RESEARCH ARTICLE **Open Access**

Gema Lingkungan Kesehatan
Vol. 24, No. 1 (2026), pp 12 - 18
e-ISSN 2407-8948 p-ISSN 16933761
doi: https://doi.org/10.36568/gelinkes.v24i1.394 *Journal Homepage: https://gelinkes.poltekkesdepkes-sby.ac.id/*

Factors Associated with Breast Milk Quality Related to Cigarette Smoke Exposure: A Cross Sectional Study in Balai Agung Health Center, Musi Banyuasin Regency

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The quality of breast milk is an important factor in supporting infant growth and health, but it can be influenced by environmental and behavioural factors, including exposure to cigarette smoke. This study aims to analyse the relationship between exposure to cigarette smoke, exposure to household cigarette smoke, and breastfeeding patterns with breast milk quality in breastfeeding mothers in the working area of the Balai Agung Community Health Centre, Musi Banyuasin Regency. This study used an analytical observational design with a cross-sectional approach involving 60 breastfeeding mothers of infants aged 0–6 months who were selected purposively. Data were collected through structured interviews and breast milk quality tests in the laboratory, then analysed descriptively and bivariately using statistical tests with a significance level of 5%. The results showed that the majority of respondents were exposed to cigarette smoke (63.3%) and lived with smokers at home (70.0%). Mothers exposed to cigarette smoke had a nine times greater risk of producing poor-quality breast milk compared to mothers who were not exposed (OR = 9.00; p = 0.002). Exposure to cigarette smoke in the household was also significantly associated with breast milk quality (OR = 6.00; p = 0.015). In addition, non-exclusive breastfeeding patterns increased the risk of poor-quality breast milk by more than five times (OR = 5.44; p = 0.004). This study concluded that exposure to cigarette smoke and breastfeeding patterns are important determinants of breast milk quality, so efforts to protect breastfeeding mothers from cigarette smoke and strengthen exclusive breastfeeding practices need to be prioritised in primary health care services.

Keywords: Breast milk quality, Exposure to cigarette smoke, Smoke-free households, Breastfeeding patterns, Breastfeeding mothers

INTRODUCTION

Breast milk is the gold standard of nutrition for infants because it provides nutrients, immunological components, and bioactive factors that play an important role in growth and protection against infectious and chronic diseases (Lokossou et al., 2022). Global evidence shows that breastfeeding contributes to reduced infant mortality, improved cognitive development, and protection against obesity and non-communicable diseases later in life (Weetman10 et al., 2021).

However, these benefits are highly dependent on the quality of breast milk, which is determined not only by its nutritional content but also by the integrity of bioactive components such as secretory immunoglobulin A, lactoferrin, and antioxidants (Macchi et al., 2021). The quality of breast milk is influenced by various maternal and environmental factors, including the mother's nutritional status, exposure to pollutants, and health behaviours during lactation. Recent studies show that environmental exposure, particularly air pollution and cigarette smoke, can alter the chemical and biological composition of breast milk (Thanhaeuser et al., 2022).

Such exposure has the potential to reduce the protective substances in breast milk and increase toxic contaminants, thereby affecting the biological value of breast milk as the best natural food for babies. Cigarette smoke contains more than 7,000 harmful chemicals, including nicotine, carbon monoxide, heavy metals, and carcinogenic compounds such as polycyclic aromatic hydrocarbons (PAHs) (Gupta & Qanungo, 2023). Nicotine is lipophilic and easily accumulates in breast milk, so babies can be exposed to it through breastfeeding(Coccia, 2021). Biomonitoring studies show that nicotine and its metabolite (cotinine) levels in breast milk are significantly higher in mothers who smoke or are exposed to second-

hand smoke than in mothers who are not exposed (Benowitz & Fraiman, 2017).

Exposure to cigarette smoke not only increases contaminants in breast milk, but also affects the physiological process of lactation. Nicotine is known to inhibit the secretion of prolactin and oxytocin, which play an important role in breast milk production and release, thereby reducing the volume and quality of breast milk (Benowitz & Fraiman, 2017).

