Women and Birth 35 (2022) e286–e293

Contents lists available at ScienceDirect

Women and Birth

journal homepage: www.elsevier.com/locate/wombi

Association between expressed breast milk feeding and breastfeeding duration in Hong Kong mothers

Heidi Sze Lok Fan[a], Daniel Yee Tak Fong[a], Kris Yuet Wan Lok[a,*], Marie Tarrant[b]

[a] School of Nursing, Li Ka Shing Faculty of Medicine, University of Hong Kong, Hong Kong
[b] School of Nursing, Faculty of Health and Social Development, University of British Columbia, Kelowna, BC, Canada

ARTICLE INFO

Article history:
Received 17 January 2021
Received in revised form 6 May 2021
Accepted 21 June 2021

Keywords:
Breast milk
Milk expression
Breastfeeding
Hong Kong
Chinese

ABSTRACT

Background: Expressed breast milk feeding has increased substantially in the past two decades. Once used primarily for preterm infants, feeding expressed breast milk is now more common in mothers giving birth to healthy term infants. However, the effect of expressed breast milk feeding on breastfeeding duration is unclear.
Objectives: To assess the association between breast milk expression practices and breastfeeding duration in women giving birth to healthy infants.
Methods: From 2017 to 2018, we recruited 821 new mothers from two public hospitals in Hong Kong. Participants were followed up at 1.5, 3, and 6 months postpartum or until they stopped breastfeeding. The proportion, type, and mode of all milk feeding were assessed at each follow-up.
Results: At 1.5 months postpartum, 47.9%, 37.7%, and 14.4% of participants were feeding by direct breastfeeding only, mixed-mode feeding, and expressed breast milk only, respectively. Participants feeding expressed breast milk only were more likely to be supplementing with infant formula. When compared with participants who provided only direct breastfeeding, participants who gave only expressed breast milk at 1.5 months had 57% lower odds of breastfeeding continuation at three months postpartum. After stratification by infant formula supplementation, expressed breast milk feeding only at 1.5 months was associated with an increased risk of breastfeeding cessation in participants supplementing with infant formula (adjusted hazard ratio [aHR] = 1.86, 95% CI = 1.17–2.95).
Conclusion: In the first six months postpartum, giving only expressed breast milk is associated with early breastfeeding cessation, especially in participants who are also supplementing with infant formula.

Statement of significance

Problem or issue
Feeding expressed breast milk is increasingly common in mothers who give birth to healthy term infants. However, the effect of expressed breast milk feeding on breastfeeding duration is unclear. Discordant findings in previous studies may result from discrepancies in measurement time points and the frequency and proportion of expressed breastfeeding feeding.
What is already known
Women who experience breastfeeding difficulties are more likely to feed expressed breast milk.

What this paper adds
Feeding expressed breast milk only is associated with early breastfeeding cessation, especially in participants who are also supplementing with infant formula.

Background

Breastfeeding provides numerous health benefits [1], and a longer duration of exclusive breastfeeding provides greater benefits [2]. The World Health Organization recommends that infants should be exclusively breastfed for the first six months, after which they should be introduced to nutritious complementary feeding with continued breastfeeding until two years of age or above [3].

Over the past two decades, breastfeeding rates have increased in many developed countries [4,5] and the mode of breastfeeding has been changing. Although most breastfed infants continue to be

* Corresponding author at: School of Nursing, University of Hong Kong, 4/F, William M.W. Mong Block, 21 Sassoon Road, Pokfulam, Hong Kong.
E-mail address: krislok@hku.hk (K.Y.W. Lok).

http://dx.doi.org/10.1016/j.wombi.2021.06.007
1871-5192/

fed directly at the breast, new mothers are increasingly feeding expressed breast milk [6,7]. A high proportion of new mothers now pump and feed at least some expressed breast milk to their infants, with a recent study showing that 84.6% of participants gave expressed breast milk to their infants at least once within the first six months [8]. Another study conducted in the United States showed that 73.9% of participants had ever used a breast pump [9]. The benefits of breastfeeding are not only from breast milk, but also from the mode of feeding. Studies show that compared with direct breastfeeding, expressed breast milk feeding is associated with increased infant weight gain [10] and increased risk of childhood asthma [11]. Furthermore, prolonged storage of expressed breast milk is associated with decreased nutrient content [12]. Mothers can also experience pain during pumping [13] and have an increased risk of mastitis if they pump milk several times per day [14]. Although there may be differences in the health outcomes between the different modes of feeding breast milk, expressed breast milk feeding undoubtedly provides more health benefits than infant formula as it contains immunoglobulins that protect infants from infections [15].

The effects of pumping or feeding expressed breast milk on breastfeeding duration are unclear [16]. Some studies show that breast milk expression and pumping can prolong breastfeeding duration [9,17,18], others show that these practices are associated with earlier breastfeeding cessation [19–21], and some show no association [22–24]. One of the possible reasons for discrepancies in these study findings is the inconsistent measurement of expressed breast milk feeding. In some studies, the assessed exposure was breast pump use [9,25] and breast milk expression [7,13] instead of expressed breast milk feeding. However, researchers have also found that women may express their breast milk without feeding it to their infants [13]. Furthermore, variations in measurement time points and the amount of expressed breastfeeding feeding may also contribute to the differences in findings. Geraghty et al. [26] found that feeding any expressed breast milk at one month postpartum was associated with early breastfeeding cessation in term infants. However, there was no association between any expressed breast milk feeding at two months postpartum and breastfeeding duration. Jiang et al. [23] reported that exclusively expressed breast milk feeding at six weeks postpartum was associated with early breastfeeding cessation, while the combination of direct breastfeeding with breast milk expression showed no effect on breastfeeding duration.

