## RESEARCH

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# Breast milk feeding practices and frequencies among complementary-fed children: a crosssectional study in Northern Thailand



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### Abstract

**Background** The available data on milk feeding patterns and feeding frequency during the complementary feeding phase are limited. This study aimed to examine breastfeeding practices and assess the associations between milk feeding type, feeding method, and feeding frequency among complementary-fed children.

**Methods** This cross-sectional study was conducted between January and May 2024 at well-baby clinics in Chiang Mai, Thailand, and included 1,122 parents of children aged 6–24 months. Milk feeding practices were assessed through 24-hour recall interviews and categorized by feeding type and feeding method. Subgroup analyses were conducted for bottle-fed and breastfed children. Poisson regression was used to evaluate the effect modifications of child age on daytime and nighttime feeding frequency across different feeding methods and types.

**Results** The overall prevalence of breastfeeding was 46.3%, whereas bottle feeding was reported in 76.5% of the children. The average feeding frequency was 5.8 times per 24 h, with 2.1 feedings occurring at night. Among children who exclusively consumed breast milk until 18–24 months, 95.2% were fed directly from the breast. Compared with a single milk type or a single feeding method, the trend of partial breastfeeding and combined feeding methods was associated with significantly higher feeding frequencies. At night, children who were exclusively formula-fed or bottle-fed had fewer nighttime feedings than those who were exclusively breastfed or directly breastfed at 12, 18, and 24 months. However, subgroup analysis revealed minimal differences in nighttime feeding frequency between the feeding groups.

**Conclusions** This study revealed a high prevalence of discontinued breastfeeding and bottle feeding among young children. For those who continued exclusive breast milk consumption until nearly two years of age, direct breastfeeding remained the predominant feeding method. The associations between feeding method and milk type with feeding frequency were more pronounced during the daytime. However, at night, the relationships between feeding frequency and these factors were less consistent in both the overall and subgroup analyses, suggesting that nighttime feeding frequency is likely influenced by multiple factors beyond milk type and feeding method. Future longitudinal studies are needed to identify additional determinants of feeding frequency and their implications for child health.

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Keywords Breastfeeding, Bottle feeding, Complementary feeding, Feeding frequency, Milk formula

#### Background

Complementary feeding is the period when foods and liquids beyond breast milk or infant formula are introduced to meet an infant's increasing nutritional needs. This stage typically begins at six months of age and continues until approximately 23 months of age [1]. Despite the introduction of solid foods, milk remains a critical source of calcium and other essential nutrients, supporting growth and development throughout this period [1, 2]. With respect to milk type, health authorities, including the World Health Organization (WHO), the American Academy of Pediatrics, and the Ministry of Public Health in Thailand, recommend continuing breastfeeding for at least two years or more to support and promote optimal child health and development [3-5]. With respect to milk feeding methods, the WHO promotes cup feeding as a safer alternative to bottle feeding, emphasizing its potential to reduce contamination risks and prevent disruptions to natural suckling behaviors [5]. The transition to cup feeding generally occurs between 12 and 15 months of age, depending on the child's individual developmental readiness [2]. In practice, however, a 2022 national survey in Thailand revealed a low prevalence of continued breastfeeding among children aged 0-23 months, with only 25% of children being breastfed, in contrast to a notably high prevalence of bottle feeding at 78.6% [6]. These findings are consistent with global survey reports on young children [7, 8], which indicate a progressive decline in breastfeeding rates with increasing age, often accompanied by a corresponding increase in the use of formula milk and bottle-feeding [9, 10].

The available information on milk feeding frequency among children receiving complementary foods is limited, despite its well-established importance for both infant and maternal health. Frequent milk feeding plays a crucial role in maintaining an adequate milk supply for breastfeeding mothers [2]. However, excessive intake of beverages, including milk, during the complementary feeding period may suppress appetite for solid foods, potentially leading to imbalanced dietary intake and compromised nutritional adequacy [11]. High-frequency nocturnal feeding has been associated with increased night awakening in infants aged 6-12 months, contributing to sleep disturbances [12, 13]. Moreover, frequent milk feeding in late infancy, whether through breastfeeding or bottle feeding, has been linked to a greater risk of early childhood dental caries [14]. On the other hand, reducing the frequency of night-time feed may offer a protective effect against obesity in early childhood [15].

Previous studies have established associations between milk feeding type, feeding method, and feeding frequency. Evidence suggests that breastfed infants, whether exclusively or partially, exhibit more frequent nighttime awakenings than formula-fed infants do [16-18]. However, earlier research revealed no significant differences in feeding frequency on the basis of feeding type [19, 20]. With respect to feeding methods, direct breastfeeding has been associated with more frequent feedings, likely due to its dual role in providing both nutrition and comfort [2]. However, the evidence on the associations between milk feeding type or method and feeding frequency remains limited and inconclusive. This study aimed to investigate breastfeeding practices and examine the associations between milk feeding type, feeding method, and milk feeding frequency among complementary-fed children. The findings are expected to contribute to a deeper understanding of milk feeding behaviors during the complementary feeding stage and provide a foundation for evidence-based guidelines to promote optimal complementary feeding practices.