In addition, exposure to cigarette smoke is associated with increased oxidative stress, which reduces the levels of antioxidants in breast milk, such as vitamins C and E, which are important in protecting babies from cell damage caused by free radicals(Belpoggi et al., 2021). Changes in breast milk quality due to exposure to cigarette smoke have direct implications for infant health. Infants exposed to nicotine through breast milk are reported to have a higher risk of respiratory disorders, recurrent infections, and sleep and metabolic regulation disorders (Martínez & Jensen, 2023). In developing countries, exposure to second-hand smoke in the home is the main source of exposure for breastfeeding mothers, especially in environments with a high prevalence of male smoking (Schønning et al., 2021).

Although international evidence shows that exposure to cigarette smoke affects breast milk quality, most studies focus on active smokers in developed countries and use varying indicators of breast milk quality. Contextual evidence on the impact of passive exposure to cigarette smoke at the household level on breast milk quality, particularly in primary health care settings in middle-income countries such as Indonesia, is still limited. Therefore, this study is important to fill this evidence gap and provide a strong scientific basis for strengthening promotional and preventive interventions in protecting breastfeeding mothers and infants from exposure to cigarette smoke.

METHOD

This study utilised an analytical observational design with a mixed-methods approach combining quantitative and qualitative methods. The quantitative approach was used to analyse the relationship between exposure to cigarette smoke and breast milk quality based on objectively measurable indicators, while the qualitative approach aimed to deepen understanding of the context of exposure to cigarette smoke in the household environment and breastfeeding practices among mothers during lactation. The use of this mixed approach was chosen to enhance the interpretive power of the results and provide a more comprehensive picture of the phenomenon under study.

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The study population included all breastfeeding mothers with infants aged 0–6 months residing in the working area of the Balai Agung Community Health Centre. The study sample was determined using purposive sampling techniques, taking into account the suitability of respondents for the study objectives. Participating breastfeeding mothers were those who were willing to follow all research procedures and did not have certain medical conditions that could affect breast milk production or composition. The sample size was determined based on the calculation of the minimum sample size required for multivariate analysis with a 95% confidence level and adequate test power.

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Quantitative data collection was conducted through interviews using structured questionnaires and breast milk sampling using standard sterile procedures. The collected breast milk samples were then analysed in an accredited laboratory to determine breast milk quality parameters in accordance with predetermined indicators. To complement the quantitative data, qualitative data was collected through structured interviews with selected respondents to explore in depth the mothers' experiences related to exposure to cigarette smoke, perceptions of health risks, and breastfeeding practices in the family environment.

Quantitative data analysis was conducted in stages, beginning with descriptive analysis to describe the characteristics of respondents and the distribution of research variables. Next, bivariate analysis was performed to assess the relationship between exposure to cigarette smoke and breast milk quality. To control for confounding variables, multivariate analysis with logistic regression was used, and the results were presented in the form of odds ratios with 95% confidence intervals. P-values less than 0.05 were considered statistically significant. Qualitative data were analysed using a thematic analysis approach through a process of coding and grouping themes, which were used to strengthen and enrich the interpretation of quantitative findings.

This study has obtained ethical approval from the Medical and Health Research Ethics Committee of the Faculty of Medicine, Sriwijaya University, with letter number: 137-2022. All respondents were provided with a comprehensive explanation of the purpose, procedures, benefits, and potential risks of the research before signing the written consent form (informed consent). The confidentiality and anonymity of respondents' data were fully maintained in accordance with the principles of health research ethics.

RESULTS AND DISCUSSION

Characteristics of Exposure and Quality of Respondents' Breast Milk

A total of 60 breastfeeding mothers participated in this study. More than half of the respondents were exposed to cigarette smoke, either directly or indirectly. In addition, the proportion of mothers with poor breast milk quality was still relatively high. The distribution of cigarette smoke exposure, breastfeeding patterns, and breast milk quality are presented in Table 1.