Therefore studies that have examined the association between expressed breast milk feeding and breastfeeding duration show contradictory findings [16,17,19]. The inconsistent measurement of expressed breast milk feeding [27] and the varied terminology used to describe expressed breast milk feeding presents a challenge when comparing study findings. Furthermore, studies show that the effect of pumping or expressed breast milk feeding on breastfeeding outcomes varies with the proportion of expressed breast milk feeding [6,20,28] and the time of measurement [6,28,29]. However, only two previous studies have examined the effect of different breastfeeding modes at various time points and breastfeeding duration [6,23]. Therefore, the objective of this study was to assess the effect of expressed breast milk feeding on breastfeeding duration in healthy mothers across the first six months postpartum.

Methods

Design, setting and participants

This prospective cohort study was conducted in Hong Kong from 2017 to 2018. At the time of this study, Hong Kong had eight public and eleven private hospitals providing in-patient obstetric services [30]. The study setting and methods are described in detail elsewhere [8]. Briefly, eligible participants were recruited by a trained research nurse within 24 h after birth from the postpartum units of two public hospitals in Hong Kong. Women were screened for eligibility and were invited to participate in the study if they met the following inclusion criteria: (1) a singleton pregnancy; (2) intention to breastfeed; (3) Cantonese speaking; and (4) no serious medical or obstetric complications. Women were ineligible to participate if their infant met any of the following criteria: (1) preterm (<37 weeks' gestation); (2) a five-minute Apgar score <8; (3) birth weight <2500 g; (4) severe medical conditions or congenital malformations; (5) admission to the special care baby unit for 48 h or more after birth; or (6) ever admitted to the neonatal intensive care unit.

Data collection and measurements

Participants were invited to complete a self-administered questionnaire immediately after recruitment. The self-administered questionnaire contained questions about sociodemographic characteristics, family members' breastfeeding preferences, and participants' intention to breastfeed exclusively. Maternal and neonatal health histories and infant feeding data during the 48-h postnatal hospital stay were retrieved from the health records. Participants received telephone follow-up at 1.5, 3, and 6 months postpartum or until breastfeeding stopped, whichever came first. During telephone follow-up, the frequencies of the different modes of breast milk feeding and the type of infant feeding (e.g., direct breastfeeding, expressed breast milk feeding, and infant formula feeding) in the preceding 24-h period were collected [31]. If participants indicated that they had completely stopped breastfeeding, we recorded the total number of weeks of any and exclusive breastfeeding, and no further follow-up was conducted.

Study definitions and variable descriptions

Breastfeeding was defined as an infant receiving any breast milk, either directly from the breast or expressed breast milk [32]. This term is used broadly to encompass any type of breast milk feeding and when the distinction between the mode of breast milk feeding is not required. In this paper, we use the term "expressed breast milk feeding" to indicate the removal of breast milk from the breast by hand expression or pumping, which was then fed to the infant using a bottle, cup or syringe [33]. The term "direct breastfeeding" is used to indicate the feeding of breast milk directly from the breast.

The primary exposure variable was the proportion of expressed breast milk feeding, recorded as a continuous variable and then collapsed into three levels: (i) none (0%): direct breastfeeding only; (ii) mixed (>0%–<100%): both direct breastfeeding and expressed breast milk feeding, and (iii) full (100%): expressed breast milk feeding only. Because there were no differences in study findings between different expressed breast milk feeding levels, we combined the participants into one mixed-mode feeding group. The proportion of expressed breast milk feeding was computed as the proportion of all breast milk feeds that were expressed (0–100%), irrespective of supplementation with infant formula. The outcome variables were breastfeeding continuation at three and six months postpartum (yes or no) and the total number of weeks of any breastfeeding. The proportion of breast milk feeding was categorised into three levels: (i) low proportion of breastfeeding (>0–50%); (ii) high proportion of breastfeeding (≥50%–<100) and (iii) exclusive breastfeeding (100%).

Measured confounders included three main categories: socio-demographic characteristics, breastfeeding-related variables, and

birth-related variables. Sociodemographic variables included maternal age, maternal education, household income, length of residence in Hong Kong, and intention to return to work postpartum. Breastfeeding-related variables included intention to breastfeed exclusively, childbirth class attendance, breastfeeding class attendance, previous breastfeeding experience, and partner's infant feeding preference. Birth-related variables included any expressed breastfeeding in hospital and mode of birth. Furthermore, infant formula supplementation at 1.5 and 3 months postpartum was dichotomised (no/yes) and included as a confounding variable. These variables have been associated with breastfeeding duration in this and other populations [34–38]. Any expressed breast milk feeding in the hospital was included as a covariate because research shows that early breast milk expression is associated with the early onset of copious milk production [39].

Sample size calculation

Several studies have examined the difference in breastfeeding outcomes among participants with different modes of breastfeeding. Jiang et al. [23] reported that at six weeks postpartum, approximately 35.6% of the breastfeeding mothers had direct breastfeeding only, 41.8% had mixed-mode feeding and 22.6% had expressed breast milk feeding only. Expressed breast milk feeding only was associated with an increased risk of early breastfeeding cessation (aRR = 1.77; 95% CI: 1.25–2.48). Another study by Bai et al. [6] found that among breastfeeding participants, 58.1% were directly breastfeeding only, 23.1% were mix-mode feeding, and 18.8% were feeding expressed breast milk only at one month postpartum. The fully adjusted risk of breastfeeding cessation was 1.25 (95% CI: 1.04–1.51) in participants feeding only expressed breast milk. Based on data reported in the previous study [6], we estimated that approximately 40% of participants would have direct breastfeeding only, 15% would use mixed-mode feeding, 15% would feed expressed breast milk only, and 30% would be feeding infant formula at 1.5 months postpartum. The sample size calculation was estimated on the difference between direct breastfeeding only and expressed breast milk feeding only, as previous studies have shown no significant difference between mixed-mode feeding and direct breastfeeding only [6,23]. We estimated that at 26 weeks postpartum, the hazard rate would be 0.6 in the group with direct breastfeeding only and 0.4 in the group feeding only expressed breast milk. After accounting for a loss to follow-up rate of 20%, approximately 510 participants who were still breastfeeding at 1.5 months postpartum were required to achieve 80% power and a 1.25% nominal level of significance by log-rank test. We estimated that 5% of the participants would be lost to follow-up from recruitment to 1.5 months postpartum, so approximately 767 participants were needed. Therefore, the target was to recruit 800 participants.