#### Methods

#### Study design and participants

This cross-sectional study was conducted between January and May 2024 and employed a convenience sampling method. The participants included parents of children aged 6 to 24 months who attended well-baby clinics at three tertiary care hospitals in Chiang Mai, Thailand. These hospitals were strategically selected to represent the northern, central, and southern regions of the province. Eligible participants were parents who could accurately report their child's milk consumption and sleep patterns within the preceding 24 h. The exclusion criteria included parents who were illiterate in Thai, those unable to provide informed consent or complete the interview process, and parents of children with specific health conditions requiring specialized nutrition or feeding techniques (e.g., children with hypotonia, food allergies, or autism spectrum disorders with selective eating behaviors). Additionally, children who followed an atypical diet within the 24 h preceding the interview due to illness, feasting days, or special ceremonies were excluded from the study. The sample size was calculated on the basis of breastfeeding prevalence rates in Thailand, which were 31.3% for infants aged 12–15 months and 18.7% for infants aged 20-23 months [6]. For mothers of breastfed children aged 6-12 months, a confidence level of 97%, a margin of error of 5%, and a design effect of 1.0 required a sample size of 405 participants. For mothers of breastfed children aged 12-17 months and 18-24 months, the same confidence level, margin of error, and design effect required a sample size of 286 participants for each

group. The final sample included 977 mothers. Ethical approval for the study was obtained from the Research Ethics Committee of the Faculty of Medicine, Chiang Mai University (No. 186/2023), on June 19, 2023. Written informed consent was obtained from all participants prior to their interviews.

#### Data collection

Individual interviews, conducted by two well-trained interviewers under the supervision of the first author, lasted 15–20 min. The interviews followed a structured set of questions and used a web-based application specifically developed for this study. The data collected included parental and child characteristics along with milk feeding patterns over the previous 24-hour period (from 08:00 on the preceding day to 08:00 on the day of the interview).

#### Statistical analysis

Descriptive statistics are reported as the means and standard deviations (SDs) for normally distributed numerical data, medians and interquartile ranges (IQRs) for nonnormally distributed numerical data and counts with percentages (%) for categorical data. The assumption of a normal distribution was derived from visual inspection of the histogram and quantile-quantile plots by two investigators (KO and WK). Poisson regression for count data with robust standard error correction was used for the inference of differences in events consisting of feeding frequency. The data were separately analyzed via four Poisson regression models consisting of two diurnal periods (daytime and nighttime feeding) across two outcomes: feeding type and feeding method. Modeling of the effect modification was performed via continuous input of child age on categorical inputs of types and methods. The interaction plots are presented with point estimates of the mean feeding frequency and 95% confidence intervals. The pairwise comparisons between each type and method were carried out at four time points, each consisting of 6, 12, 18 and 24 months of child age. Six pairwise comparisons across four statistical models were identified, in which the Bonferroni correction of type I error was applied across all twenty-four pairwise comparisons. A Bonferroni-corrected *p* value of less than 0.05 was considered statistically significant. No missing data imputation was carried out because of the negligible proportion of incomplete cases, thereby utilizing the missing completely at random (MCAR) assumption.

#### Results

#### Study population characteristics

The study included 1,122 children aged 6 to 24 months. Among them, 54.1% were between 6 and 11 months, 21.3% were between 12 and 17 months, and 24.6% were between 18 and 24 months.



Fig. 1 Categorization by milk type, feeding method, and subgroup classification. (A) *Breastmilk-only:* Exclusive feeding with breastmilk. A.1 *Direct breast-feeding only:* Feeding exclusively through direct breastfeeding. A.2 *Bottle feeding with breastmilk only:* Feeding exclusively with breastmilk via a bottle. A.3 *Combined feeding method with breastmilk only:* A combination of direct breastfeeding and bottle feeding with breastmilk. (B) *Partial breastfeeding:* Feeding that includes both breastmilk and formula. (C) *Formula-only:* Exclusive feeding with formula. (D) *Direct breastfeeding only:* Feeding the infant exclusively through direct breastfeeding. Feeding through both direct breastfeeding and bottle feeding. (F) *Bottle feeding only:* Feeding exclusively via a bottle. F.1 *Breastmilk via bottle feeding:* Feeding only breastmilk via a bottle. F.2 *Formula only via bottle feeding:* Feeding only formula via a bottle. F.3 *Formula and breastmilk via bottle feeding:* Feeding both formula and breastmilk via a bottle feeding: Feeding only formula via a bottle.

 Table 1
 Descriptive characteristics of the study population by appropriate complementary feeding practices

Table 2	Descriptive	milk feeding	type and	l method	by child	age
group an	nong the sti	udy populatio	on			

Characteristics	Total, <i>n</i> (%) (N=1122)
Child	
Age (months), median ( $P_{25}$ - $P_{75}$ )	10.0 (7.0–17.0)
6–11	607 (54.1)
12–17	239 (21.3)
18–24	276 (24.6)
Gender	
Male	605 (53.9)
Female	517 (46.1)
<b>Caregiver</b> ( <i>n</i> = 1,122)	
Household guardian	
Both biological parents	456 (40.6)
Mother only	365 (32.5)
Maternal grandmother	169 (15.1)
Others	132 (11.8)
Occupational status	
Stay-at-home	625 (55.7)
Active/Workplace-based Occupations	497 (44.3)
Working	
Educational level of primary caregiver ( $n = 1,122$ )	
12th grade and less	570 (50.8)
Some colleges, no degree	198 (17.6)
Bachelor's degree and higher 335 (29.9)	
Not known 19 (2.7)	
Household income per month, Baht (USD) ( $n = 1113$ ), median (P <sub>25</sub> -P <sub>75</sub> )	20,000 (15000– 30000)
≤ 15,000 (432)	337 (30.3)
15,001–30,000 (432–864)	539 (48.4)
≥ 30.001 (432)	237 (21.3)

Household Guardian: The individual who resides with the child and is primarily responsible for their care and supervision. Primary Caregiver: When the household guardian is reported as both biological parents, the data should default to the mother for consistency in record-keeping and analysis

Thailand's GDP per capita in 2023 was 7,171.8 USD [21]

With respect to household composition, the largest proportion of children (40.6%) lived with both parents. Among primary caregivers, 50.8% had an education level of 12th grade or below, and 55.7% were stay-at-home caregivers. Further demographic details are presented in Table 1.

