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Factors Associated With Prelacteal Feeding of Commercial Milk Formula: An Analysis of Cohort Data From the BADUTA Study in Indonesia

Siti Nurokhmah[1,2] | Min Kyaw Htet[3,4,5] | Elaine Ferguson[6] | Michael J. Dibley[4] | Umi Fahmida[1,3]

[1]Department of Nutrition, Faculty of Medicine, Universitas Indonesia – Dr. Cipto Mangunkusumo General Hospital, Jakarta, Indonesia | [2]Department of Nutrition Science, Faculty of Health Science, Universitas Muhammadiyah Surakarta, Surakarta, Central Java, Indonesia | [3]Southeast Asian Ministers of Education Organization Regional Center for Food and Nutrition (SEAMEO RECFON), Pusat Kajian Gizi Regional Universitas Indonesia, Jakarta, Indonesia | [4]School of Public Health, The University of Sydney, Sydney, New South Wales, Australia | [5]Sinergi Qalbu Fikri, Depok, Indonesia | [6]Department of Population Health, Faculty of Epidemiology and Population Health, London School of Hygiene and Tropical Medicine, London, UK

Correspondence: Michael J. Dibley (michael.dibley@sydney.edu.au)

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ABSTRACT

Introducing commercial milk formula (CMF) as prelacteal feeds can disturb exclusive breastfeeding and shorten breastfeeding duration. However, the prelacteal feeding of CMF has been growing alongside its increasing sales in Indonesia. This study examined predictors of the CMF feeding in the Malang and Sidoarjo districts of Indonesia. This analysis used post-delivery data collected from 676 mothers in a cohort evaluation of a cluster randomised controlled trial (Baduta study). Multivariate random effects logistic models were employed to assess factors associated with the CMF feeding. A total of 467 (69.1%) respondents reported giving CMF to their infants during the first 3 days after delivery. Mothers with low breastfeeding self-efficacy (BFSE) were at a higher risk of providing CMF within 3 days of birth compared to those with medium or high BFSE (adjusted odds ratio (aOR) 8.12; 95% confidence interval (CI) (4.26–15.48). Receiving explanations to solve breastfeeding problems from health professionals (aOR: 1.87; 97% CI: 1.12–3.11) and primipara parity (aOR: 1.71; 95% CI: 1.12–3.04) were positively associated with the CMF feeding. Early initiation of breastfeeding (EIBF) was protective against CMF feeding (aOR: 0.40; 95% CI: 0.22–0.58). There was an interaction between EIBF and BFSE. EIBF was protective among mothers with high or medium BFSE, but had no effect among those with low BFSE. CMF feeding was prevalent in Indonesia. Future strategies should focus on improving health-staff capacity to strengthen BFSE during pregnancy and provide adequate counselling for mothers with breastfeeding problems.

1 | Introduction

Breastfeeding is a natural behaviour and a recommended practice with numerous benefits. It is associated with reduced risk of infant morbidity and mortality and lower risk of adult metabolic diseases (Victora et al. 2016). Benefits for mothers include alleviating the likelihood of developing type 2 diabetes and cancers, particularly breast cancer and ovarian cancers, and acting as a natural contraception method that increases birth spacing (Victora et al. 2016). Optimal breastfeeding practices start from early initiation of breastfeeding, followed by exclusive breastfeeding for the first 6 months, and continued breastfeeding for up to 2 years or beyond (WHO and UNICEF 2003). Globally, these recommended breastfeeding practices could

Summary

- Nearly 7 in 10 newborns received commercial milk formula during the first 3 days of their life. Parity, breastfeeding self-efficacy, early initiation of breastfeeding and receiving explanations to solve breastfeeding problems were the predictors of this practice.
- Mothers with medium and high breastfeeding self-efficacy who performed early initiation of breastfeeding were less likely to introduce early commercial milk formula. However, this practice was not influenced by early initiation of breastfeeding among those with low breastfeeding self-efficacy.
- Support from healthcare providers regarding breastfeeding difficulties was positively associated with the outcome indicating the need to improve the quality of the service.

save more than 800,000 infants and 20,000 maternal lives annually (Victora et al. 2016). From an economic standpoint, the annual cost of not breastfeeding as recommended is estimated to be US$341.3 billion (Walters, Phan, and Mathisen 2019). However, despite the numerous well-recognised benefits, 53% of the world's infants are not exclusively breastfed in 2022 (Global Breastfeeding Collective, UNICEF, and WHO 2022).

Prelacteal feeding, defined as introducing liquid/solid foods, except for breastmilk, within the first 3 days after delivery, is a common practice that disturbs the recommended breastfeeding practices, namely early initiation of breastfeeding, exclusive breastfeeding and continued breastfeeding (Asim et al. 2020; Das et al. 2019; Neves et al. 2022; Pérez-Escamilla et al. 2022; Rahmartani, Quigley, and Carson 2024). Evidence from other studies suggests that this practice also correlates with the increasing risk of illness, hospital admissions and stunted growth (Hajeebhoy et al. 2014; Legesse et al. 2014; Nguyen et al. 2020). Despite these negative consequences, around a third of newborns in LMICs receive prelacteal feeds (Neves et al. 2022). However, a large variation is observed across regions, with Middle East and North Africa scoring the highest prevalence (57%) and the lowest in Eastern and Southern Africa (23%) (Pérez-Escamilla et al. 2023). Further, we also see a difference regarding the types of prelacteal feeds. Milk-based prelacteal feeds account for the largest proportion in LMICs (Neves et al. 2022), while plain water, butter and honey are predominant in sub-Saharan Africa (Berde and Ozcebe 2017), Ethiopia (Mose and Abebe 2021) and Pakistan (Asim et al. 2020), respectively.

