studies are needed to re-  
361 examine the current definitions of “breast milk feeding” by taking into account both the

362 duration and exclusivity of breast milk feeding as well as the method of breast milk delivery.  
363 Further studies are also needed to identify the reasons why more infants are given expressed  
364 breast milk and to assess the effect of the breast milk delivery mechanism on maternal and  
365 child health outcomes.

For Peer Review

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Table 1. Characteristics of participants

Characteristics	Total (N=2450) %
Maternal age	
18-24 years	6.2
25-29 years	24.1
30-34 years	44.3
≥35 years	25.4
Maternal education	
Primary	3.2
Secondary	57.4
University degree or above	39.5
Monthly household income (HKD) <sup>a</sup>	
< \$15,000	19.7
\$15,000-\$29,999	34.7
≥ \$30,000	45.6
Length of residence in Hong Kong	
< 5years	9.2
5 to ≥15 years	29.1
Since birth	61.7
Participant breastfed as a child	
No	56.1
Yes	43.9
Previous breast milk feeding experience	
No	63.3
Yes	36.7
Husband's infant feeding preference	
Breast milk feeding only	52.0
Infant formula & mixed feeding	13.4
No preference	34.7
Delivery type	
Spontaneous vaginal delivery	75.4
Assisted vaginal delivery	6.5
Planned cesarean delivery	8.4
Emergency cesarean delivery	9.7
Return to work postpartum	
No	30.7
Yes	69.3

<sup>a</sup>1USD=7.78 HKD

Table 2. Unadjusted odds ratios of exclusive expressed breast milk feeding at 1, 2, 3, 6 months postpartum by participants' characteristics

Characteristics	1 month <sup>a</sup>		2 months <sup>a</sup>		3 months <sup>a</sup>		6 months <sup>a</sup>	
	OR <sup>b</sup>	95% CI	OR <sup>b</sup>	95% CI	OR <sup>b</sup>	95% CI	OR <sup>b</sup>	95% CI
Study Cohort								
Cohort 1	1	--	1	--	1	--	1	--
Cohort 2	3.18	2.28-4.42	2.86	2.00-4.08	2.55	1.71-3.79	4.10	2.33-7.20
Proportion of infant formula supplementation <sup>c</sup>								
0%	1	--	1	--	1	--	1	--
>0–50%	1.82	1.27-2.61	1.77	1.21-2.59	1.47	0.96-2.23	1.36	0.83-2.24
>50–99%	7.13	4.88-10.41	5.64	3.71-8.56	3.45	2.16-5.51	2.54	1.33-4.85
Maternal age								
18-24 years	1	--	1	--	1	--	1	--
25-29 years	1.60	0.61-4.20	4.40	1.03-18.76	6.11	0.81-46.03	3.59	0.46-27.87
30-34 years	2.26	0.89-5.74	5.16	1.23-21.59	8.48	1.15-62.52	4.73	0.63-35.67
≥35 years	1.69	0.65-4.39	2.76	0.64-11.83	4.21	0.56-31.90	2.44	0.31-19.13
Maternal education								
Primary	0.35	0.11-1.15	0.34	0.10-1.13	0.11	0.01-0.81	0.15	0.02-1.15
Secondary	0.81	0.60-1.08	0.63	0.46-0.88	0.52	0.36-0.76	0.49	0.31-0.78
University degree or above	1	--	1	--	1	--	1	--
Monthly household income (HKD) <sup>d</sup>								
< \$15,000	0.29	0.18-0.49	0.25	0.14-0.43	0.19	0.10-0.38	0.13	0.05-0.33
\$15,000-\$29,999	0.61	0.43-0.85	0.60	0.42-0.87	0.60	0.39-0.90	0.47	0.28-0.80
≥ \$30,000	1	--	1	--	1	--	1	--
Length of residence in Hong Kong								
< 5 years	0.25	0.12-0.49	0.13	0.05-0.38	0.14	0.05-0.36	0.25	0.10-0.63
5 to ≥15 years	0.47	0.33-0.67	0.47	0.40-0.89	0.60	0.40-0.88	0.36	0.21-0.63
Since birth	1	--	1	--	1	--	1	--
Participant breastfed as a child								
No	1	--	1	--	1	--	1	--
Yes	0.41	0.29-0.56	0.46	0.32-0.67	0.48	0.33-0.69	0.32	0.19-0.52
Previous breast milk feeding experience								
No	1	--	1	--	1	--	1	--
Yes	0.42	0.30-0.59	0.38	0.26-0.57	0.42	0.28-0.61	0.43	0.26-0.69
Husband's infant feeding preference								
Breast milk feeding only	1	--	1	--	1	--	1	--
Infant formula & mixed feeding	1.71	1.03-2.84	1.03	0.45-2.35	1.18	0.54-2.59	1.18	0.40-3.50
No preference	2.48	1.81-3.39	1.92	1.32-2.78	1.92	1.33-2.78	2.23	1.40-3.54