Statistical analysis

Descriptive statistics were used to summarise and compare the characteristics of participants by mode of breastfeeding at 1.5 months postpartum. Bivariable and multivariable logistic regression was used to assess the effect of the proportion of expressed breast milk feeding at 1.5 months and three months postpartum on breastfeeding continuation at three months and six months postpartum. Hosmer-Lemeshow tests were used to assess the goodness of fit of the logistic regression and the Variance Inflation Factor (VIF) was examined to assess multicollinearity between variables. Kaplan Meier curves and log-rank tests were used to compare the breastfeeding duration by the proportion of expressed breast milk feeding at 1.5 months and three months postpartum. Finally, Cox proportional hazards regression was used to assess the association between the proportion of expressed breast milk feeding and the duration of any breastfeeding. We used log-log plots of estimated survival curves to test the proportional hazards assumption. In multivariable analyses, hierarchical regression was used to increase the accuracy of the models and estimates. Model 1 included sociodemographic variables, breastfeeding-related and birth-related variables. Model 2 further adjusted for the proportion of infant formula given at 1.5 and 3 months postpartum. As infant formula supplementation is a strong predictor of breastfeeding duration [40], we assessed the association between expressed breast milk feeding and breastfeeding duration and then stratified the sample by infant formula supplementation.

All data analysis was done with Stata version 14.0 (Stata Corp, College Station, TX, USA). The significance level was set as 0.05, and a 95% confidence interval (CI) was used throughout the study.

Ethical approval

Ethical approval for this study was obtained from the institutional review boards of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (UW 16-2045) and the participating hospitals [KW/EX-17-050(109-15); KC/KE-16-0261/ER-1]. The study was conducted following the principles of the Helsinki Declaration and all participants gave informed written consent.

Results

A total of 821 participants were recruited into the study. Subsequently, 60 participants were excluded for the following reasons: they became ineligible after recruitment (n = 17), were missing demographic data (n = 5), or were completely lost to follow-up (n = 38). Among the 761 participants who had a postpartum follow-up, 620 participants continued to breastfeed at 1.5 months postpartum, and 526 participants continued to breastfeed at three months postpartum. However, 10 and 12 participants did not provide data on the breastfeeding mode at 1.5 and three months postpartum, respectively. Therefore, 610 and 514 participants, respectively, were included in the analyses at 1.5 and three months postpartum.

The characteristics of the participants by the mode of breastfeeding at 1.5 months postpartum are presented in Table 1. Among participants who were still breastfeeding at 1.5 months, 47.9%, 37.7%, and 14.4% had direct breastfeeding only, mixed-mode feeding, and expressed breast milk feeding only, respectively. In our sample, almost one-half (44.1%) were 30−34 years of age, and the majority of the participants (55.7%) were born in Hong Kong. A high proportion of participants were planning to return to work postpartum (59.2%). Participants who fed only expressed breast milk were more likely to be born in Hong Kong ($P < .001$) and to be returning to work postpartum ($P < .001$), and were less likely to have previous breastfeeding experience ($P < .001$) and to intend to breastfeed exclusively ($P = .003$).

Fig. 1 shows the proportion of breastfeeding by the mode of breastfeeding at different time points. Participants who were feeding expressed breast milk only were more likely to have an overall lower proportion of breastfeeding over the first six months postpartum. At 1.5 months postpartum, a higher proportion of participants who only fed breast milk directly were exclusively breastfeeding compared to participants giving mixed-mode feeding and only expressed breast milk feeding ($P < .001$). At three and six months postpartum, participants who had direct breastfeeding only and mixed-mode feeding had similar total proportions of breastfeeding, while participants giving only expressed breast milk were more likely to have a lower proportion of breastfeeding.

Table 1
Comparison of the characteristics of study participants by mode of breastfeeding at 1.5 months postpartum.

Demographic variable	Total	Mode of breastfeeding at 1.5 months postpartum			p-Value
		Direct breastfeeding only	Mixed-mode feeding	Expressed breast milk feeding only	
	N = 610 (%)	N = 292 (%)	N = 230 (%)	N = 88 (%)	
Maternal age (years)					.085
18–29	180 (29.5)	99 (33.9)	53 (23.0)	28 (31.8)	
30–34	269 (44.1)	121 (41.4)	108 (47.0)	40 (45.5)	
≥35	161 (26.4)	72 (24.7)	69 (30.0)	20 (22.7)	
Maternal education					<.001
<University degree	403 (66.1)	212 (72.6)	128 (55.7)	63 (71.6)	
University degree or above	207 (33.9)	80 (27.4)	102 (44.4)	25 (28.4)	
Monthly family income (HKD)[a]					<.001
<$15,000	35 (5.7)	23 (7.9)	8 (3.5)	4 (4.6)	
$15,000–$34,999	313 (51.3)	180 (61.4)	96 (41.7)	37 (42.1)	
≥$35,000	262 (43.0)	89 (30.5)	126 (54.8)	47 (53.4)	
Length of residence in Hong Kong					<.001
<5 years	57 (9.3)	44 (15.1)	8 (3.5)	5 (5.7)	
≥5 years	213 (34.9)	128 (43.8)	62 (27.0)	23 (26.1)	
Since birth	340 (55.7)	120 (41.1)	160 (69.6)	60 (68.2)	
Intention to return to work postpartum					<.001
No	249 (40.8)	164 (56.2)	62 (27.0)	23 (26.1)	
Yes	361 (59.2)	128 (43.8)	168 (73.0)	65 (73.9)	
Previous breastfeeding experience					<.001
No	303 (49.7)	113 (38.7)	137 (59.6)	53 (60.2)	
Yes	307 (50.3)	179 (61.3)	93 (40.4)	35 (39.8)	
Intention to exclusively breastfeed					.003
No	240 (39.3)	105 (36.0)	86 (37.4)	49 (55.7)	
Yes	370 (60.7)	187 (64.0)	144 (62.6)	39 (44.3)	
Partner's infant feeding preference					.301
Breastfeeding	251 (41.2)	132 (45.2)	84 (36.5)	35 (39.8)	
Infant formula & mixed feeding	59 (9.7)	24 (8.2)	27 (11.7)	8 (9.1)	
No preference	300 (49.2)	136 (46.6)	119 (51.7)	45 (51.1)	
Attended childbirth class(es)					.001
No	263 (43.1)	141 (48.3)	77 (33.5)	45 (51.1)	
Yes	347 (56.9)	151 (51.7)	153 (66.5)	43 (48.9)	
Attended breastfeeding class(es)					.415
No	326 (53.4)	162 (55.5)	115 (50.0)	49 (55.7)	
Yes	284 (46.6)	130 (44.5)	115 (50.0)	39 (44.3)	
Any expressed breastfeeding in hospital					.768
No	413 (67.7)	201 (68.8)	155 (67.4)	57 (64.8)	
Yes	197 (32.3)	91 (31.2)	75 (32.6)	31 (35.2)	
Mode of birth					.893
Spontaneous vaginal	450 (73.8)	214 (73.3)	173 (75.2)	63 (71.6)	
Assisted vaginal	34 (5.6)	15 (5.1)	13 (5.7)	6 (6.8)	
Planned caesarean	66 (10.8)	36 (12.3)	20 (8.7)	10 (11.4)	
Emergency caesarean	60 (9.8)	27 (9.3)	24 (10.4)	9 (10.2)	