In Indonesia, almost 30% of mothers use commercial milk formula (CMF) as prelacteal feed, which accounts for roughly 80% of mothers giving prelacteal feeds choose CMF (Badan Penelitian dan Pengembangan Kesehatan 2018), and it increased to 90% in 2023 (Badan Kebijakan Pembangunan Kesehatan 2024). A systematic review suggests that mothers' decisions on early feeding are highly influenced by infant behaviours, such as crying and fussiness (Vilar-Compte et al. 2022). Mothers often perceive it as infant hunger cues and often believe that their breastmilk is insufficient; therefore, they subsequently introduce other feeds, primarily in the form of CMF. The aggressive marketing of formula milk companies plays a crucial role in mothers' decision-making on infant feeding in multiple ways, as the marketing also targets family members, health professionals and institutions (Johnson and Duckett 2020; Rollins et al. 2023; WHO and UNICEF 2022).

In response, the World Health Assembly (WHA) adopted the International Code of Marketing Breast Milk Substitutes in 1981 (World Health Organization 1981), which was subsequently supported by further WHA resolutions (World Health Organization 1981). The set of regulations known as 'the Code' aims to enhance infants' nutrition by protecting and promoting breastfeeding, stopping the inappropriate marketing of breastmilk substitutes (BMS), and ensuring their appropriate use when necessary (United Nations Children's Fund UNICEF 2023). However, violations of the Code are numerous, especially when national regulations are weak. In Indonesia, the Code is partially adopted and implemented only within the health system (Hidayana, Februhartanty, and Parady 2017). Even with this limited adoption, unethical marketing within the health systems and public spaces is prevalent (Hidayana, Februhartanty, and Parady 2017), and online marketing by CMF manufacturers, their representatives as well as health staff became more aggressive during the COVID-19 pandemic (Hidayana et al. 2023).

The marketing of milk formula is a structural factor influencing CMF feeding, which interacts with other determinants (Pérez-Escamilla et al. 2023). Other factors including socio-demographic characteristics (wealth status, place of residence, mothers' education), delivery- or health-related factors (place and type of delivery, skin-to-skin contact, early initiation of breastfeeding, antenatal care, infant feeding counselling) and infants' characteristics (birth order, preceding birth interval, perceived birth size) also contribute to the mothers' decisions regarding prelacteal feeding, including CMF (Asim et al. 2020; Birhan, Birhan, and Alene 2021; Nurokhmah, Masitoh, and Werdani 2021; Rahmartani, Carson, and Quigley 2020; Titaley et al. 2023). These studies utilise national survey data with any prelacteal feeding as the outcome, while studies concentrating on CMF feeding as the outcome are scarce. Therefore, to add to the body of literature on the growing use of CMF, this study used primary longitudinal data to analyse the maternal, household, socioeconomic, delivery and infant characteristics associated with the introduction of CMF during the first 3 days of an infant's life.

2 | Methods

2.1 | Study Setting and Data Source

Data were derived from a cohort evaluation of the BADUTA project conducted in the Sidoarjo and Malang districts of East Java, Indonesia. The project began in 2014 and data for the cohort evaluation was collected from 2015 to 2016 (Fahmida et al. 2020). The project was a cluster randomised controlled trial, with child growth as the primary outcome and breastfeeding indicators as secondary outcomes. Six subdistricts representing both urban and rural areas were randomly assigned as intervention or comparison groups. The interventions included

(i) strengthening the health system through training on infant and young child feeding and the Baby Friendly Hospital Initiative and (ii) promoting behaviour change via campaigns utilising advertisements on television channels, health information through short message services and increased marketing of an affordable water filter product (Nazava), alongside educational sessions on sanitation and hygiene practices (Dibley et al. 2020).

2.2 | Sampling and Data Collection

Six clusters from two districts were selected using a restricted randomisation method to achieve a balanced distribution of variables between the treatment and comparison group subdistrict clusters (Dibley et al. 2020). The sampling frame was a list of pregnant women in their last trimester obtained from *Puskesmas* staff and *Posyandu* volunteers from all 105 villages in the selected sub-districts (i.e., clusters). *Puskesmas* and *Posyandu* are public health services at the community level but are under different administrative offices. *Puskesmas* delivers primary healthcare and is supervised by the district health office. *Posyandu*, translated as Integrated Health Post, is a village-based community initiative for preventive health services such as nutrition education for pregnant women and growth monitoring of infants and young children. *Posyandu* is run by community volunteers (health cadres) and financially supported by the village. Cadres usually receive training in anthropometric measurements and counselling. They work closely and are supervised by *Puskesmas* staff, often nutritionists and village midwives.

The recruitment process excluded individuals who met the following criteria: (i) having severe anaemia (Hb < 7 g/dL as measured by hemocue), (ii) having any known chronic illness, (iii) planning to give birth and stay outside the study area for more than 7 days and (iv) intending to move outside the subdistrict within the next 2 years. Following the child's birth, the exclusion criteria included the presence of any observable congenital illness or the occurrence of multiple births, such as twins.

Data were collected through interviewer-administered questionnaires that were translated into Indonesian. The interviewers utilised structured information error-detecting forms on tablets employing Dimagi's CommCare technology. The data were collected at two time points: (i) information regarding respondents' identity and household variables was gathered during the third trimester of pregnancy at recruitment, and (ii) data concerning infant and delivery characteristics, including CMF feeding, were obtained within 1-week post-delivery. Details regarding the sampling procedure and data collection are available in a previous publication (Fahmida et al. 2020). Supporting Information S1: Figure S1 shows the flowchart of the participants in this study.

2.3 | Definition of Variables

The outcome variable was the introduction of commercial milk formula within the first 3 days post-delivery (CMF feeding), derived from an open-ended question: "Within the first 3 days after birth, was (baby's name) fed any drink/food or liquid?". Interviewers did not read any response options; instead, they further probed the answer by asking, 'Is there anything else?'. CMF feeding was classified as 'Yes' if the responses included formula milk.