#### Milk feeding types and methods

The predominant type of milk provided to children was formula-only milk, accounting for 53.7% of the sample. This was followed by breastmilk-only feeding (33.1%) and partial breastfeeding (13.2%). In terms of milk feeding methods, bottle feeding was the most common method, accounting for 58.3% of the cases. This was followed by direct breastfeeding at 23.4% and combined feeding methods at 18.2%. The prevalence of children receiving

	Total (N=1109)	Child age groups (months), n (%)				
		6–11 ( <i>n</i> =604)	12–17 (n=239)	18–24 ( <i>n</i> =266)		
Milk types						
Breastmilk-only Feeding	367 (33.1)	299 (49.5)	47 (19.7)	21 (7.9)		
Formula-only Feeding	596 (53.7)	236 (39.1)	154 (64.4)	206 (77.4)		
Partial breastfeeding	146 (13.2)	69 (11.4)	38 (15.9)	39 (14.7)		
Milk feeding methods						
Direct breastfeeding only	260 (23.4)	207 (34.3)	33 (13.8)	20 (7.5)		
Bottle feeding only	647 (58.3)	277 (45.9)	163 (68.2)	207 (77.8)		
Combined feeding method	202 (18.2)	120 (19.9)	43 (18.0)	39 (14.7)		
Subgroup breastmilk-						
only feeding (n=367)						
Direct breastfeeding only	260 (70.8)	207 (69.2)	33 (70.2)	20 (95.2)		
Bottle feeding only	37 (10.1)	31 (10.4)	6 (12.8)	0 (0.0)		
Combined feeding method	70 (19.1)	61 (20.4)	8 (17.0)	1 (4.8)		
Subgroup bottle feed- ing only (n = 647)						
Breastmilk-only feeding	37 (5.7)	31 (11.2)	6 (3.7)	0 (0.0)		
Formula-only feeding	596 (92.1)	236 (85.2)	154 (94.5)	206 (99.5)		
Partial breastfeeding	14 (2.2)	10 (3.6)	3 (1.8)	1 (0.5)		
Milk feeding fre- quency (mean±SD)						
Daytime (08:00-20:00)	3.7 (1.7)	4.5 (1.5)	3.2 (1.4)	2.3 (1.4)		
Nighttime (20:00-08:00)	2.1 (1.5)	2.5 (1.5)	1.8 (1.4)	1.5 (1.3)		
24 h	5.8 (2.5)	7.0 (2.2)	4.9 (1.8)	3.8 (2.1)		

formula only and bottle feeding increased with age, with the oldest group in our study showing percentages of 77.4% and 77.8%, respectively. Among the children in the breastmilk-only subgroup (n = 367), the majority (95.2%) who maintained exclusive breastfeeding until 18–24 months were fed directly by breastfeeding. In contrast, in the bottle-feeding-only subgroup (n = 647), none of the participants received exclusive breast milk, and only 0.5% were partially breastfed. On average, the milk feeding frequency during the daytime was 3.7, whereas the nighttime feeding frequency averaged 2.1, as shown in Table 2.

# Feeding frequency during the daytime and nighttime by milk type

Figure 2 illustrates trends in milk-feeding frequency during both the daytime and the nighttime, categorized by milk type and stratified by child age. Across all milk types, a consistent decline in feeding frequency was observed from 6 to 24 months. During the daytime, children receiving partial breastfeeding presented higher



**Fig. 2** Feeding frequency during the day and night by milk type. (**A**) Daytime feeding frequency by child age and feeding type. (**B**) daytime feeding frequency by child age and feeding method in the bottle feeding only subgroup. (**C**) nighttime feeding frequency by child age and feeding type. (**D**) nighttime feeding frequency by child age and feeding method in the bottle feeding only subgroup. Poisson regression was conducted to assess the effect modification of child age on the frequency of daytime and nighttime feeding across different methods and types of feeding

feeding frequencies than other groups did, both in the overall analysis and within the bottle-feeding-only subgroup. Nighttime feeding frequency was lower across all ages, with a less pronounced decline over time and smaller differences in feeding frequency between age groups than daytime feeding.