[a] 1 USD = 7.78 HK.

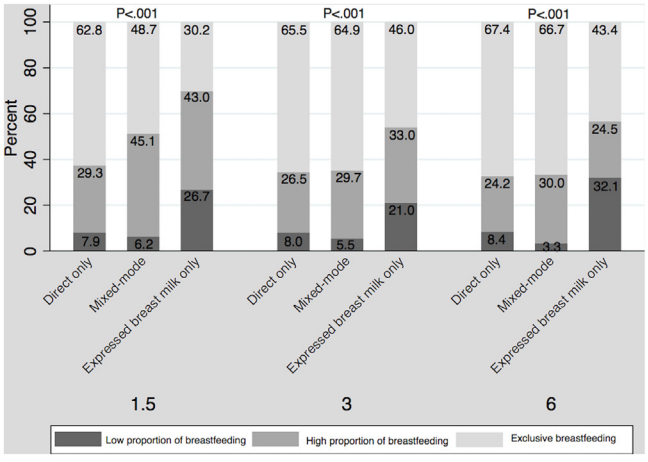

Fig. 1. Proportion of breastfeeding by breastfeeding mode over the first 6 months of life.

Table 2 shows the association between the mode of breastfeeding and continuation of any breastfeeding at three months and six months. Expressed breast milk feeding only at 1.5 months was associated with lower odds of continued breastfeeding at three months postpartum in all the unadjusted and adjusted models. In the partially adjusted model, expressed breast milk feeding only at 1.5 months postpartum strongly reduced the odds of breastfeeding continuation at three (model 1, aOR = 0.32, 95% CI = 0.17–0.58) and six months (model 1, aOR = 0.29, 95% CI = 0.17–0.50) postpartum. However, after adjusting for infant formula supplementation, the effect of expressed breast milk feeding on breastfeeding continuation was reduced. Expressed breast milk feeding only at 1.5 months postpartum was associated with 57% and 64% reduced odds of breastfeeding continuation at three months (aOR = 0.43, 95% CI = 0.22–0.82) and six months (aOR = 0.36, 95%CI = 0.21–0.64) postpartum. Similarly, expressed breast milk feeding at three months postpartum was associated with lower odds of breastfeeding continuation at six months postpartum (aOR = 0.39, 95% CI = 0.20–0.74).

Table 2
Unadjusted and adjusted odds ratios of the associations between mode of breastfeeding and breastfeeding continuation.

		ORs of breastfeeding continuation at 3 months postpartum (95% CI)			ORs of breastfeeding continuation at 6 months postpartum (95% CI)		
	N (%)	Unadjusted	Model 1[a]	Model 2[b]	Unadjusted	Model 1[a]	Model 2[b]
Mode of breastfeeding at 1.5 months postpartum (n = 610)							
Direct only	292 (47.9)	1.0	1.0	1.0	1.0	1.0	1.0
Mixed-mode	230 (37.7)	1.19 (0.69–2.04)	1.32 (0.73–2.38)	1.56 (0.84–2.89)	0.74 (0.51–1.06)	0.75 (0.50–1.12)	0.83 (0.55–1.27)
Expressed breast milk only	88 (14.4)	0.25 (0.15–0.44)	0.32 (0.17–0.58)	0.43 (0.22–0.82)	0.24 (0.14–0.39)	0.29 (0.17–0.50)	0.36 (0.21–0.64)
Mode of breastfeeding at 3 months postpartum (n = 514)							
Direct only	201 (39.1)	/	/	/	1.0	1.0	1.0
Mixed-mode	212 (41.3)	/	/	/	0.94 (0.60–1.47)	0.92 (0.50–1.66)	0.91 (0.50–1.67)
Expressed breast milk only	101 (19.7)	/	/	/	0.33 (0.20–0.55)	0.34 (0.18–0.64)	0.39 (0.20–0.74)

[a] Adjusted for maternal age, maternal education, household income, length of residence in Hong Kong, intention to return to work postpartum, intention to exclusively breastfeed, childbirth class attendance, breastfeeding class attendance, previous breastfeeding experience and partner's infant feeding preference, any expressed breastfeeding in hospital and mode of birth.
[b] Further adjusted for infant formula supplementation at 1.5 or 3 months postpartum.

Table 3
Unadjusted and adjusted odds ratios of the associations between mode of breastfeeding and breastfeeding duration stratified by infant formula supplementation.