Independent covariates comprised maternal, household and infant and delivery characteristics. Maternal factors included age during pregnancy (years), education (primary or no formal education, high school, college or university), currently working (yes or no), middle-upper arm circumference (MUAC) during pregnancy in centimeters (≥ 23.5 and < 23.5), the number of antenatal care (ANC) visits (< 4 or ≥ 4), first-time ANC visit (trimester 1, trimester 2 or trimester 3), ever to the *Puskesmas* (yes, no), ever been to the *Posyandu* (yes, no), own a mobile phone (yes, no), parity (primipara, multipara) and breastfeeding self-efficacy (BFSE) (high or medium, low) (Dennis 2003).

Household factors included wealth and food security. The wealth variable was obtained using the Demographic and Health Survey (DHS) method, which generates scores based on a household's ownership of specific goods, such as televisions and bicycles, building materials used to construct homes, and the types of water access and sanitation facilities used that were categorised into terciles from poorest (lowest 33.3%) to richest (top 33.3%) (Rutstein and Staveteig 2014). The household food security index was generated using the short form of the Household Food Security Scale and presented in three categories: food secure, food insecure without hunger, and food insecure with hunger (Blumberg et al. 1999). Lastly, infant and delivery variables included infant sex (female, male), birthweight below 2.5 kilograms (yes, no), place of delivery facility (non-health facility, clinics, hospital), caesarean delivery (yes, no), early initiation of breastfeeding or EIBF (yes, no), given colostrum (yes, no). EIBF was defined as putting infants to the mother's breast within the first hour of birth (WHO and UNICEF 2021). We also included variables for individuals delivering breastfeeding information to mothers and explaining how to solve breastfeeding problems, categorised as yes, from health professionals; yes, from non-health professionals; and no.

2.4 | Statistical Analysis

All analyses were performed utilising Stata/IC 15.1 (StataCorp, College Station, Texas, USA). Bivariate analyses were conducted using Pearson chi-square tests and independent *t-test*. We analysed factors associated with CMF feeding using random effect logistic regression models to address clustering. The initial random effects model was a crude model that incorporated treatment allocation. Subsequently, we built a full model with all covariates, followed by manual stepwise deletions to form the final model. The final model included only covariates with $p < 0.05$. We checked for multicollinearity using the variance inflation factor for each model and *p-values* from likelihood ratio (LR) tests. Finally, interactions between covariates in the final model were evaluated using the LR and Wald tests with a significance threshold set at $p < 0.05$.

3 | Results

3.1 | Characteristics of Respondents

Of the 729 pregnant women initially recruited for cohort evaluation, 691 remained in the study after childbirth. Following data

cleaning, a total of 676 respondents were included in the analysis (Supporting Information S1: Figure S1). The average age of the mothers was 28 ± 6.2 years, and most were high school graduates (66.4%) and not working (79.0%) (Table 1). Most respondents reported high or medium self-efficacy for breastfeeding. Although almost half of the respondents were at the lowest wealth terciles, 74.9% of them were from food-secure households. Approximately 50% of infants received EIBF, and nearly one-third were born through caesarean section. Table 1 also presents the percentages of CMF feeding according to respondents' characteristics.

3.2 | Prevalence and Type of Prelacteal Feeding

Nearly three in four infants were given some liquid/solid food in their first 3 days of life, where CMF was the most common prelacteal feed at 69.1% (Figure 1), and 59.2% of infants were fed only CMFs. Other types of liquids included honey, drinking water, coconut water and water with less than 8% sugar. The solid foods given were bananas (3.0% of the respondents) and "Other" prelacteal food (i.e., sugar, dates, papaya, rice and commercial infant cereal) in less than 1% of infants. Figure 2 shows that 14% of mothers feeding CMF gave one or more prelacteal feeds.

3.3 | Factors Associated With CMF Feeding

Table 2 compares the crude and final models for the determinants of prelacteal feeding of CMF. BFSE, parity, EIBF and received explanations to solve breastfeeding problems were significantly associated with the outcome in both models. Mothers with low self-efficacy were over eight times more likely to introduce CMF feeding than those with high or medium self-efficacy (adjusted odds ratio [aOR] 8.12; 95% CI: 4.26–15.48). Women who delivered for the first time had 1.85 times higher odds of CMF feeding than multiparous women. The odds were similar for mothers who received explanations to solve breastfeeding problems from health professionals compared to those who did not receive such information.

3.4 | Interaction Between BFSE and EIBF on CMF Feeding

We found a significant interaction between BFSE and EIBF ($p = 0.014$ [LR test] and 0.022 [Wald test]) when examining potential effect modification among covariates in the final model presented in Table 2 (Supporting Information S1: Table S1). Figure 3 illustrates the combined effect of both covariates on CMF feeding. Among respondents with high or medium self-efficacy, the proportion of CMF feeding was much higher in those who did not practice EIBF (73.8%) than in those practising EIBF (48.9%). However, within the cohort of mothers with low self-efficacy, EIBF did not influence CMF feeding. Further information regarding this interaction analysis is presented in Supporting Information S1: Table S2.

4 | Discussion

This study revealed that nearly 70% of mothers in the Sidoarjo and Malang districts of East Java practised CMF feeding. In general, EIBF is strongly protective against CMF feeding. Other predictors of CMF feeding included BFSE, receiving explanations to solve breastfeeding problems and parity. Mothers with low BFSE, those receiving the explanation from health professionals, and primipara mothers were more likely to feed CMF than other mothers. These findings underscore the importance of enhancing EIBF in addition to strengthening BFSE, particularly among young primiparous mothers. Improving support quality for breastfeeding difficulties is also crucial at this early stage, especially within healthcare settings.