#### Associations between feeding type and frequency

Table 3 presents a comparison of total feeding frequency during the day and night across different milk feeding types, with a subgroup analysis of those using only the bottle method with different milk types. The results of different milk feeding methods revealed that partial breastfeeding was significantly associated with a greater frequency of milk feeding than formula-only feeding at 12, 18, and 24 months. Specifically, the mean differences for daytime feedings were 1.44 (p < 0.001), 1.73 (p < 0.001), and 1.86 (p = 0.015), respectively. Similarly, the mean differences for nighttime feedings were 0.71 (p < 0.001), 1.03 (p < 0.001), and 1.31 (p = 0.001), respectively. For daytime feedings, partial breastfeeding also resulted in a significantly greater feeding frequency than did breastmilkonly feeding at 12 months, with a mean difference of 1.11 (p < 0.001), and at 18 months, with a mean difference of 1.52 (p = 0.005). Nighttime feeding patterns consistently indicated that formula-only feeding was associated with fewer nighttime feedings than was breastmilk-only feeding across all age groups. At 6, 12, 18, and 24 months, the mean differences were -0.56 (p = 0.007), -0.67 (p < 0.001), -0.75 (p < 0.001), and -0.80 (p = 0.004), respectively. In the bottle-feeding-only subgroup, significant differences in feeding frequency during daytime feeding were observed at 12 and 18 months. At 12 months, children receiving partial breastfeeding presented significantly higher feeding frequencies than did those receiving breastmilk only, with a mean difference of 3.87 (p = 0.007), and those receiving formula only, with a mean difference of 4.76 (p < 0.001). Similarly, at 18 months, partial breastfeeding was associated with a significantly greater feeding frequency than formula feeding was, with a mean difference of 5.06 (p < 0.001). In contrast, the nighttime feeding frequency did not significantly differ among milk types within the bottle-feeding-only subgroup.

#### Associations between feeding method and frequency

Table 4 presents a comparison of total feeding frequency during the day and night across different milk-feeding methods. A consistent pattern was observed at 12, 18,



Fig. 3 Feeding frequency during the day and night by feeding method. (A) Daytime feeding frequency by child age and feeding method (B) daytime feeding frequency by child age and feeding method in the breastmilk only subgroup. (C) nighttime feeding frequency by child age and feeding method. (D) nighttime feeding frequency by child age and feeding method in the breastmilk only subgroup. Poisson regression was conducted to assess the effect modification of child age on the frequency of daytime and nighttime feeding across different methods and types of feeding

and 24 months, where the combined feeding method resulted in a significantly higher daytime feeding frequency than did both direct breastfeeding and bottle-feeding. Specifically, the mean differences between the combined feeding method and direct breastfeeding were 1.33 (p < 0.001), 1.75 (p = 0.001), and 1.95 (p = 0.039) at 12, 18, and 24 months, respectively. Similarly, compared with bottle-feeding, the combined feeding method resulted in mean differences of 1.46 (p < 0.001), 1.78 (p = 0.001), and 1.92 (p = 0.013) at these time points. Notably, at 6 months, the combined feeding method was associated with a significantly higher daytime feeding frequency than bottle-feeding was, with a mean difference of 0.89 (p = 0.015).

Compared with direct breastfeeding, bottle feeding was associated with a lower feeding frequency at 12, 18, and 24 months, with mean differences of -0.56 (p < 0.001), -0.70 (p < 0.001), and -0.79 (p = 0.002), respectively. At 12 months, the combined feeding method resulted in significantly greater nighttime feeding frequencies than did both direct breastfeeding, with a mean difference of 2.25 (p = 0.004), and bottle-feeding, with a mean difference of 2.81 (p < 0.001). At 18 months, the combined feeding

method resulted in significantly higher nighttime feeding frequencies than did bottle-feeding, with a mean difference of 1.48 (p < 0.001).

In the subgroup of infants receiving only breast milk, a similar trend in daytime feeding frequency was observed across all age groups (6, 12, 18, and 24 months), with the combined feeding method consistently resulting in a higher feeding frequency than both direct breastfeeding and bottle-feeding. The mean differences between the combined feeding method and direct breastfeeding were 1.00 (*p* = 0.012), 1.84 (*p* < 0.001), 2.33 (*p* < 0.001), and 2.59 (*p* = 0.022) at 6, 12, 18, and 24 months, respectively. Compared with bottle-feeding, the combined feeding method resulted in significantly greater feeding frequencies at 6, 12, and 18 months, with mean differences of 1.48 (p=0.005), 1.93 (p<0.001), and 2.20 (p=0.027), respectively. For nighttime feeding in this subgroup, at 12 months, the combined feeding method was associated with a significantly greater feeding frequency than both direct breastfeeding, with a mean difference of 3.36 (p=0.010), and bottle-feeding, with a mean difference of 4.14 (p = 0.001). However, no significant differences in