	ORs of breastfeeding continuation at 3 months postpartum (95% CI)				ORs of breastfeeding continuation at 6 months postpartum (95% CI)			
	Infant formula supplementation							
	No		Yes		No		Yes	
	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Mode of breastfeeding at 1.5 months postpartum (n = 610)								
Direct only	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mixed-mode	0.90 (0.31–2.61)	0.90 (0.26–3.15)	1.82 (0.95–3.48)	1.80 (0.87–3.72)	0.73 (0.42–1.26)	0.73 (0.40–1.34)	1.00 (0.60–1.68)	0.89 (0.49–1.64)
Expressed breast milk only	1.30 (0.16–10.71)	1.35 (0.14–13.09)	0.34 (0.18–0.66)	0.34 (0.16–0.73)	0.44 (0.18–1.04)	0.42 (0.17–1.06)	0.28 (0.13–0.56)	0.28 (0.12–0.62)
Mode of breastfeeding at 3 months postpartum (n = 514)								
Direct only	/	/	/	/	1.0	1.0	1.0	1.0
Mixed-mode	/	/	/	/	0.65 (0.33–1.30)	0.68 (0.26–1.76)	1.44 (0.75–2.75)	1.10 (0.47–2.55)
Expressed breast milk only	/	/	/	/	0.26 (0.12–0.58)	0.29 (0.10–0.81)	0.55 (0.27–1.13)	0.38 (0.15–0.96)

[a] Adjusted for maternal age, maternal education, household income, length of residence in Hong Kong, intention to return to work postpartum, intention to exclusively breastfeed, childbirth class attendance, breastfeeding class attendance, previous breastfeeding experience and partner's infant feeding preference, any expressed breastfeeding in hospital and mode of birth.

The effect of the breastfeeding mode on breastfeeding duration was stratified by infant formula supplementation (Table 3). Among participants who were exclusively breastfeeding, expressed breast milk feeding only at 1.5 months postpartum was not associated with breastfeeding continuation. However, among participants who were supplementing with infant formula, feeding expressed breast milk only was associated with early breastfeeding cessation. In the adjusted analysis, participants feeding expressed breast milk only at three months were less likely to continue breastfeeding at six months postpartum, irrespective of whether participants were exclusively breastfeeding (aOR = 0.29, 95% CI = 0.10–0.81) or supplementing with infant formula (aOR = 0.38, 95% CI = 0.15–0.96). The goodness-of-fit tests of the logistic regression models produced a p-value of 0.14 to 0.34, indicating that the models fit the data. There was also no evidence of multicollinearity with VIF values that ranged from 1.03 to 2.47.

Kaplan-Meier survival curves show the association between the mode of breastfeeding at 1.5 months and three months and the risk of subsequent breastfeeding cessation (Fig. 2). Overall, participants feeding expressed breast milk only had the shortest duration of breastfeeding with minimal difference between participants giving direct breastfeeding only and mixed-mode feeding ($P < .001$).

Table 4 shows the unadjusted and adjusted Hazard Ratios (aHRs) of breastfeeding cessation by mode of breastfeeding at 1.5 and 3 months postpartum. In the adjusted models, expressed breast milk feeding only at 1.5 months (aHR = 1.80, 95% CI = 1.20–2.71) and three months (aHR = 1.80; 95% CI 1.02–3.17) was associated with a higher risk of breastfeeding cessation. After stratification, expressed breast milk feeding only at 1.5 months was associated with a higher risk of breastfeeding cessation among participants with infant formula supplementation (aHR = 1.86; 95% CI 1.17–2.95) while the association was not significant in participants who were exclusively breastfeeding (aHR = 2.12; 95% CI 0.73–6.20). Mixed-mode feeding was not significantly associated with breastfeeding duration in all of the analyses. The log–log plots for the Cox regression models show no violations of the proportional-hazards assumption.

Discussion

Study findings show that participants who fed only expressed breast milk were more likely to also supplement with infant formula and to have shorter breastfeeding duration. Among participants who were exclusively breastfeeding, there was no association between the breastfeeding mode at 1.5 months postpartum and breastfeeding continuation at 3 and 6 months postpartum or the overall duration of breastfeeding. However, feeding only expressed breast milk at three months postpartum, even in the absence of infant formula supplementation, was

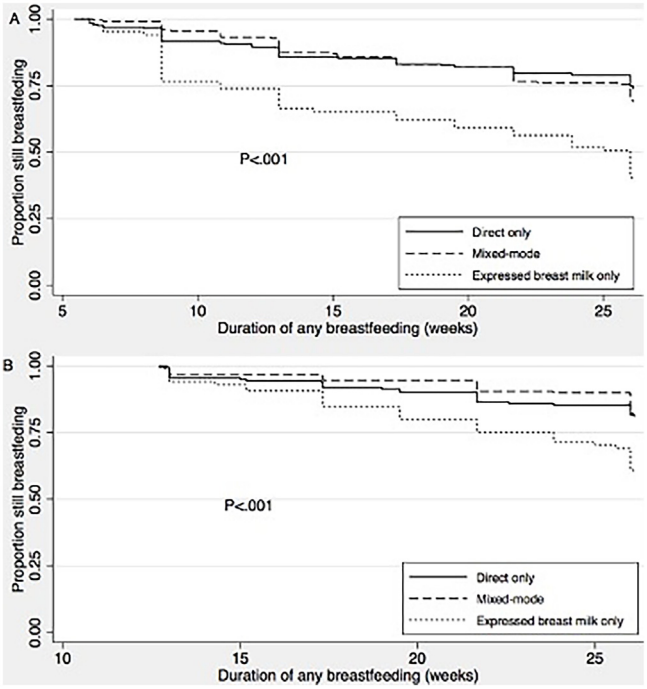

Fig. 2. Mode of breastfeeding at (A) 1.5 months and (B) 3 months postpartum and the risk of subsequent breastfeeding cessation.

negatively associated with breastfeeding continuation at six months.