The proportion of infants receiving CMF in this study exceeded the figures reported at both the national and provincial levels in the 2018 Basic Health Research. In the 2018 survey, 38.5% of infants in East Java Province received any prelacteal feeds, with 90.3% of those received CMF feeding (Badan Penelitian dan Pengembangan Kesehatan 2018), compared with 74.0% and 93.4% in our study. At the national level, 33.1% of the infants received any prelacteal feeds, of which 81.4% were given CMF (Badan Penelitian dan Pengembangan Kesehatan 2018). The observed difference can be attributed to variations in study design. This cohort study interviewed mothers 1 week postpartum, while the national and provincial cross-sectional surveys included mothers of infants aged 0–11 months of age at the time of data collection. Therefore, memory bias was more likely to occur in the survey. In addition, populations at the national (Indonesia) and provincial (East Java) levels were more diverse than the respondents in the current analysis, which might contribute to the difference. Secular changes were unlikely to account for these differences, given that data from all three studies were collected at around the same period (i.e., between 2015 and 2016).

The variety and types of prelacteal feed given to newborns were similar across all three studies. CMF is by far the predominant prelacteal food given to infants (81.4%–93.4%), followed by honey (9.7%–13.5%) (Badan Penelitian dan Pengembangan Kesehatan 2018). Other types of prelacteal feeds, including banana, water, water with sugar, coconut water and rice, were shown to have much lower percentages compared to honey or CMF (less than 5% in all three studies) (Badan Penelitian dan Pengembangan Kesehatan 2018). These phenomena are in line with a study conducted in LMICs, indicating that CMF is more common in countries with higher levels of development (Neves et al. 2022).

Three individual-level factors—parity, EIBF and BFSE—were significantly associated with CMF feeding. Firstborn infants had a higher probability of receiving CMF feeding, aligning with the existing literature. A hospital-based cross-sectional study and a community-based cohort study in Nepal and Cambodia found that primiparous mothers were more likely to introduce CMF and other prelacteal feeds than multiparous mothers (Champeny et al. 2019; Khanal et al. 2016). Some studies from Indonesia also indicated that higher parity is protective against prelacteal feeding (Nurokhmah, Masitoh, and Werdani 2021; Titaley et al. 2023). A possible explanation for this finding is that first-time mothers may need more experience and knowledge about newborn care and infant-feeding practices, mainly CMF feeding, than their counterparts. At the same time, they often rely on older women in the household or community,

TABLE 1 | Characteristics of participants by prelacteal feeding of CMF ($N = 676$).

Variables	Total		Prelacteal feeding of CMF		p[a]
	n	%[b]	*n*	%[c]	
Maternal factors					
Age at pregnancy, years[d]	28 ± 6.2		28 ± 6.1		0.447
Education level					0.222
Primary or no formal education	177	26.2	115	65.0	
High school	449	66.4	320	71.3	
College or university	50	7.4	32	64.0	
Currently working					0.106
Yes	142	21.0	106	74.6	
No	534	79.0	361	67.6	
MUAC at pregnancy (centimetres)					0.803
≥ 23.5	528	78.1	366	69.3	
< 23.5	148	21.9	101	68.2	
ANC visits (times)					0.149
< 4	25	3.7	14	56.0	
≥ 4	651	96.3	453	69.6	
First ANC visit					0.528
Trimester 1	556	82.3	387	69.6	
Trimester 2 or 3	120	17.8	80	66.7	
Ever been to Puskesmas					0.797
Yes	364	53.9	253	69.5	
No	312	46.2	214	68.6	
Ever been to Posyandu		0.0			0.075
Yes	406	60.1	270	66.5	
No	270	39.9	197	73.0	
Own mobile phone					0.127
Yes	526	77.8	371	70.5	
No	150	22.2	96	64.0	
Breastfeeding self-efficacy					< 0.001
High or medium	493	72.9	296	60.0	
Low	183	27.1	171	93.4	
Parity					0.036
Primipara	263	38.9	194	73.8	
Multipara	413	61.1	273	66.1	
Household factors					
Wealth index					0.055
Poor	314	46.4	205	65.3	
Middle	181	26.8	125	69.1	
Rich	181	26.8	137	75.7	
Food security index					0.079
Food secure	506	74.9	359	70.9	
Food insecure without hunger	159	23.5	103	64.8	
Food insecure with hunger	11	1.6		0.0	

(Continues)

TABLE 1 | (Continued)

Variables	Total		Prelacteal feeding of CMF		p^a
	n	%[b]	*n*	%[c]	
Infants and delivery factors					
Sex of infant					0.050
Female	350	51.8	230	65.7	
Male	326	48.2	237	72.7	
Low birthweight					0.417
Yes	56	8.3	36	64.3	
No	620	91.7	431	69.5	
Place of delivery					0.004
Nonhealth facility	28	4.1	16	57.1	
Clinics	366	54.1	237	64.7	
Hospitals	282	41.7	214	75.9	
Caesarean delivery					< 0.001
Yes	191	28.3	154	80.6	
No	485	71.7	313	64.5	
Early initiation of breastfeeding					< 0.001
Yes	337	49.9	195	57.9	
No	339	50.1	272	80.2	
Given colostrum					0.026
Yes	645	95.4	440	68.2	
No	31	4.6	27	87.1	
Received information on breastfeeding					0.058
Yes, from health professionals	264	39.0	171	64.8	
Yes, from non-health professionals	34	5.0	28	82.3	
No	378	55.9	268	70.9	
Received explanations to solve breastfeeding problems					0.006
Yes, from health professionals	128	18.9	101	78.9	
Yes, from non-health professionals	20	3.0	17	85.0	
No	528	78.1	349	66.1	

Note: CMF, commercial milk formula. *Posyandu* or Integrated Health Post, community-based activities run by community health volunteers (cadres) supervised by a village midwife to do growth monitoring for under five and nutrition education, including for pregnant women. *Puskesmas*, community health centres; these government-mandated health clinics are responsible for the population at subdistrict or level.
[a]From independent *T*-test for continuous variables and a Chi-Square test for categorical variables.
[b]Weighed column percentages (n of "Total" divided by *N*).
[c]Weighed row percentages (n of "Prelacteal feeding of CMF" divided by *n* of "Total").
[d]Data are in means ± standard deviation.

such as mothers and mothers-in-law, who follow traditional practices and may recommend CMF feeding.