Age (mo) Comparator (type)		Reference (type)	Daytime			Nighttime		
			Events	95%Cl	p value	Events	95%CI	<i>p</i> value
Feeding ty	oe (overall feeding meth	ods)						
6	Formula-only feeding	Breastmilk-only feeding	-0.50	(-1.04, 0.05)	0.137	-0.56	(-1.05, -0.07)	0.007**
6	Partial breastfeeding	Breastmilk-only feeding	0.42	(-1.00, 1.84)	> 0.999	-0.22	(-1.11, 0.67)	> 0.999
6	Partial breastfeeding	Formula-only feeding	0.92	(-0.48, 2.32)	> 0.999	0.34	(-0.56, 1.24)	> 0.999
12	Formula-only feeding	Breastmilk-only feeding	-0.33	(-0.74, 0.09)	0.549	-0.67	(-0.97, -0.37)	< 0.001**
12	Partial breastfeeding	Breastmilk-only feeding	1.11	(0.31, 1.92)	< 0.001**	0.04	(-0.50, 0.58)	> 0.999
12	Partial breastfeeding	Formula-only feeding	1.44	(0.71, 2.17)	< 0.001**	0.71	(0.19, 1.23)	< 0.001**
18	Formula-only feeding	Breastmilk-only feeding	-0.21	(-0.89, 0.47)	> 0.999	-0.75	(-1.20, -0.29)	< 0.001**
18	Partial breastfeeding	Breastmilk-only feeding	1.52	(0.22, 2.81)	0.005**	0.29	(-0.38, 0.95)	> 0.999
18	Partial breastfeeding	Formula-only feeding	1.73	(0.59, 2.87)	< 0.001**	1.03	(0.43, 1.63)	< 0.001**
24	Formula-only feeding	Breastmilk-only feeding	-0.13	(-0.93, 0.66)	> 0.999	-0.80	(-1.47, -0.13)	0.004**
24	Partial breastfeeding	Breastmilk-only feeding	1.72	(-0.12, 3.57)	0.110	0.51	(-0.59, 1.62)	> 0.999
24	Partial breastfeeding	Formula-only feeding	1.86	(0.16, 3.56)	0.015*	1.31	(0.30, 2.32)	0.001**
Subgroup	lassification for bottle fe	eding only						
6	Formula-only feeding	Breastmilk-only feeding	0.24	(-0.99, 1.14)	> 0.999	-0.51	(-1.91, 0.88)	> 0.999
6	Partial breastfeeding	Breastmilk-only feeding	2.26	(-1.26, 6.42)	> 0.999	0.19	(-1.83, 2.21)	> 0.999
6	Partial breastfeeding	Formula-only feeding	2.26	(-1.22, 6.23)	> 0.999	0.71	(-0.85, 2.26)	> 0.999
12	Formula-only feeding	Breastmilk-only feeding	-0.33	(-1.05, 0.86)	> 0.999	0.19	(-0.94, 1.32)	> 0.999
12	Partial breastfeeding	Breastmilk-only feeding	3.87	(0.26, 3.76)	0.007**	0.70	(-0.64, 2.04)	> 0.999
12	Partial breastfeeding	Formula-only feeding	4.76	(0.61, 3.59)	< 0.001**	0.51	(-0.25, 1.28)	> 0.999
18	Formula-only feeding	Breastmilk-only feeding	-0.37	(-1.87, 1.51)	> 0.999	0.57	(-1.18, 2.31)	> 0.999
18	Partial breastfeeding	Breastmilk-only feeding	2.59	(-0.47, 3.59)	0.628	0.93	(-0.85, 2.71)	> 0.999
18	Partial breastfeeding	Formula-only feeding	5.06	(0.58, 2.91)	< 0.001**	0.36	(-0.14, 0.87)	0.998
24	Formula-only feeding	Breastmilk-only feeding	-0.36	(-2.31, 1.86)	> 0.999	0.75	(-1.07, 2.56)	> 0.999
24	Partial breastfeeding	Breastmilk-only feeding	1.52	(-1.47, 3.91)	> 0.999	0.99	(-0.88, 2.87)	> 0.999
24	Partial breastfeeding	Formula-only feeding	2.79	(-0.30, 3.18)	0.343	0.25	(-0.45, 0.94)	> 0.999

Pairwise comparisons of the total frequency of feeding during the daytime and nighttime across age groups (6, 12, 18, and 24 months) and feeding types (p values and 95% confidence intervals were adjusted with Bonferroni correction across 48 pairwise comparisons), \*p < 0.05, \*\*p < 0.01

nighttime feeding frequency were observed among the other age groups.

#### Discussion

Our study included 1,122 parents of children aged 6 to 24 months. Most of these children resided either with both parents or exclusively with their mothers. Among primary caregivers, approximately half were stay-at-home caregivers, and a similar proportion had attained a high school education or lower. Most children were predominantly fed formula and relied on bottle feeding, with nighttime feeding remaining common. Additionally, the study identified distinct patterns of associations between milk type, feeding method, and feeding frequency, which varied on the basis of the time of day and the child's age.

#### **Milk feeding practices**

The results revealed a low rate of continued breastfeeding beyond the age of 12 months. The continued breastfeeding rate was 35.6% for children aged 12–23 months and 22.6% at 12–28 months. These rates are lower than the regional average for Southeast Asia, where 59% of mothers continue breastfeeding when their children are 12–23 months old [7]. Additionally, our findings fall below the global rates reported in a 2023 survey, which indicated that 71% of women continued breastfeeding until one year and that 45% continued breastfeeding until two years [8]. One of the key findings reveals that most children who continue breastfeeding until the age of two belong to the direct breastfeeding-only group. This finding emphasizes the importance of further research on interventions that promote prolonged breastfeeding, particularly in relation to the method of milk feeding.