These findings suggest that although mixed-mode feeding may not negatively affect breastfeeding duration, expressed breast milk feeding only is detrimental to breastfeeding continuation. Additionally, studies have shown that women express breast milk because of perceived insufficient milk [13] or experiencing various breastfeeding problems [13,41], suggesting that breast milk expression is often used to solve problems with direct breastfeeding [41]. Although high levels of breast milk expression over time can result in decreased milk volume, some also find pumping tedious, timing-consuming, and inconvenient [41]. These factors may contribute to difficulties in maintaining breastfeeding among mothers who only feed expressed breast milk. The effect of expressed breast milk feeding on breastfeeding duration may be more detrimental .if expressed breast milk feeding is in lieu of direct breastfeeding or before direct breastfeeding has been adequately established. Therefore, establishing direct breastfeeding should be emphasised, and adequate support should be provided to women with direct breastfeeding problems in the early postpartum period.

Although this study shows that feeding expressed breast milk only was associated with early breastfeeding cessation, findings also reinforce the detrimental effect of early infant formula supplementation on breastfeeding continuation. It is well established that infant formula supplementation is associated with early breastfeeding cessation [42–45]. However, few studies on the association between the breastfeeding mode and breastfeeding duration have adjusted for infant formula supplementation [23,46]. This study suggests that expressed breast milk feeding only in the early postpartum period is associated with shorter breastfeeding duration in participants who are also supplementing with infant formula, but not if women are exclusively breastfeeding. Another possible explanation is that mothers who are exclusively breastfeeding have higher breastfeeding self-efficacy [47,48] and may be more persistent in breastfeeding [48,49]. Further research is needed to examine breastfeeding self-efficacy among mothers with different modes of breastfeeding.

The majority of the previous studies examining the association between expressed breast milk feeding and breastfeeding duration examined expressed breast milk feeding [50] or breast milk expression [22,24,29] as dichotomous categories. Like other studies [6,21,28], our study shows that breastfeeding duration was similar between participants who were only directly breastfeeding and those who were giving mixed-mode feeding. This finding indicates that feeding expressed milk itself may not be detrimental to breastfeeding duration, but the absence of any direct breastfeeding and supplementation with infant formula increases the risk of cessation.

Strengths and limitations

To our knowledge, this is one of a few studies that has examined the association between different proportions of expressed breast milk feeding [6,20,28] and breastfeeding cessation at different time points [17,18,26] while adjusting for infant formula supplementation [6,23,51]. In addition, this study was a prospective cohort study with regular follow-up. During the telephone follow-up, participants were asked to recall the proportion of infant feeding in the 24 h preceding the call, which helped to minimise recall bias.

There are also several study limitations. First, women who were intending to breastfeed participated voluntarily, and this may have

Table 4
Unadjusted and adjusted hazard ratios of breastfeeding cessation by mode of breast milk feeding at 1.5 and 3 months postpartum.

	HRs of breastfeeding cessation (95% CI)						
	Total			Infant formula supplementation			
				No		Yes	
	Unadjusted	Model 1[a]	Model 2[b]	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Mode of breastfeeding at 1.5 months postpartum (n = 610)							
Direct only	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mixed-mode	1.17 (0.84–1.64)	1.08 (0.75–1.55)	0.94 (0.66–1.35)	1.54 (0.80–2.96)	1.62 (0.77–3.44)	0.78 (0.53–1.15)	0.81 (0.53–1.23)
Expressed breast milk only	2.86 (1.97–4.15)	2.24 (1.51–3.34)	1.80 (1.20–2.71)	1.99 (0.74–5.33)	2.12 (0.73–6.20)	1.89 (1.25–2.86)	1.86 (1.17–2.95)
Mode of breastfeeding at 3 months postpartum (n = 514)							
Direct only	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mixed-mode	0.96 (0.61–1.52)	0.90 (0.50–1.62)	0.91 (0.51–1.63)	1.42 (0.57–3.52)	1.96 (0.60–6.42)	0.71 (0.42–1.22)	0.82 (0.42–1.61)
Expressed breast milk only	2.28 (1.42–3.64)	2.20 (1.25–3.89)	1.80 (1.02–3.17)	4.22 (1.67–10.71)	5.50 (1.68–18.08)	1.24 (0.72–2.14)	1.50 (0.77–2.95)

[a] Adjusted for maternal age, maternal education, household income, length of residence in Hong Kong, intention to return to work postpartum, intention to exclusively breastfeed, childbirth class attendance, breastfeeding class attendance, previous breastfeeding experience and partner's infant feeding preference, any expressed breastfeeding in hospital and mode of birth.

[b] Further adjusted for infant formula supplementation at 1.5 or 3 months postpartum.

resulted in selection bias, whereby the recruited participants were more favourable toward breastfeeding than the general population. They may have been more likely to persist in breastfeeding or to provide expressed breast milk when they encountered breastfeeding problems. Second, as this was a prospective cohort study, there was some loss to follow-up. Participants who stopped breastfeeding may have been more reluctant to receive telephone follow-up. However, the overall loss to follow-up rate was low (4.6%), so it was unlikely that this significantly affected the study findings. In addition, only a small proportion of participants were exclusively breastfeeding and feeding only expressed breast milk. These numbers may have limited the study power to assess any potential interaction between the mode of breastfeeding and infant formula supplementation.

Conclusion

Giving only expressed breast milk is associated with early breastfeeding cessation. Among participants who had infant formula supplementation, having expressed breast milk feeding in-hospital was associated with longer breastfeeding duration. It may be difficult for women to maintain breastfeeding by expressed breast milk feeding only. Increased education on expressed breast milk feeding and targeted breastfeeding support may be needed to help mothers with direct breastfeeding problems.

Ethical approval

Ethical approval for this study was obtained from the institutional review boards of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (UW 16-2045) and the participating hospitals [KW/EX-17-050(109-15); KC/KE-16-0261/ER-1]. The study was conducted following the principles of the Helsinki Declaration and all participants gave informed written consent.

Funding

This study was supported by the University of Hong Kong.

Conflict of interest

None declared.