We found that mothers who experienced food insecurity with hunger were unlikely to give CMF to their newborns compared to those from food-secure families. Food insecurity with hunger represents the most severe form of poverty, where people have no food at home or even go several days without eating (Hjelm, Mathiassen, and Wadhwa 2016). Under these circumstances, providing infant formula is practically impossible.

The most noticeable determinant of CMF in the current study is BFSE, in which mothers with low BFSE had much higher odds of CMF. The influence of BFSE on CMF is also shown in previous studies (Boban and Zakarija-Grković 2016; Champeny et al. 2019). BFSE reflects mothers' confidence in breastfeeding their infants and is associated with their perception of milk supply (Galipeau et al. 2018), a common reason for CFM feeding (Pérez-Escamilla et al. 2023). Therefore, the higher self-efficacy, the less likely mothers are to introduce CMF. Interventions based on BFSE could potentially prevent CMF feeding, which subsequently supports exclusive breastfeeding as CMF can disrupt the establishment of breastfeeding (Neves et al. 2022; Pérez-Escamilla et al. 2022). Another significant aspect of BFSE is that it modified the association between EIBF and CMF in the current study.

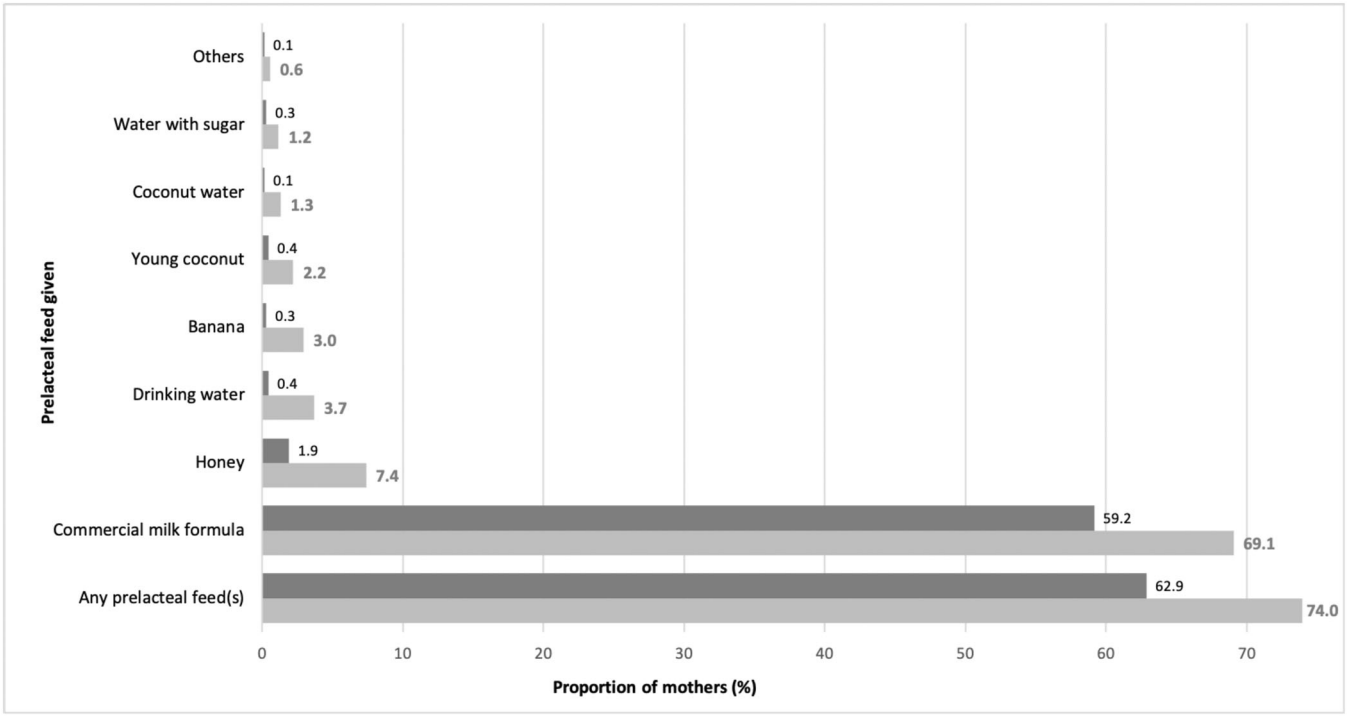

FIGURE 1 | Percentage of mothers who reported giving prelacteal feeds to their newborns within the first 3 days after delivery by type. The darker bars indicate the percentage of infants given only one particular type of prelacteal. Others: sugar, dates, papaya, rice and commercial baby cereals. The denominator represents the total number of respondents ($n = 676$).