In terms of feeding methods, direct breastfeeding is considered the ideal approach, with sippy cup or cup feeding recommended as the safest alternative when direct breastfeeding is not feasible [22, 23]. In our study, the prevalence of exclusive bottle-feeding across all age groups was 58.3%, closely aligning with findings from a recent meta-analysis that reported a global bottle-feeding rate of 57% among mothers of children under five years of age [9]. However, significant variation exists within Asia. For example, bottle-feeding rates among children aged 0–23 months have been reported to be 37.9% in Indonesia [10] and 86% in Pakistan [24]. These wide disparities can be explained by the complex and multifactorial

Table 4	Comparison	of total feeding	a freauenc	v durina	a the da	v and nigh	nt across age	aroups b'	v feedinc	ı method
				/						

Comparator (type)	Reference (type)	Daytime			Nighttime		
		Events	95%CI	p value	Events	95%Cl	p value
hod							
Bottle feeding method	Direct breastfeeding only	-0.30	(-0.90, 0.30)	> 0.999	-0.39	(-0.83, 0.04)	0.166
Combined feeding method	Direct breastfeeding only	0.59	(-0.29, 1.46)	> 0.999	4.53	(-0.79, 9.85)	0.271
Combined feeding method	Bottle feeding method	0.89	(0.08, 1.70)	0.015*	4.92	(-0.40, 10.24)	0.121
Bottle feeding method	Direct breastfeeding only	-0.13	(-0.59, 0.33)	> 0.999	-0.56	(-0.83, -0.30)	< 0.001**
Combined feeding method	Direct breastfeeding only	1.33	(0.64, 2.01)	< 0.001**	2.25	(0.35, 4.14)	0.004**
Combined feeding method	Bottle feeding method	1.46	(0.90, 2.02)	< 0.001**	2.81	(0.92, 4.70)	< 0.001**
Bottle feeding method	Direct breastfeeding only	-0.03	(-0.77, 0.72)	> 0.999	-0.70	(-1.13, -0.26)	< 0.001**
Combined feeding method	Direct breastfeeding only	1.75	(0.36, 3.13)	0.001**	0.78	(-0.35, 1.91)	> 0.999
Combined feeding method	Bottle feeding method	1.78	(0.57, 2.98)	< 0.001**	1.48	(0.38, 2.58)	< 0.001**
Bottle feeding method	Direct breastfeeding only	0.03	(-0.83, 0.88)	> 0.999	-0.79	(-1.44, -0.15)	0.002**
Combined feeding method	Direct breastfeeding only	1.95	(0.04, 3.86)	0.039**	-0.14	(-1.61, 1.33)	> 0.999
Combined feeding method	Bottle feeding method	1.92	(0.18, 3.66)	0.013**	0.65	(-0.75, 2.06)	> 0.999
assification for breastmilk-only							
Bottle feeding method	Direct breastfeeding only	-0.48	(-1.59, 0.64)	> 0.999	0.07	(-1.31, 1.44)	> 0.999
Combined feeding method	Direct breastfeeding only	1.00	(0.10, 1.90)	0.012*	6.51	(-0.12, 13.15)	0.062
Combined feeding method	Bottle feeding method	1.48	(0.22, 2.73)	0.005**	6.45	(-0.32, 13.21)	0.088
Bottle feeding method	Direct breastfeeding only	-0.09	(-1.12, 0.94)	> 0.999	-0.78	(-1.91, 0.36)	> 0.999
Combined feeding method	Direct breastfeeding only	1.84	(1.16, 2.52)	< 0.001**	3.36	(0.37, 6.35)	0.010*
Combined feeding method	Bottle feeding method	1.93	(0.85, 3.01)	< 0.001**	4.14	(0.95, 7.32)	0.001**
Bottle feeding method	Direct breastfeeding only	0.13	(-1.69, 1.96)	> 0.999	-1.26	(-3.03, 0.50)	> 0.999
Combined feeding method	Direct breastfeeding only	2.33	(0.89, 3.78)	< 0.001**	1.39	(-2.41, 5.19)	> 0.999
Combined feeding method	Bottle feeding method	2.20	(0.10, 4.30)	0.027*	2.66	(-1.50, 6.82)	> 0.999
Bottle feeding method	Direct breastfeeding only	0.25	(-1.98, 2.48)	> 0.999	-1.52	(-3.39, 0.34)	0.383
Combined feeding method	Direct breastfeeding only	2.59	(0.52, 4.66)	0.002**	0.18	(-3.89, 4.25)	> 0.999
Combined feeding method	Bottle feeding method	2.34	(-0.47, 5.15)	0.333	1.71	(-2.70, 6.11)	> 0.999
	Comparator (type) hod Bottle feeding method Combined feeding method	Comparator (type)Reference (type)hodDirect breastfeeding onlyCombined feeding methodDirect b	Comparator (type)Reference (type)Daytime EventshodDirect breastfeeding only-0.30Combined feeding methodDirect breastfeeding only0.59Combined feeding methodBottle feeding method0.89Bottle feeding methodDirect breastfeeding only-0.13Combined feeding methodDirect breastfeeding only-0.13Combined feeding methodDirect breastfeeding only1.33Combined feeding methodDirect breastfeeding only-0.03Combined feeding methodDirect breastfeeding only-0.03Combined feeding methodDirect breastfeeding only-0.03Combined feeding methodDirect breastfeeding only-0.03Combined feeding methodDirect breastfeeding only1.75Combined feeding methodDirect breastfeeding only1.95Combined feeding methodDirect breastfeeding only1.92assification for breastmilk-onlyDirect breastfeeding only-0.48Combined feeding methodDirect breastfeeding only-0.09Combined feeding methodDirect breastfeeding only-0.09Combined feeding methodDirect breastfeeding only-0.09Combined feeding methodDirect breastfeeding only-0.03Combined feeding methodDirect breastfeeding only-0.09Combined feeding methodDirect breastfeeding only-0.09Combined feeding methodDirect breastfeeding only-0.09Combined feeding methodDirect breastfeeding only2.33Combined	Comparator (type)Reference (type)DaytimeFvents95%ClhodDirect breastfeeding only-0.30(-0.90, 0.30)Combined feeding methodDirect breastfeeding only0.59(-0.29, 1.46)Combined feeding methodBottle feeding method0.89(0.08, 1.70)Bottle feeding methodDirect breastfeeding only-0.13(-0.59, 0.33)Combined feeding methodDirect breastfeeding only-0.13(-0.59, 0.33)Combined feeding methodDirect breastfeeding only-0.03(-0.77, 0.72)Combined feeding methodDirect breastfeeding only-0.03(-0.77, 0.72)Combined feeding methodDirect breastfeeding only-0.30(-0.77, 0.72)Combined feeding methodDirect breastfeeding only-0.03(-0.77, 0.72)Combined feeding methodDirect breastfeeding only0.03(-0.83, 0.88)Combined feeding methodDirect breastfeeding only0.03(-0.83, 0.88)Combined feeding methodDirect breastfeeding only1.95(0.04, 3.86)Sottle feeding methodDirect breastfeeding only1.92(0.18, 3.66)assification for breastmilk-onlyDirect breastfeeding only-0.09(-1.12, 0.94)Combined feeding methodDirect breastfeeding only1.00(0.10, 1.90)Combined feeding methodDirect breastfeeding only-0.09(-1.12, 0.94)Combined feeding methodDirect breastfeeding only1.03(0.68, 3.01)Bottle feeding methodDirect breastfeeding only	Comparator (type)Reference (type)DaytimeImage: transmission of the transmission of transm	Comparator (type)Reference (type)DaytimeNighttineFixed 895%Cl $p$ valueEventshodBottle feeding methodDirect breastfeeding only0.59(-0.90, 0.30)>0.999-0.39Combined feeding methodDirect breastfeeding only0.59(-0.29, 1.46)>0.9994.53Combined feeding methodDirect breastfeeding only0.13(-0.59, 0.33)>0.999-0.56Combined feeding methodDirect breastfeeding only-0.13(-0.59, 0.33)>0.999-0.56Combined feeding methodDirect breastfeeding only-0.03(-0.77, 0.72)>0.999-0.70Combined feeding methodDirect breastfeeding only-0.03(-0.77, 0.72)>0.999-0.70Combined feeding methodDirect breastfeeding only-0.03(-0.83, 0.88)>0.999-0.79Combined feeding methodDirect breastfeeding only1.75(0.36, 3.13)0.001**1.48Bottle feeding methodDirect breastfeeding only1.92(0.14, 3.86)0.03**-0.14Combined feeding methodDirect breastfeeding only1.92(0.18, 3.66)0.013**0.65Sification for breastmilk-onlyDirect breastfeeding only1.00(0.10, 1.90)0.012*6.51Combined feeding methodDirect breastfeeding only1.00(0.10, 1.90)0.012*6.51Combined feeding methodDirect breastfeeding only1.00(0.10, 1.90)0.012*6.51Combined feeding methodDirect	Comparator (type)Reference (type)DaytimeNighttimeFixed 395%Cl $p$ valueEvents95%ClEvents95%ClBottle feeding methodDirect breastfeeding only0.59(-0.29, 1.46)> 0.9994.53(-0.79, 9.85)Combined feeding methodDirect breastfeeding only0.59(-0.29, 1.46)> 0.9994.53(-0.79, 9.85)Combined feeding methodDirect breastfeeding only-0.13(-0.59, 0.33)> 0.999-0.56(-0.83, 0.04)Combined feeding methodDirect breastfeeding only1.33(0.64, 2.01)< 0.001**