CRediT authorship contribution statement

Heidi Sze Lok Fan: Formal analysis, Investigation, Data curation, Writing - original draft, Writing - review & editing, Visualization. **Daniel Yee Tak Fong:** Writing - review & editing. **Kris Yuet Wan Lok:** Resources, Writing - review & editing, Project administration, Funding acquisition. **Marie Tarrant:** Conceptualization, Methodology, Formal analysis, Writing - review & editing, Visualization, Supervision.

Acknowledgement

We thank the University of Hong Kong for supporting this study.

References

[1] C.G. Victora, R. Bahl, A.J. Barros, et al., Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect, Lancet 387 (10017) (2016) 475–490.
[2] J. Raisler, C. Alexander, P. O'Campo, Breast-feeding and infant illness: a dose-response relationship? Am. J. Public Health 89 (1) (1999) 25–30.
[3] World Health Organization, UNICEF, Global Strategy for Infant and Young Child Feeding, World Health Organization, Geneva, Switzerland, 2003.
[4] Centers for Disease Control Prevention, Breastfeeding Rates, (2019) . (Accessed 23 July 2020) https://www.cdc.gov/breastfeeding/data/nis_data/results.html.
[5] D.M. Hornbeak, M. Dirani, W.K. Sham, et al., Emerging trends in breastfeeding practices in Singaporean Chinese women: findings from a population-based study, Ann. Acad. Med. Singap. 39 (2) (2010) 88.
[6] D.L. Bai, D.Y.T. Fong, K.Y.W. Lok, J.Y.H. Wong, M. Tarrant, Practices, predictors and consequences of expressed breast-milk feeding in healthy full-term infants, Public Health Nutr. 20 (3) (2017) 492–503.
[7] C.W. Binns, N.N. Win, Y. Zhao, J.A. Scott, Trends in the expression of breastmilk 1993-2003, Breastfeed. Rev. 14 (3) (2006) 5–9.
[8] H.S.L. Fan, D.Y.T. Fong, K.Y.W. Lok, M. Tarrant, Expressed breast milk feeding practices in Hong Kong Chinese women: a descriptive study, Midwifery 91 (2020)102835.
[9] P.G. Chen, L.W. Johnson, M.S. Rosenthal, Sources of education about breastfeeding and breast pump use: what effect do they have on breastfeeding duration? An analysis of the Infant Feeding Practices Survey II, Matern. Child Health J. 16 (7) (2012) 1421–1430.
[10] R. Li, J. Magadia, S.B. Fein, L.M. Grummer-Strawn, Risk of bottle-feeding for rapid weight gain during the first year of life, Arch. Pediatr. Adolesc. Med. 166 (5) (2012) 431–436.
[11] A. Klopp, L. Vehling, A.B. Becker, et al., Modes of infant feeding and the risk of childhood asthma: a prospective birth cohort study, J. Pediatr. 190 (2017) 192–199 e2.
[12] N. Hanna, K. Ahmed, M. Anwar, A. Petrova, M. Hiatt, T. Hegyi, Effect of storage on breast milk antioxidant activity, Arch. Dis. Child. Fetal Neonatal 89 (6) (2004) F518–F520.
[13] S.N. Clemons, L.H. Amir, Breastfeeding women's experience of expressing: a descriptive study, J. Hum. Lact. 26 (3) (2010) 258–265.
[14] M. Cullinane, L.H. Amir, S.M. Donath, et al., Determinants of mastitis in women in the CASTLE study: a cohort study, BMC Fam. Pract. 16 (1) (2015) 181.
[15] M.H. Labbok, D. Clark, A.S. Goldman, Breastfeeding: maintaining an irreplaceable immunological resource, Nat. Rev. Immunol. 4 (7) (2004) 565–572.
[16] H.M. Johns, D.A. Forster, L.H. Amir, H.L. McLachlan, Prevalence and outcomes of breast milk expressing in women with healthy term infants: a systematic review, BMC Pregnancy Childbirth 13 (1) (2013) 212.
[17] K. Schwartz, H.J. D'Arcy, B. Gillespie, J. Bobo, M. Longeway, B. Foxman, Factors associated with weaning in the first 3 months postpartum, J. Fam. Pract. 51 (5) (2002) 439–444.
[18] N.N. Win, C.W. Binns, Y. Zhao, J.A. Scott, W.H. Oddy, Breastfeeding duration in mothers who express breast milk: a cohort study, Int. Breastfeed. J. 1 (1) (2006) 28.
[19] J. Yourkavitch, K.M. Rasmussen, B.W. Pence, et al., Early, regular breast-milk pumping may lead to early breast-milk feeding cessation, Public Health Nutr. 21 (9) (2018) 1726–1736.
[20] J.P. Felice, P.A. Cassano, K.M. Rasmussen, Pumping human milk in the early postpartum period: its impact on long-term practices for feeding at the breast and exclusively feeding human milk in a longitudinal survey cohort, Am. J. Clin. Nutr. 103 (5) (2016) 1267–1277.
[21] S.A. Keim, K.M. Boone, R. Oza-Frank, S.R. Geraghty, Pumping milk without ever feeding at the breast in the Moms2Moms study, Breastfeed. Med. 12 (7) (2017) 422–429.
[22] S. Geraghty, B. Davidson, M. Tabangin, A. Morrow, Predictors of breastmilk expression by 1 month postpartum and influence on breastmilk feeding duration, Breastfeed. Med. 7 (2) (2012) 112–117.
[23] B. Jiang, J. Hua, Y. Wang, Y. Fu, Z. Zhuang, L. Zhu, Evaluation of the impact of breast milk expression in early postpartum period on breastfeeding duration: a prospective cohort study, BMC Pregnancy Childbirth 15 (2015) 1–13.
[24] J.R. Demirci, D.L. Bogen, An ecological momentary assessment of primiparous women's breastfeeding behavior and problems from birth to 8 weeks, J. Hum. Lact. 33 (2) (2017) 285–295.
[25] E. Bream, H. Li, L. Furman, The effect of breast pump use on exclusive breastfeeding at 2 months postpartum in an inner-city population, Breastfeed. Med. 12 (3) (2017) 149–155.
[26] S.R. Geraghty, J.C. Khoury, H.J. Kalkwarf, Human milk pumping rates of mothers of singletons and mothers of multiples, J. Hum. Lact. 21 (4) (2005) 413–420.
[27] A. Hörnell, C. Aarts, E. Kylberg, Y. Hofvander, M. Gebre-Medhin, Breastfeeding patterns in exclusively breastfed infants: a longitudinal prospective study in Uppsala, Sweden, Acta Paediatr. 88 (2) (1999) 203–211.
[28] W.W. Pang, J.Y. Bernard, G. Thavamani, et al., Direct vs. expressed breast milk feeding: relation to duration of breastfeeding, Nutrients 9 (6) (2017) 547.
[29] H.A. Dabritz, B.G. Hinton, J. Babb, Maternal hospital experiences associated with breastfeeding at 6 months in a northern California county, J. Hum. Lact. 26 (3) (2010) 274–285.
[30] Baby Friendly Hospital Initiative Hong Kong Association, World Breastfeeding Week 2018: Annual Survey Summary, Baby Friendly Hospital Initiative Hong Kong Association, Hong Kong, 2018.
[31] World Health Organization, Indicators for Assessing Infant and Young Child Feeding Practices. Part 1: Definitions, World Health Organization, Geneva, Switzerland, 2008.
[32] World Health Organization, Indicators for Assessing Breast Feeding Practices, World Health Organization, Geneva, Switzerland, 1991.
[33] K.M. Rasmussen, J.P. Felice, E.J. O'Sullivan, C.D. Garner, S.R. Geraghty, The meaning of "breastfeeding" is changing and so must our language about it, Breastfeed. Med. 12 (9) (2017) 510–514.