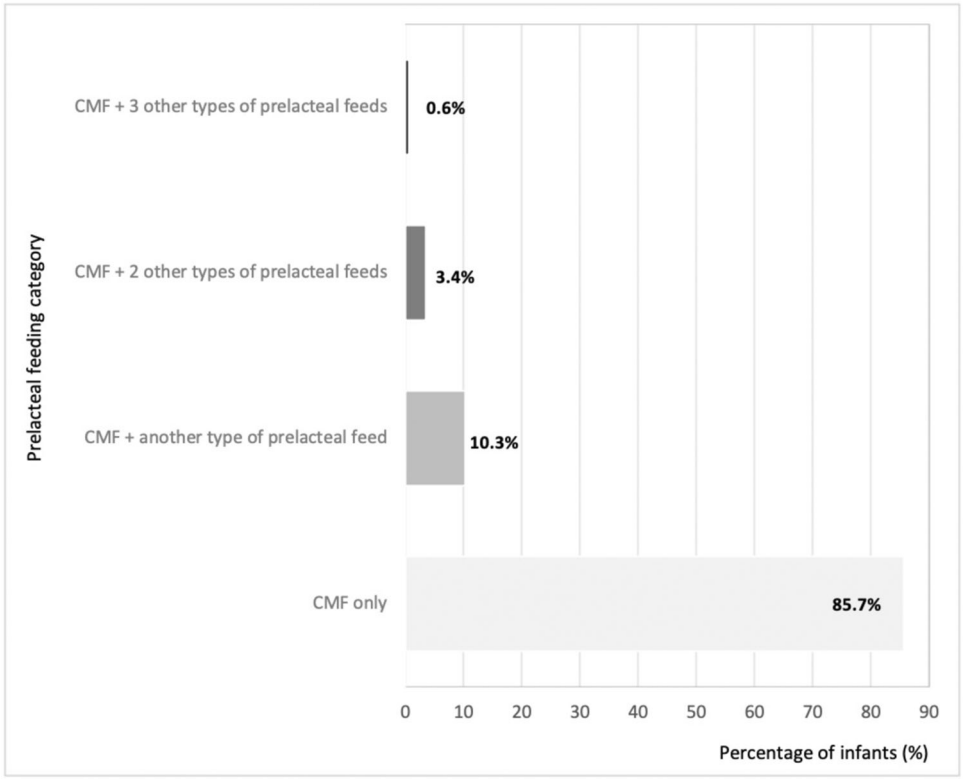

FIGURE 2 | Percentage of mothers who gave prelacteal feeding of commercial milk formula only and with other types of prelacteal feeds. CMF, commercial milk formula. The denominator is the number of mothers giving prelacteal feeding of commercial milk formula ($n = 467$).

TABLE 2 | Crude and final models for prelacteal feeding of CMF among mothers in East Java ($N = 676$).

	Crude model			Final model		
	cOR	**(95% CI)**	***p***	**aOR**	**(95% CI)**	***p***
Maternal factors						
Age at pregnancy, years	1.01	(0.98, 1.04)	0.425	1.04	(0.99, 1.08)	0.084
Education level			0.346			
Primary or no formal education	1.00					
High school	1.21	(0.81, 1.82)	0.354[a]			
College or university	0.81	(0.40, 1.64)	0.555[a]			
Currently working	1.26	(0.82, 1.95)	0.288			
MUAC at pregnancy, >= 23.5cms	0.97	(0.65, 1.45)	0.88			
ANC visits, >= 4 times	1.60	(0.70, 3.66)	0.273			
First ANC visit, trimester 1	0.97	(0.62, 1.52)	0.908			
Ever been to Puskesmas	1.13	(0.80, 1.59)	0.483			
Ever been to Posyandu	0.88	(0.61, 1.27)	0.499			
Own mobile phone	1.24	(0.82, 1.85)	0.307			
Breastfeeding self-efficacy			< 0.0001			< 0.0001
High or medium	1.00			1.00		
Low	8.82	(4.75, 16.40)	< 0.001[a]	8.12	(4.26, 15.48)	< 0.001[a]
Parity, primipara	1.54	(1.09, 2.19)	0.014	1.71	(1.12, 3.04)	0.035
Wealth index			0.621			
Poor	1.00					
Middle	1.19	(0.79, 1.78)	0.397			
Rich	1.22	(0.72, 2.07)	0.46			
Food security index			0.221			0.100
Food secure	1.00			1.00		
Food insecure without hunger	0.86	(0.58, 1.28)	0.466[a]	0.93	(0.61, 1.43)	0.746[a]
Food insecure with hunger	0.35	(0.10, 1.22)	0.101[a]	0.20	(0.04, 0.87)	0.032[a]
Sex of infant, male	1.35	(0.96, 1.89)	0.079			
Low birthweight	0.79	(0.44, 1.41)	0.425			
Place of delivery			0.016			
Non-health facility	1.00					
Clinics	1.59	(0.69, 3.65)	0.276[a]			
Hospitals	2.57	(1.07, 6.15)	0.034[a]			
Caesarean delivery	2.24	(1.47, 3.40)	0.0001			
Early initiation of breastfeeding	0.36	(0.25, 0.52)	< 0.0001	0.40	(0.22, 0.58)	< 0.001
Given colostrum	0.30	(0.10, 0.87)	0.012			
Received information on breastfeeding			0.268			
Yes, from health professionals	0.86	(0.61, 1.23)	0.425[a]			
Yes, from non-health professionals	1.77	(0.69, 4.48)	0.231[a]			
No	1.00					
Received explanations to solve breastfeeding problems			0.002			0.034
Yes, from health professionals	2.03	(1.26, 3.27)	0.003[a]	1.87	(1.12, 3.11)	0.026[a]

(Continues)

TABLE 2 | (Continued)

	Crude model			Final model		
	cOR	(95% CI)	*p*	aOR	(95% CI)	*p*
Yes, from non-health professionals	3.00	(0.85, 10.60)	0.088[a]	1.89	(0.49, 7.32)	0.357[a]
No	1.00					

Note: Odds ratio and 95% CI generated using random effect logistic regression with the cluster as the random effect. Age at pregnancy is a continuous variable; education level, breastfeeding self-efficacy, wealth index and food security index are categorical; and all other variables are binary categorical.*Posyandu* or Integrated Health Post, community-based activities run by community health volunteers (cadres) supervised by a village midwife, to do growth monitoring for under five and nutrition education, including for pregnant women. *Puskesmas*, community health centre, government-mandated health clinics responsible for the population at subdistrict or level.Crude model was adjusted for treatment allocation, while the final model was adjusted for all covariates in that model. All *p* values are generated from the likelihood ratio test unless indicated otherwise.

Abbreviations: aOR, adjusted odds ratio; ANC, antenatal care; CI, confidence interval; cOR, crude odds ratio; MUAC, middle-upper arm circumference.

[a]From Wald test.