Pairwise comparisons of the total frequency of feeding during the daytime and nighttime across age groups (6, 12, 18, and 24 months) and feeding types (*p* values and 95% confidence intervals were adjusted with Bonferroni correction across 48 pairwise comparisons), \**p* < 0.05, \*\**p* < 0.01

nature of bottle-feeding practices, which are shaped by various individual- and community-level determinants, such as maternal education, employment status, media exposure, access to breastfeeding counseling, and the frequency of healthcare visits [25, 26]. In Thailand, formal policies promoting breastfeeding have been implemented in both hospital and workplace settings [27]. However, there are no strict measures to discourage bottle feeding. Moreover, online platforms, particularly those featuring celebrities and public figures, frequently portray bottle feeding with expressed milk. Since these platforms serve as a primary source of child-feeding information for Thai parents [28], their widespread influence may shape parental perceptions and reinforce the belief that bottle feeding is the standard method.

The Ministry of Public Health in Thailand provides guidance for complementally fed children over 12 months of age and recommends milk intake twice daily along with three regular meals [4]. Nonetheless, our study revealed that children over 12 months of age were fed milk 4–5 times per day, exceeding these recommendations. For night feeding, bedtime milk feeding is generally discouraged after 12–15 months of age [4, 23]. However, in our study, the oldest age group (18–24 months) demonstrated an average of 1.5 night-time feedings per night. This frequency is significantly higher than the average nighttime waking frequency of 0.7 times per night reported in earlier systematic reviews that included studies from a global context [29]. The discrepancies between our results, established guidelines, and previous studies may stem from population-specific influences, including maternal education, postnatal care quality, and local sleep-related habits shaping parental choices [9, 10, 30, 31].