Table 2. Unadjusted odds ratios of exclusive expressed breast milk feeding at 1, 2, 3, 6 months postpartum by participants' characteristics

Characteristics	1 month <sup>a</sup>		2 months <sup>a</sup>		3 months <sup>a</sup>		6 months <sup>a</sup>	
	OR <sup>b</sup>	95% CI	OR <sup>b</sup>	95% CI	OR <sup>b</sup>	95% CI	OR <sup>b</sup>	95% CI
Delivery type								
Spontaneous vaginal delivery	1	--	1	--	1	--	1	--
Assisted vaginal delivery	0.74	0.36-1.49	1.36	0.68-2.35	0.82	0.36-1.85	0.64	0.19-2.13
Planned cesarean delivery	1.99	1.28-3.09	1.63	0.99-2.70	1.63	0.92-2.89	1.19	0.56-2.53
Emergency cesarean delivery	1.46	0.90-2.36	1.44	0.85-2.45	1.42	0.78-2.58	1.52	0.73-3.14
Return to work postpartum								
No	1	--	1	--	1	--	1	--
Yes	2.13	1.50-3.02	3.00	2.03-4.42	3.14	2.03-4.86	4.60	2.58-8.21

<sup>a</sup> Sample size for mothers who still breastfed at each time points were as follows: 1 month, n=1584; 2 months, n=1249; 3 months, n=1027; 6 months, n=710

<sup>b</sup> OR: Odds ratio

<sup>c</sup> Supplementation with infant formula was measured at 1, 2, 3, and 6 months for each model

<sup>d</sup> 1 USD=7.78 HKD

Table 3. Adjusted odds ratios of exclusive expressed breast milk feeding at 1, 2, 3, 6 months postpartum by participants' characteristics

Characteristics	1 month <sup>a</sup>		2 months <sup>a</sup>		3 months <sup>a</sup>		6 months <sup>a</sup>	
	aOR <sup>b</sup>	95% CI	aOR <sup>b</sup>	95% CI	aOR <sup>b</sup>	95% CI	aOR <sup>b</sup>	95% CI
Study Cohort								
Cohort 1	1	--	1	--	1	--	1	--
Cohort 2	3.45	2.34-5.08	3.16	2.10-4.75	2.49	1.58-3.91	4.14	2.19-7.85
Proportion of infant formula supplementation <sup>c</sup>								
0%	1	--	1	--	1	--	1	--
>0–50%	1.81	1.22-2.66	1.76	1.17-2.65	1.54	0.98-2.42	1.29	0.74-2.24
>50–99%	5.62	3.68-8.57	5.21	3.24-8.38	2.95	1.74-4.98	2.47	1.16-5.24
Maternal age								
18-24 years	1	--	1	--	1	--	1	--
25-29 years	1.16	0.41-3.29	3.28	0.70-15.34	5.36	0.67-42.79	1.35	0.16-11.43
30-34 years	1.51	0.54-4.20	3.27	0.71-15.19	6.36	0.80-50.43	1.39	0.17-11.69
≥35 years	1.22	0.42-3.52	1.81	0.38-8.69	3.63	0.44-29.68	0.90	0.10-7.92
Maternal education								
Primary	1.16	0.30-4.58	1.72	0.44-6.71	0.44	0.05-3.67	1.48	0.16-13.80
Secondary	1.48	1.01-2.16	1.25	0.83-1.88	1.14	0.72-1.81	1.26	0.70-2.24
University degree or above	1	--	1	--	1	--	1	--
Monthly household income (HKD) <sup>d</sup>								
< \$15,000	0.58	0.30-1.12	0.67	0.32-1.39	0.57	0.25-1.30	0.31	0.10-0.90
\$15,000-\$29,999	0.59	0.39-0.89	0.60	0.39-0.93	0.71	0.44-1.16	0.53	0.29-0.98
≥ \$30,000	1	--	1	--	1	--	1	--
Length of residence in Hong Kong								
< 5 years	0.69	0.31-1.53	0.38	0.14-1.05	0.40	0.13-1.20	1.16	0.38-3.58
5 to ≥15 years	0.71	0.50-1.10	0.67	0.42-1.05	1.02	0.63-1.67	0.67	0.34-1.29
Since birth	1	--	1	--	1	--	1	--
Participant breastfed as a child								
No	1	--	1	--	1	--	1	--
Yes	0.76	0.51-1.13	0.62	0.41-0.95	0.79	0.50-1.25	0.64	0.35-1.15
Previous breast milk feeding experience								
No	1	--	1	--	1	--	1	--
Yes	0.47	0.32-0.69	0.72	0.48-1.09	0.56	0.35-0.89	0.67	0.37-1.20
Husband's infant feeding preference								
Breast milk feeding only	1	--	1	--	1	--	1	--
Infant formula & mixed feeding	1.54	0.87-2.73	1.23	0.63-2.41	1.03	0.42-2.53	1.60	0.47-5.37
No preference	1.77	1.24-2.52	1.26	0.86-1.83	1.42	0.94-2.15	1.53	0.91-2.58