Table 1.
Distribution of Exposure to Cigarette Smoke, Breastfeeding Patterns, and Breast Milk Quality (n = 60)

Variable	n	%
Exposure to cigarette smoke		
Exposed	38	63.3
Not exposed	22	36.7
Exposure to cigarette smoke in the home		
There are smokers in the house.	42	70.0
No smoking	18	30.0
Breastfeeding patterns		
Exclusive	34	56.7
Not exclusive	26	43.3
Quality of breast milk		
Baik	40	66.7
Less	20	33.3

Based on Table 1, most breastfeeding mothers in this study were exposed to cigarette smoke (63.3%), and the majority of respondents lived in homes with family members who smoked (70.0%). These findings indicate that exposure to cigarette smoke in the household environment is a dominant condition among breastfeeding mothers in the working area of the Balai Agung Community Health Centre.

In terms of breastfeeding practices, more than half of respondents had implemented exclusive breastfeeding (56.7%)**.** However, 33.3% of mothers had poor breast milk quality**,** indicating that breast milk quality is not only influenced by breastfeeding patterns, but also by environmental factors, particularly exposure to cigarette smoke. This distribution provides an initial picture that exposure to cigarette smoke and breast milk quality are relevant health issues that need to be analysed further.

The Relationship Between Exposure to Cigarette Smoke and Breast Milk Quality

Table 2 shows the relationship between exposure to cigarette smoke and breast milk quality. Breastfeeding mothers exposed to cigarette smoke had a significantly higher proportion of poor-quality breast milk compared to mothers who were not exposed. The analysis showed a statistically significant relationship.

Table 2.
Relationship between Exposure to Cigarette Smoke and Breast Milk Quality (n = 60)

Exposure to Cigarette Smoke	Good breast milk quality n (%)	Poor breast milk quality n (%)	Total n (%)	p-value	OR (crude)
Exposed	20 (52.6)	18 (47.4)	38 (63.3)	0.002	9.00
Not exposed	20 (90.9)	2 (9.1)	22 (36.7)		
Total	40 (66.7)	20 (33.3)	60 (100)		

The results of the analysis in Table 2 show that breastfeeding mothers exposed to cigarette smoke had a significantly higher proportion of poor-quality breast milk (47.4%) compared to mothers who were not exposed (9.1%). This difference was found to be statistically significant (p = 0.002)**.**

The odds ratio (OR = 9.00) indicates that mothers exposed to cigarette smoke have a nine times greater risk of producing poor quality breast milk compared to mothers who are not exposed. These findings confirm that exposure to cigarette smoke is a dominant risk factor strongly associated with a decline in breast milk quality.

The Relationship between Exposure to Household Tobacco Smoke and Breast Milk Quality

Table 3 shows that the presence of smokers in the home is significantly associated with breast milk quality. Mothers who live with smokers have a higher risk of producing poor-quality breast milk than mothers who live in smoke-free homes.

Table 3.
Relationship between Exposure to Household Tobacco Smoke and Breast Milk Quality (n = 60)

Exposure to Household Cigarette Smoke	Good breast milk quality n (%)	Poor breast milk quality n (%)	Total n (%)	p-value	OR (crude)
There are smokers in the house.	24 (57.1)	18 (42.9)	42 (70.0)	0,015	6,00
No smoking	16 (88.9)	2 (11.1)	18 (30.0)		
Total	40 (66.7)	20 (33.3)	60 (100)		

As shown in Table 3, the presence of smokers in the home is significantly associated with breast milk quality. Mothers who live with smokers show a proportion of poor-quality breast milk of 42.9%, which is much higher than mothers who live in homes without smokers (11.1%).

This relationship was statistically significant (p = 0.015) with an OR = 6.00**,** meaning that mothers living in households with smokers had a six times greater risk of producing poor quality breast milk. These findings confirm that passive exposure in the home environment is an important determinant of breast milk quality, even when mothers do not actively smoke.

