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Original Research/Systematic Review

Storage and Thawing Practices of Expressed Breast Milk and Their Association with Growth in Infants Aged 0–6 Months

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ABSTRACT

***Background**: Expressed breast milk (EBM) is one of the most commonly used alternatives for breastfeeding among working mothers to ensure that infants continue to receive adequate nutrition. The quality of expressed breast milk is highly influenced by proper storage and thawing practices. Inappropriate handling during these processes may reduce nutritional content and increase the risk of contamination, potentially affecting infant growth.*

***Methods:** This study employed a quantitative cross-sectional design using a total sampling technique involving 391 respondents. Data were analyzed using univariate and bivariate analyses. The Chi-square test was applied to examine the relationships between EBM storage practices, EBM thawing practices, and infant growth.*

***Results:** Statistical analysis revealed a significant association between expressed breast milk storage practices and infant growth ($p < 0.001$). A significant association was also found between expressed breast milk thawing practices and infant growth ($p < 0.001$).*

***Conclusion:** Proper storage and thawing practices of expressed breast milk play an important role in supporting the growth of infants aged 0–6 months.*

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expressed breast milk, breast milk storage, breast milk thawing, infant growth, working mothers

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INTRODUCTION

Exclusive breastfeeding is defined as providing only breast milk to infants during the first six months of life and has been proven to meet infants' nutritional needs while supporting physical growth and brain development (World Health Organization (WHO, 2020; Pambudi et al., 2024). The Indonesian Ministry of Health recommends exclusive breastfeeding for the first six months of life, followed by continued breastfeeding alongside complementary feeding until two years of age, based on strong scientific evidence regarding the benefits of breast milk for infant health and growth (Kementerian Kesehatan Republik Indonesia (Kemenkes RI, 2022).

Exclusive breastfeeding plays a crucial role in supporting infant growth and development through its optimal composition of macro- and micronutrients. Breastfeeding exclusively for the first six months has been shown to prevent growth disorders such as stunting, whereas inadequate breastfeeding increases the risk of stunting, wasting, and underweight conditions that may have long-term consequences on child development and health outcomes (Chen et al., 2024; Kemenkes RI, 2022; UNICEF, 2021; Brockway et al., 2024).

Despite its benefits, achieving exclusive breastfeeding remains challenging, particularly among working mothers who often experience time constraints that limit direct breastfeeding. In Indonesia, female labor force participation reached 53.41% in 2024, while the rates in West Java Province and Depok City were 80.31% and 55.12%, respectively (Badan Pusat Statistik, 2024). As a result, many working mothers rely on expressed breast milk (EBM) as an alternative feeding method to maintain exclusive breastfeeding. However, inappropriate handling of expressed breast milk may compromise its nutritional quality and reduce the effectiveness of breastfeeding practices (Edemba et al., 2022; Pambudi et al., 2024).

Nationally, the exclusive breastfeeding coverage rate in Indonesia reached only 68.6% in 2023, remaining below the national target of 80% (Kemenkes RI, 2023). Although West Java has achieved the national target, variations in expressed breast milk management practices may still influence infant nutritional status and growth outcomes. This concern is reflected in the continued prevalence of childhood nutritional problems in Indonesia, including stunting, underweight, and wasting (Kemenkes RI, 2023; Syahri et al., 2024).

Proper management of expressed breast milk, particularly storage and thawing practices, is essential for maintaining its nutritional and immunological quality. Inappropriate thawing methods, such as using hot water or microwave heating, may damage nutrients and antibodies contained in breast milk. Similarly, improper storage practices related to storage containers, temperature, and duration may increase the risk of contamination and nutrient degradation (Edemba et al., 2022; Hernández-Olivas et al., 2023; Siviroj et al., 2024). These changes may reduce nutrient intake and subsequently affect infant health and growth outcomes (Liang et al., 2022; Stinson et al., 2024).

The importance of appropriate expressed breast milk management is consistent with Mercer's Becoming a Mother Theory, which emphasizes maternal adaptation in fulfilling infant needs through knowledge, attitudes, and caregiving skills (Mercer, 2004). Previous studies have demonstrated that educational interventions can significantly improve mothers' knowledge and practices regarding breast milk expression, storage, and thawing, thereby preserving the nutritional quality of breast milk provided to infants (Agustina & Noviasari, 2021; Putri et al., 2024). Preliminary observations conducted in Depok City indicated that expressed breast milk management practices among working mothers were still suboptimal.