Table 3. Adjusted odds ratios of exclusive expressed breast milk feeding at 1, 2, 3, 6 months postpartum by participants' characteristics

Characteristics	1 month <sup>a</sup>		2 months <sup>a</sup>		3 months <sup>a</sup>		6 months <sup>a</sup>	
	aOR <sup>b</sup>	95% CI	aOR <sup>b</sup>	95% CI	aOR <sup>b</sup>	95% CI	aOR <sup>b</sup>	95% CI
Delivery type								
Spontaneous vaginal delivery	1	--	1	--	1	--	1	--
Assisted vaginal delivery	0.65	0.29-1.46	1.58	0.79-3.14	0.72	0.30-1.72	0.82	0.22-3.02
Planned cesarean delivery	2.44	1.48-4.04	2.27	1.29-4.01	1.84	0.98-3.44	1.33	0.58-3.07
Emergency cesarean delivery	1.14	0.66-1.99	1.35	0.75-2.41	1.03	0.54-1.97	1.13	0.51-2.53
Return to work postpartum								
No	1	--	1	--	1	--	1	--
Yes	1.43	0.93-2.21	1.94	1.21-3.09	1.90	1.13-3.19	2.86	1.42-5.75

<sup>a</sup> Sample size for infants who received breast milk at each time points were as follows: 1 month, n=1584; 2 months, n=1249; 3 months, n=1027; 6 months, n=710

<sup>b</sup> aOR: Adjusted odds ratio. Adjusted for all the variables shown in the table

<sup>c</sup> Supplementation with infant formula was measured at 1, 2, 3, and 6 months for each model

<sup>d</sup> 1 USD=7.78 HKD

Table 4. Unadjusted and adjusted hazards ratios of breast milk feeding cessation by different levels of expressed breast milk feeding at 1, 2, 3, and 6 months postpartum

Expressed Breast Milk Feeding	Unadjusted Model		Adjusted Model	
	HR	95% CI	aHR <sup>a</sup>	95% CI
Levels of expressed breast milk feeding at 1 month <sup>b</sup>				
0%	1	--	1	--
>0–50%	1.07	0.91-1.27	0.99	0.83-1.18
>50–99%	1.40	1.13-1.73	1.08	0.87-1.36
100%	1.82	1.54-2.14	1.25	1.04-1.51
Levels of expressed breast milk feeding at 2 months <sup>b</sup>				
0%	1	--	1	--
>0–50%	0.82	0.66-1.01	0.81	0.65-1.02
>50–99%	1.15	0.92-1.43	1.10	0.86-1.40
100%	1.60	1.33-1.93	1.19	0.96-1.46
Levels of expressed breast milk feeding at 3 months <sup>b</sup>				
0%	1	--	1	--
>0–50%	0.92	0.74-1.16	0.93	0.72-1.20
>50–99%	1.11	0.88-1.41	1.19	0.90-1.57
100%	1.61	1.30-2.01	1.43	1.12-1.84
Levels of expressed breast milk feeding at 6 months <sup>b</sup>				
0%	1	--	1	--
>0–50%	0.74	0.53-1.03	1.03	0.69-1.54
>50–99%	0.98	0.69-1.40	1.38	0.91-2.10
100%	1.67	1.24-2.26	1.91	1.34-2.73

<sup>a</sup> Adjusted for study cohort, supplementation with infant formula, maternal age, maternal education level, monthly household income, length of residence in Hong Kong, participant breastfed as a child, previous breast milk feeding experience, husband's infant feeding preference, delivery type, and mother returning to work postpartum