[34] M. Tarrant, D.Y. Fong, K.M. Wu, et al., Breastfeeding and weaning practices among Hong Kong mothers: a prospective study, BMC Pregnancy Childbirth 10 (2010) 27.
[35] D.L. Bai, D.Y.T. Fong, K.Y.W. Lok, M. Tarrant, Relationship between the infant feeding preferences of Chinese mothers' immediate social network and early breastfeeding cessation, J. Hum. Lact. 32 (2) (2016) 301–308.
[36] K.Y.W. Lok, D.L. Bai, N.P.T. Chan, J.Y.H. Wong, M. Tarrant, The impact of immigration on the breastfeeding practices of Mainland Chinese immigrants in Hong Kong, Birth 45 (1) (2018) 94–102.
[37] D. Thulier, J. Mercer, Variables associated with breastfeeding duration, J. Obstet. Gynecol. Neonatal Nurs. 38 (3) (2009) 259–268.
[38] D.A. Forster, H.M. Johns, H.L. McLachlan, A.M. Moorhead, K.M. McEgan, L.H. Amir, Feeding infants directly at the breast during the postpartum hospital stay is associated with increased breastfeeding at 6 months postpartum: a prospective cohort study, BMJ Open 5 (5) (2015)e007512.
[39] D. Fok, I.M. Aris, J. Ho, et al., Early initiation and regular breast milk expression reduces risk of lactogenesis II delay in at-risk Singaporean mothers in a randomised trial, Singapore Med. J. 60 (2) (2019) 80.
[40] D. Howel, H. Ball, Association between length of exclusive breastfeeding and subsequent breastfeeding continuation, J. Hum. Lact. 29 (4) (2013) 579–585.
[41] J.P. Felice, S.R. Geraghty, C.W. Quaglieri, R. Yamada, A.J. Wong, K.M. Rasmussen, "Breastfeeding" without baby: a longitudinal, qualitative investigation of how mothers perceive, feel about, and practice human milk expression, Matern. Child Nutr. 13 (3) (2017)e12426.
[42] A. Hörnell, Y. Hofvander, E. Kylberg, Solids and formula: association with pattern and duration of breastfeeding, Pediatrics 107 (3) (2001) e38-e.
[43] J. Coreil, J.E. Murphy, Maternal commitment, lactation practices, and breastfeeding duration, J. Obstet. Gynecol. Neonatal Nurs. 17 (4) (1988) 273–278.
[44] A. Vogel, B. Hutchison, E. Mitchell, Factors associated with the duration of breastfeeding, Acta Paediatr. 88 (12) (1999) 1320–1326.
[45] M. Tarrant, K.Y. Lok, D.Y. Fong, et al., Effect of a hospital policy of not accepting free infant formula on in-hospital formula supplementation rates and breastfeeding duration, Public Health Nutr. 18 (14) (2015) 2689–2699.
[46] D.L. Bai, D.Y. Fong, K.Y. Lok, J.Y. Wong, M. Tarrant, Practices, predictors and consequences of expressed breast-milk feeding in healthy full-term infants, Public Health Nutr. 20 (3) (2017) 492–503.
[47] R. Blyth, D.K. Creedy, C.L. Dennis, W. Moyle, J. Pratt, S.M. De Vries, Effect of maternal confidence on breastfeeding duration: an application of breastfeeding self-efficacy theory, Birth 29 (4) (2002) 278–284.
[48] K. McQueen, L.E. Sieswerda, W. Montelpare, C.L. Dennis, Prevalence and factors affecting breastfeeding among Aboriginal women in Northwestern Ontario, J. Obstet. Gynecol. Neonatal Nurs. 44 (1) (2015) 51–68.
[49] D. McCarter-Spaulding, R. Gore, Breastfeeding self-efficacy in women of African descent, J. Obstet. Gynecol. Neonatal Nurs. 38 (2) (2009) 230–243.
[50] W.W. Pang, I.M. Aris, D. Fok, et al., Determinants of breastfeeding practices and success in a multi-ethnic Asian population, Birth 43 (1) (2016) 68–77.
[51] H.A. Dabritz, B.G. Hinton, J. Babb, Evaluation of lactation support in the workplace or school environment on 6-month breastfeeding outcomes in Yolo County, California, J. Hum. Lact. 25 (2) (2009) 182–193.