Although previous studies have investigated breastfeeding practices and infant nutrition, limited evidence is available regarding the relationship between expressed breast milk storage and thawing practices and infant growth among working mothers in Indonesia. Therefore, this study aimed to analyze the association between expressed breast milk storage and thawing practices and the growth of infants aged 0–6 months among mothers living in Depok City, Indonesia. The findings of this study are expected to contribute to the development of evidence-based educational interventions and breastfeeding support programs to promote optimal infant growth and health.

MATERIALS AND METHOD

This study employed a correlational research design with a cross-sectional approach. The research was conducted between November and December 2024 in Depok City, Indonesia, and received ethical approval from Universitas Pembangunan Nasional "Veteran" Jakarta (Approval No. 330/XII/2025/KEP). The study population consisted of working mothers who provided expressed breast milk to their infants. A total of 391 respondents were selected using purposive sampling. Data were collected through an electronic questionnaire that included respondent characteristics, a breast milk storage practices questionnaire consisting of 13 true-false items (score range: 13–26), and a breast milk thawing practices questionnaire consisting of 14 true-false items (score range: 14–28).

Prior to data collection, all instruments underwent validity and reliability testing. The storage practices questionnaire demonstrated strong reliability with a Cronbach's alpha coefficient of 0.718, while the thawing practices questionnaire demonstrated strong reliability with a Cronbach's alpha coefficient of 0.726. Data were analyzed using univariate and bivariate statistical methods. The Chi-square test was employed to determine the relationships between expressed breast milk storage practices, thawing practices, and infant growth among infants aged 0–6 months.

RESULTS

Table 1. Characteristics of Mothers, Infants, Expressed Breast Milk Storage Practices, and Thawing Practices

Variables	Univariate Analysis Results
Maternal Characteristics	
Maternal Age (Median; SD; Range, years)	27.00; 2.511; 21–35
Educational Level, n (%)	
Senior High School/Vocational School	228 (58.3)
Diploma	67 (17.1)
Bachelor's Degree	96 (24.6)
Previous Experience Managing Expressed Breast Milk, n (%)	
Yes	84 (21.5)
No	307 (78.5)
Infant Characteristics	
Infant Age (Median; SD; Range, months)	4.00; 1.156; 1–6
Sex, n (%)	
Male	170 (43.5)
Female	221 (56.5)
Birth Status, n (%)	
Preterm	22 (5.6)
Full-term	369 (94.4)
Expressed Breast Milk Storage Practices, n (%)	
Appropriate	363 (92.8)
Inappropriate	28 (7.2)
Expressed Breast Milk Thawing Practices, n (%)	
Appropriate	350 (89.5)
Inappropriate	41 (10.5)

Table 1 presents the characteristics of the respondents and infants included in the study. The median maternal age was 27 years (range: 21–35 years). Most mothers had completed senior high school or vocational education (58.3%), and the majority had no prior experience managing expressed breast milk (78.5%). The median infant age was 4 months (range: 1–6 months). Most infants were female (56.5%) and born full-term (94.4%). Regarding expressed breast milk management practices, 92.8% of mothers reported appropriate storage practices, while 89.5% reported appropriate thawing practices.

Table 2. Association Between Expressed Breast Milk Storage Practices and Infant Growth

Storage Practices	Appropriate Growth n (%)	Inappropriate Growth n (%)	Total n (%)	p-value	OR (95% CI)
Appropriate	163 (44.9)	200 (55.1)	363 (100)		
Inappropriate	0 (0.0)	28 (100.0)	28 (100)	<0.001	0.551 (0.502–0.605)
Total	**163 (41.7)**	**228 (58.3)**	**391 (100)**		

Table 2 shows the association between expressed breast milk storage practices and infant growth among infants aged 0–6 months. Chi-square analysis revealed a statistically

significant association between storage practices and infant growth ($p < 0.001$). The odds ratio (OR = 0.551; 95% CI: 0.502–0.605) indicates that proper storage practices were significantly associated with infant growth outcomes. These findings suggest that maintaining appropriate storage conditions for expressed breast milk may help preserve its nutritional quality and support infant growth.