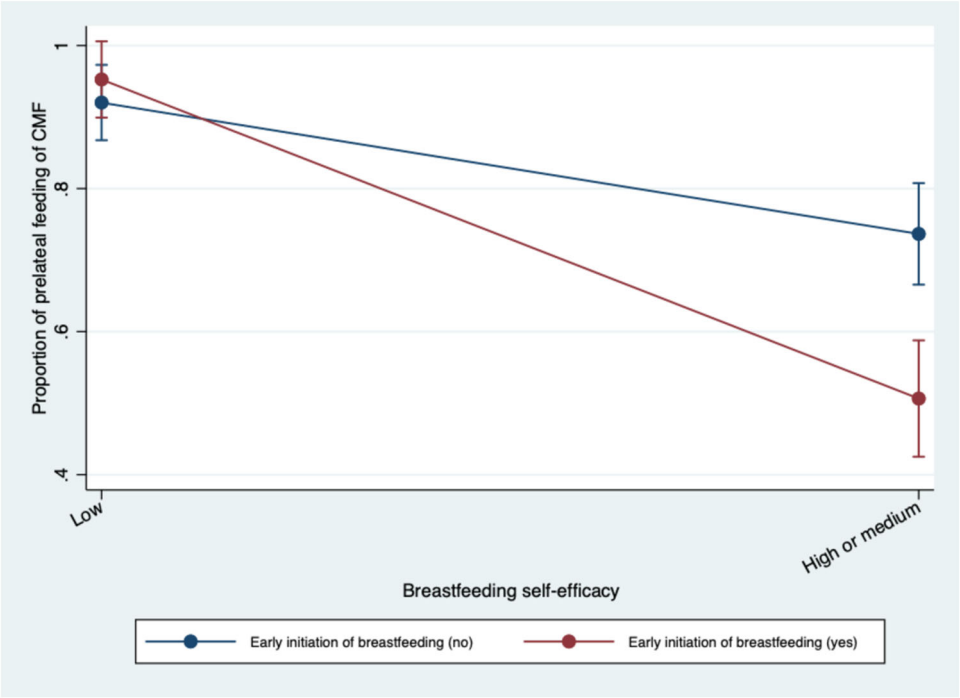

FIGURE 3 | The combined effect of breastfeeding self-efficacy and early initiation of breastfeeding ($p = 0.017$) on prelacteal feeding of CMF adjusted for mother's age at pregnancy, parity and food security index.

EIBF was the strongest predictor of CMF after BFSE. In the same way, previous studies also show that mothers with higher BFSE are less likely to introduce CMF (Champeny et al. 2019; Kiani et al. 2018; Temesgen et al. 2018). CMF feeding delays the production of breastmilk by interfering with infants' suckling at the breast, which affects the release of prolactin (WHO 2009). This practice is contrary to EIBF, which activates the secretion of prolactin and oxytocin that drives the production of breastmilk (WHO 2009). In other words, both variables are not only related but can also lead to a vicious cycle: CMF feeding delays breastfeeding initiation and the delay in breastfeeding initiation promotes CMF feeding (Inayati et al. 2012). Thus, promoting EIBF and discouraging CMF feeding are both critical components of optimal early infant feeding.

Although EIBF reduced the odds of CMF in the pooled analysis, our subgroup analysis indicated that this association was found only among mothers with high or medium self-efficacy. The results suggested no evidence for the correlation between both variables among mothers with low self-efficacy. Further, if we compare the magnitude of impact and the strength of evidence for BFSE and EIBF, the former had around 8 times bigger odds of CMF with solid evidence. Based on these findings, interventions to improve BFSE should be of priority, as mothers with low self-efficacy are much more prone to CMF feeding, even if EIBF is performed.

Research on self-efficacy-based interventions has been widely conducted with the main focus on breastfeeding initiation and duration, including exclusive breastfeeding (Chipojola et al. 2020). However, investigation into their impact on CMF is limited, although the negative impacts of CMF on these breastfeeding practices have been clearly demonstrated (Pérez-Escamilla et al. 2022). In addition, our current food system enables formula milk companies to influence parents' decisions regarding CMF through their marketing strategies with limited guidance from health professionals (Rollins et al. 2023). This conclusion correlates with a previous finding that interventions-based self-efficacy

is effective only in supportive settings, such as in the Baby-Friendly Hospital Initiative (BFHI) accredited hospitals (Otsuka et al. 2014). BFHI implementation is among the organisational- and community-level determinants of infant feeding alongside BMS marketing, according to the existing literature (Taren and Lutter 2017).

BFHI is a programme introduced in 1991 to support and promote breastfeeding in hospitals by awarding the BFHI accreditation to hospitals that implement the Ten Steps to Successful Breastfeeding (Ten Steps) (World Health Organization 1991). The updated version of the Ten Steps published in 2018 incorporates the Codes and the relevant WHA resolutions (World Health Organization 1991). In other words, the implementation of the Ten Steps indicates the health systems' support for optimal breastfeeding practices and preventing CMF feeding. In Indonesia, around 5% of hospitals were reported as BFHI hospitals in 2017 (WHO 2017), and 8% of public hospitals implemented the Ten Steps in 2011 (Badan Penelitian dan Pengembangan Kesehatan 2012). Although the Ten Steps programme has been mandatory since 2004 and subsequent regulations have been issued to support the implementation, the programme lacks monitoring and evaluation (Pramono et al. 2021). An assessment in four districts of East Java suggests that the main bottlenecks include the low adherence of health facilities to implement breastfeeding policies (Step 1), skin-to-skin contact (Step 4) and rooming-in for the 24 h after delivery (Step 7) (Indrayathi et al. 2018). In addition, the percentage of health facilities with required training (Step 2) and those who do not introduce foods other than breastmilk—unless medically indicated—is still low (Step 6) (Indrayathi et al. 2018). Both factors are in line with findings from other provinces in Indonesia (Flaherman et al. 2018). Although the data used in Indrayathi et al. (2018) are not from our study location, similarities might exist as they are within the same province.

As one of the health system interventions in our study, the adherence to the BFHI in all public hospitals and clinics within the intervention clusters was expected to be higher than in non-intervention clusters. However, the average coverage of this intervention was low, ranging from 11% in the third trimester of pregnancy to 69% in the 18 months following delivery, along with other interventions on breastfeeding (Fahmida et al. 2020). This could explain why the intervention did not show any effect on CMF feeding.