# Relationships between milk feeding type, method, and frequency

This study examined the associations of milk feeding type and feeding method with milk feeding frequency among complementary fed children. However, direct comparisons between our findings and existing data are challenging, as much of the earlier research focused primarily on infants under 12 months of age, assessed nighttime awakenings rather than feeding frequencies, and mainly categorized infants as breastfed or formula-fed, without separate analyses for groups with mixed feeding types

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or a focus on different feeding methods [16–20]. To our knowledge, this study is one of the first to explore these associations by distinctly analyzing milk feeding frequencies during different periods of the day, with a detailed consideration of feeding type and method in children aged 6–24 months. Our findings indicate that partial breast milk feeding and mixed feeding methods were generally associated with higher daytime and nighttime feeding frequencies than a single milk type or a single feeding method in both the overall and subgroup analyses. This trend may be attributed to the flexibility of using multiple feeding options, which could facilitate more frequent feeding opportunities in which different caregivers can be involved and may offer feedings at varying intervals.

Nighttime feeding involves specific findings that are not present during the day. Patterns across different types of milk feeding indicate that, in all age groups, children who were exclusively formula-fed had a lower frequency of nighttime feedings than those who were exclusively breastfed. This difference may be attributed to the higher casein content in formula milk than in breast milk, which slows digestion and prolongs satiety [32]. Additionally, breastfed infants tend to consume smaller volumes per feeding [33], potentially leading to more frequent feeding episodes than formula-fed infants do. Although the statistical analysis revealed significant differences between these groups, the actual numerical differences were minimal (2-3 feedings per night). While formula feeding may slightly reduce nighttime feedings, the practical implications for caregivers are likely negligible. Future research should explore whether these minor differences influence broader outcomes, such as sleep quality or maternal well-being. Similarly, when the nighttime feeding frequency was analyzed by the feeding method, children who were bottle-fed at 12, 18, and 24 months presented fewer nighttime feedings than those who were directly breastfed. This pattern may be attributed to the practical advantages of direct breastfeeding, such as eliminating the need for nighttime formula preparation, thereby simplifying the decision to feed during the night [2, 34]. Additionally, direct breastfeeding serves as a natural soothing mechanism for infants and promotes maternal relaxation, which may facilitate a quicker return to sleep for both mothers and children [35, 36]. These combined benefits may explain the lower frequency of nighttime feeding observed among children who were bottle-fed.

However, in the subgroup analysis of nighttime feedings, the frequency of feedings among infants in the bottle-feeding subgroup did not vary significantly by milk type, in contrast to the overall analysis. Similarly, within the exclusively breastfed subgroup, the method of milk delivery did not significantly affect the nighttime feeding frequency, except at 12 months, where combined feeding methods were associated with a significantly greater frequency of nighttime feeding. These results suggest that nighttime feeding frequency may not be solely influenced by the type of milk or the method of milk delivery. Further research is needed to explore additional factors that may contribute to nighttime feeding behaviors.

#### **Study limitations**

This study has several limitations. First, its cross-sectional design precludes the establishment of causal relationships between milk type, feeding method, and feeding frequency. Second, the use of the 24-hour recall method may introduce recall bias. To address this concern and enhance the accuracy of the data, only primary caregivers who were directly responsible for all the children's meals were included in the study.

#### Conclusion

This study revealed a high prevalence of formula feeding, bottle feeding, and frequent nighttime feeding among the participants. Children who continued breastfeeding until the age of two predominantly belonged to the direct breastfeeding-only group. The feeding types and methods exhibited distinct associations with the feeding frequency, with variations observed between the daytime and nighttime. Partial breastfeeding and combined feeding methods were associated with significantly higher feeding frequencies. In contrast, at night, children who were exclusively formula-fed or bottle-fed had fewer nighttime feedings than those who were exclusively breastfed or directly breastfed at 12, 18, and 24 months. However, subgroup analyses examining bottle feeding with varying milk types and breastfeeding with different feeding methods did not consistently yield statistically significant results for each subgroup. These findings suggest that feeding frequency may be influenced by multiple factors in addition to milk type and feeding method. Future research should explore the complexities of feeding practices during the complementary feeding period to develop more effective interventions that promote prolonged breastfeeding while reducing reliance on bottle feeding. Additionally, longitudinal studies are essential for assessing the long-term effects of different feeding practices on child and maternal health outcomes and well-being, providing a stronger evidence base for comprehensive feeding recommendations.

#### Abbreviations

GDP	Gross domestic product
IQRs	Interquartile Ranges
MCAR	Missing completely at random
SDs	Standard deviations
UNICEF	United Nations Children's Fund
WHO	World Health Organization

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#### Author contributions

OK conceptualized and designed the study, managed the study approvals, supervised the interviews, coordinated fieldwork management, drafted the initial manuscript, and contributed to the critical review and revision of the manuscript. CJ assisted in designing the web-based application for data recording, supervised the data management, and contributed to the sample analysis and manuscript revision. KW conducted the statistical analysis. SP critically reviewed and provided valuable feedback on the manuscript. All the authors have read and approved the final manuscript.

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#### Data availability

No datasets were generated or analysed during the current study.

#### Declarations

#### Ethics approval and consent to participate

Ethical approval was given on 14 June 2023 by the Research Ethics Committee of the Faculty of Medicine, Chiang Mai University (No. 186/2023). Written informed consent was obtained from all participants before their interviews.

#### **Consent for publication**

Not applicable.

#### **Competing interests**

The authors declare no competing interests.

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