Table 3. Association Between Expressed Breast Milk Thawing Practices and Infant Growth

Thawing Practices	Appropriate Growth n (%)	Inappropriate Growth n (%)	Total n (%)	p-value	OR (95% CI)
Appropriate	161 (46.0)	189 (54.0)	350 (100)	<0.001	16.611 (3.950–69.863)
Inappropriate	2 (4.9)	39 (95.1)	41 (100)		
Total	**163 (41.7)**	**228 (58.3)**	**391 (100)**		

Table 3 presents the association between expressed breast milk thawing practices and infant growth. The Chi-square test demonstrated a statistically significant relationship between thawing practices and infant growth ($p < 0.001$). The odds ratio (OR = 16.611; 95% CI: 3.950–69.863) indicates that mothers who thawed expressed breast milk appropriately were approximately 16.6 times more likely to have infants with appropriate growth compared with mothers who used inappropriate thawing methods. These findings emphasize the importance of proper thawing techniques in maintaining the nutritional and bioactive components of expressed breast milk necessary for optimal infant growth.

DISCUSSION

Maternal Characteristics

The findings of this study showed that the median maternal age was 27 years, with an age range of 21–35 years, indicating that most respondents were within the productive reproductive age group. Women within this age range are generally considered to have greater physiological readiness and cognitive capacity to receive health information and implement appropriate infant feeding practices. Previous studies have reported that mothers aged 20–35 years are more likely to adopt recommended breastfeeding practices and demonstrate better compliance with guidelines regarding the expression, storage, and handling of breast milk. Furthermore, maternal age within the reproductive period has been associated with a lower risk of infant growth problems compared with younger or older maternal age groups (Mercer, 2004; Pambudi et al., 2024).

The majority of respondents had completed secondary or higher education. Educational attainment is recognized as an important determinant of maternal health behavior because it influences access to health information and the ability to understand breastfeeding recommendations. Laksono et al. (2021) reported that mothers with higher educational levels are more likely to achieve exclusive breastfeeding and adopt appropriate breastfeeding practices. Educated mothers are generally more aware of the importance of proper breast milk handling, including recommended storage temperatures, storage duration, and safe thawing techniques. Therefore, the educational profile of the participants in this study may have contributed to the high proportion of appropriate breast milk management practices observed among respondents.

Most mothers in this study had no previous experience managing expressed breast milk. Lack of prior experience may affect maternal confidence and competence in handling breast milk. However, evidence suggests that adequate education and support from healthcare professionals can compensate for limited experience and improve mothers' ability to manage expressed breast milk effectively (Agustina & Noviasari, 2021). This finding highlights the

importance of breastfeeding education programs, particularly for first-time mothers and working mothers who depend on expressed breast milk feeding.

Infant Characteristics

The median infant age was four months, indicating that most infants were still within the exclusive breastfeeding period. During the first six months of life, infants rely entirely on breast milk as their primary source of nutrition. According to WHO (2020), breast milk provides essential macronutrients, micronutrients, growth factors, and immunological components required for optimal growth and development. Therefore, maintaining the quality of expressed breast milk during storage and thawing is crucial for ensuring adequate nutrient intake among infants.

More than half of the infants in this study were female, while most were born at term. Previous studies have shown that infant sex is not a significant determinant of growth during the first six months of life when nutritional needs are adequately met through breastfeeding (Chen et al., 2024). Similarly, full-term infants generally demonstrate better feeding abilities and nutrient utilization than preterm infants, which may contribute to more favorable growth outcomes (Victora et al., cited in the article references). Nevertheless, proper management of expressed breast milk remains essential for both full-term and preterm infants to ensure nutritional adequacy and healthy growth.

Expressed Breast Milk Storage Practices

The present study found that most mothers practiced appropriate expressed breast milk storage. This finding suggests that respondents generally understood recommended storage procedures, including the use of suitable containers, adherence to storage duration guidelines, and maintenance of appropriate temperatures. Proper storage is essential because breast milk contains bioactive components that are sensitive to environmental conditions.

Research has demonstrated that inappropriate storage practices can lead to nutrient degradation and microbiological contamination. Hernández-Olivas et al. (2023) reported that refrigeration and freeze–thaw processes may affect the digestibility and bioavailability of nutrients in breast milk. Similarly, Siviroj et al. (2024) found that protein concentrations in breast milk may decrease during prolonged storage and warming processes. These changes may reduce the nutritional quality of breast milk and potentially affect infant growth.