The implementation of BFHI covers the involvement of healthcare providers during pregnancy through antenatal care and after delivery, which is vital in supporting optimal breastfeeding practices and preventing CMF feeding (Al-Numan, Fawzi, and Yassen 2023; Walsh et al. 2023). This study included two variables capturing breastfeeding support from healthcare providers. The first one, if the mother received information about breastfeeding, did not indicate any association with CMF feeding, which was similar to the result sare from a previous study in Cambodia (Champeny et al. 2019). Information regarding breastfeeding given by healthcare providers may vary across settings and does not explicitly mention CMF feeding; therefore, this variable did not affect the outcome. Additionally, healthcare providers may promote formula feeding without valid reasons, as revealed by research from Iran (Al-Numan, Fawzi, and Yassen 2023) and Indonesia (Hadihardjono et al. 2019; Hidayana et al. Februhartanty, and Parady 2017, 2023; Nuralita, Murti, and Pamungkasari 2017), which undermines the breastfeeding information that mothers ever received.

On the other hand, receiving explanations from health professionals when mothers faced breastfeeding problems nearly doubled the odds of CMF feeding compared to those who did not receive such information. This finding was not in line with previous studies suggesting that mothers' exposure to this information can prevent CMF feeding (Akello et al. 2021; Amele et al. 2019). The effectiveness of this information relies on some aspects, such as the quality of the information given and how the information is delivered. These aspects are influenced by healthcare providers' skills, attitudes and knowledge regarding breastfeeding (Gavine et al. 2017), as well as their understanding of the Code, given their susceptibility to both direct and indirect marketing of breastmilk substitutes (Rollins et al. 2016). Highly skilled health professionals who are confident in their capacity to assist with breastfeeding are more inclined to offer precise and consistent guidance, positively influencing mothers' decision to avoid CMF feeding (Almeida et al. 2020; Gavine et al. 2017). Therefore, it is crucial to improve breastfeeding support skills, especially among midwives who interact with mothers more frequently.

Furthermore, our findings on other health facility-related factors are of importance. We found that place of delivery, antenatal care, and mothers' visits to *Posyandu/Puskesmas* showed no significant effect on CMF feeding. Mothers' contact with health facilities since pregnancy may indicate if they received breastfeeding counselling, particularly regarding the avoidance of CMF feeding. These factors are correlated with the Ten Steps—breastfeeding information that pregnant women receive during antenatal visits—as breastfeeding counselling is a component of antenatal care in Indonesia (Kementerian Kesehatan 2020). A possible reason for this absence of effect of these factors could indicate that breastfeeding support within the maternal health programmes needs improvements. Additionally, from the perspective of the Ten Steps/BFHI initiative, monitoring the implementation of these maternal health programmes and the rest of the BFHI components are highly relevant in preventing unnecessary CMF feeding, as emphasised in the 2023 Lancet breastfeeding Series (Pérez-Escamilla et al. 2023).

In light of the aggressive marketing strategies employed by formula milk industries, enhanced support from healthcare systems is increasingly essential. When mothers require additional information to facilitate their breastfeeding practices, but obstacles exist to obtaining health professional advice and support, they may turn to informal sources, including family, friends, other mothers and the internet (Appleton et al. 2018). Around 50% of mothers are exposed to formula milk marketing through multiple channels including health professionals (WHO and UNICEF 2022). Healthcare practitioners, their associations and social media influencers are increasingly involved in marketing operations in Indonesia, contravening the Code (Hidayana et al. 2023). Consequently, it is imperative to regulate the online marketing of formula milk, alongside the previously outlined recommendations for healthcare services.

The findings of this study apply to the East Java context and other regions in Indonesia where CMF feeding is prevalent. However, these findings may not be generalisable to other countries, especially those where CMF feeding is uncommon. This study used information collected within 1-week post-delivery, mitigating the risk of memory bias, in contrast to studies using information collected at a later time, as seen in the DHS or other cross-sectional studies involving mothers of infants aged 0-23 months as participants.

This study also comes with limitations. Firstly, we did not collect data on mothers' exposure to BMS promotion and their perception of formula feeding. These are among the individual-level determinants of CMF that directly affect the outcome (Champeny et al. 2019; Mahesh et al. 2018). Secondly, we also did not have data on the broader determinants, such as compliance with the implementation of the Ten Steps and the BFHI accreditation, which includes the violations of the Codes within and beyond the health system. Lastly, the outcome of this study was generated from a question on any prelacteal feeding; therefore, caution is needed when interpreting the results.

5 | Conclusions and Recommendations

Almost 70% of newborns received CMF feeding in Malang and Sidoarjo. First-time mothers, low BFSE, receiving explanations to solve breastfeeding problems, and the absence of EIBF were identified as risk factors for CMF feeding. The findings underscore the strategic roles of healthcare services, especially within the place of delivery. Therefore, it is crucial to improve the quality of breastfeeding support in hospitals and other delivery clinics, along with raising awareness about the harmful effects of CMF feeding, enhancing BFSE and encouraging EIBF, particularly for first-time mothers, as CMF feeding can lead to suboptimal breastfeeding practices. Further research is needed to examine other relevant factors not covered in this study and to explore why mothers give CMF at this critical time, particularly among those coming from resource-limited households.

Author Contributions

Michael J. Dibley, Umi Fahmida, Elaine Ferguson and Min Kyaw Htet designed the study. Min Kyaw Htet managed and cleaned the data. Siti Nurokhmah performed data analyses and wrote the original draft of the manuscript. Michael J. Dibley, Elaine Ferguson and Min Kyaw Htet provided advice on data analysis. Michael J. Dibley, Min Kyaw Htet, Elaine Ferguson and Umi Fahmida reviewed the manuscript. All authors read and approved the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.