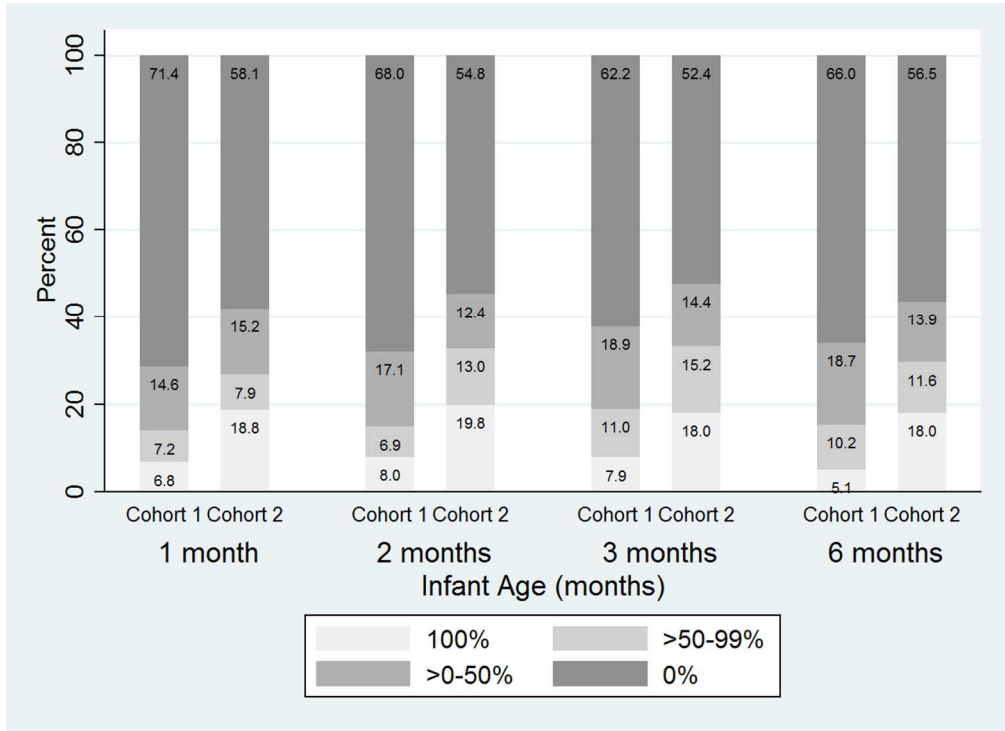
<sup>b</sup> Sample size for infants who received breast milk at each time points were as follows: 1 month, n=1584; 2 months, n=1249; 3 months, n=1027; 6 months, n=710

**Figure 1. Different levels of expressed breast milk feeding over the first six months of life by study cohort.** Sample size were as follows: 1 month, n=1584; 2 months, n=1249; 3 months, n=1027; 6 months, n=710.

**Figure 2. Kaplan-Meier survival estimates of breast milk feeding duration by different levels of expressed breast milk feeding at 1 month (a), 2 months (b), 3 months (c), and 6 months (d).** Sample size were as follows: 1 month, n=1584; 2 months, n=1249; 3 months, n=1027; 6 months, n=710.

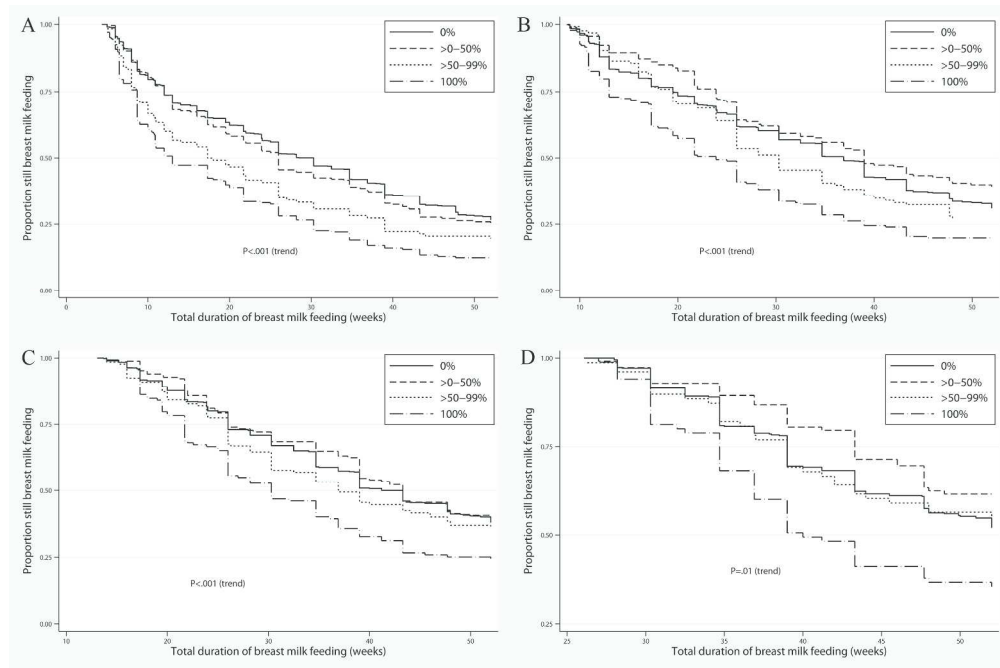
For Peer Review





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Review



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Review