The high prevalence of correct storage practices observed in this study may reflect increased awareness among working mothers regarding breast milk management. Educational interventions and support from healthcare professionals may have contributed to this positive outcome. Therefore, continuous education regarding safe breast milk storage remains necessary to ensure that mothers maintain optimal breastfeeding practices.

Expressed Breast Milk Thawing Practices

Most respondents reported appropriate thawing practices. Proper thawing methods are essential because breast milk contains heat-sensitive nutrients and immunological factors. Incorrect thawing methods, such as direct heating or microwave use, may destroy important bioactive compounds and reduce the protective benefits of breast milk. Stinson et al. (2024) demonstrated that different thawing and warming methods significantly affect breast milk composition.

Similarly, Liang et al. (2022) reported that freeze–thawing processes may alter the structural and functional properties of bioactive proteins in human milk. The WHO (2024) recommends gradual thawing under controlled temperatures to preserve the nutritional and immunological quality of expressed breast milk. The high proportion of mothers who applied appropriate thawing techniques may indicate effective dissemination of breastfeeding information through healthcare services and public health campaigns. However, the presence of mothers who still used inappropriate thawing methods suggests that ongoing education remains necessary.

Association Between Expressed Breast Milk Storage Practices and Infant Growth

This study identified a statistically significant association between expressed breast milk storage practices and infant growth ($p < 0.001$). The findings suggest that infants receiving breast milk stored according to recommended guidelines were more likely to experience appropriate growth than those receiving breast milk stored improperly. The relationship between storage practices and infant growth may be explained by the preservation of breast milk nutrients during proper storage. Breast milk contains proteins, fats, vitamins, and immunological factors that are essential for infant growth and development (Brockway et al., 2024). Improper storage conditions may accelerate nutrient degradation and increase contamination risk, potentially reducing nutrient availability to infants (Edemba et al., 2022; Hernández-Olivas et al., 2023).

Furthermore, research has shown that storage duration and temperature significantly influence protein stability and nutritional quality in human milk (Siviroj et al., 2024). Decreased nutrient concentrations may contribute to inadequate nutrient intake and suboptimal growth outcomes. Therefore, adherence to recommended storage guidelines is essential for preserving breast milk quality and supporting infant growth. Healthcare professionals, particularly nurses, play an important role in educating mothers regarding proper storage techniques, including container selection, temperature monitoring, and storage duration. Such interventions may contribute to improved breastfeeding practices and better infant growth outcomes.

Association Between Expressed Breast Milk Thawing Practices and Infant Growth

The present study also found a significant association between expressed breast milk thawing practices and infant growth ($p < 0.001$). Mothers who applied appropriate thawing methods were substantially more likely to have infants with appropriate growth than mothers who used incorrect thawing methods. This finding may be explained by the preservation of nutritional and immunological components during appropriate thawing. Human milk contains numerous bioactive compounds that are sensitive to temperature changes. Exposure to excessive heat during thawing may reduce the concentration of antibodies, enzymes, and other protective factors that contribute to infant health and growth (Liang et al., 2022; Stinson et al., 2024).

The WHO (2024) recommends gradual thawing and warming procedures to minimize nutrient loss and maintain the biological activity of breast milk components. Consistent with these recommendations, the current findings indicate that adherence to safe thawing practices may contribute to improved infant growth outcomes by preserving the nutritional integrity of expressed breast milk. The strong association observed in this study emphasizes the need for healthcare professionals to provide comprehensive breastfeeding education, particularly for working mothers who frequently rely on expressed breast milk feeding. Educational programs focusing on both storage and thawing practices may improve breastfeeding quality and support optimal infant growth during the first six months of life.

CONCLUSION

This study found that most mothers practiced appropriate expressed breast milk storage and thawing methods. Significant associations were identified between expressed breast milk storage practices and infant growth, as well as between expressed breast milk thawing practices and infant growth among infants aged 0–6 months. Proper storage and thawing practices help maintain the nutritional quality of expressed breast milk, thereby supporting optimal infant growth. Conversely, inappropriate breast milk management practices may reduce milk quality and contribute to suboptimal growth outcomes. These findings highlight the importance of health education and professional support, particularly from nurses, in promoting correct breast milk storage and thawing practices among breastfeeding mothers. Future studies are

recommended to use direct observational methods and investigate additional factors influencing infant growth, including maternal nutritional status, frequency of expressed breast milk feeding, complementary feeding practices, infant illness history, and family socioeconomic conditions.

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