The Relationship Between Breastfeeding Patterns and Breast Milk Quality

Table 4 shows that breastfeeding patterns have a significant relationship with breast milk quality. Mothers who exclusively breastfeed tend to produce good quality breast milk, while mothers with non-exclusive breastfeeding patterns have a higher proportion of poor quality breast milk.

Table 4.
Relationship between Breastfeeding Patterns and Breast Milk Quality (n = 60)

Breastfeeding Patterns	Good breast milk quality n (%)	Poor breast milk quality n (%)	Total n (%)	p-value	OR (crude)
Exclusive	28 (82.4)	6 (17.6)	34 (56.7)	0.004	5.44
Non-exclusive	12 (46.2)	14 (53.8)	26 (43.3)		
Total	40 (66.7)	20 (33.3)	60 (100)		

Based on Table 4, breastfeeding patterns show a significant relationship with breast milk quality (p = 0.004). Mothers who practised exclusive breastfeeding predominantly produced good quality breast milk (82.4%), whereas among mothers who practised non-exclusive breastfeeding, the proportion of poor quality breast milk was higher (53.8%).

An OR value of 5.44 indicates that mothers with non-exclusive breastfeeding patterns have more than five times the risk of producing poor quality breast milk compared to mothers who breastfeed exclusively. These findings confirm that exclusive breastfeeding is a dominant protective factor in maintaining breast milk quality, even in the face of adverse environmental exposures.

This study shows that exposure to cigarette smoke, exposure to cigarette smoke in the household, and breastfeeding patterns have a significant relationship with the quality of breast milk in breastfeeding mothers in the working area of the Balai Agung Community Health Centre, Musi Banyuasin Regency. These findings confirm that breast milk quality is not only influenced by the mother's biological factors, but also by complex environmental and behavioural determinants, particularly the high level of exposure to tobacco smoke at the household level. These results are consistent with international evidence stating that exposure to active and passive tobacco smoke can affect the composition, safety, and biological function of breast milk(Ye et al., 2023). The significant association between exposure to cigarette smoke and breast milk quality in this study reinforces previous findings showing that toxic substances in cigarette smoke can be transferred into breast milk. Nicotine and its main metabolite, cotinine, are lipophilic and therefore easily accumulate in breast tissue and are excreted into breast milk. A biomonitoring study by(Hori et al., 2021). in *Science of the Total Environment* shows that cotinine concentrations in breast milk increase significantly with the intensity of exposure to cigarette smoke, both in active smokers and mothers exposed to passive smoking(Coccia, 2021). This exposure has the potential to reduce breast milk quality through hormonal and metabolic mechanisms.

Physiologically, nicotine is known to affect the neuroendocrine system by increasing dopaminergic activity, which inhibits the secretion of prolactin, the main hormone involved in breast milk production. A decrease in prolactin can reduce the volume and consistency of breast milk production, thereby affecting the overall quality of breast milk(Benowitz & Fraiman, 2017). In addition, nicotine can also inhibit the release of oxytocin, which plays a role in the milk ejection reflex, so that babies do not receive optimal breast milk even if they are breastfed frequently (He et al., 2019).

The results of this study also show that exposure to cigarette smoke at the household level has a significant relationship with breast milk quality. This finding is important because it highlights the role of passive exposure as a major determinant that is often overlooked. Cross-country studies show that breastfeeding mothers who live with family members who smoke have higher levels of nicotine and cotinine in their breast milk than mothers who live in smoke-free environments (He et al., 2019). Hal This is relevant to the Indonesian context, where the prevalence of smoking among adult men is very high, making mothers and babies vulnerable to exposure to second-hand smoke (Nadhiroh et al., 2020).

Exposure to cigarette smoke in the home is also associated with increased oxidative stress in breastfeeding mothers. Cigarette smoke contains free radicals and pro-oxidant compounds that can increase lipid peroxidation and decrease the body's antioxidant capacity (Rahman et al., 2021). reported that exposure to cigarette smoke increases oxidative stress biomarkers and decreases antioxidant vitamin levels in breast milk, such as vitamins C and E (Belpoggi et al., 2021). This decrease in antioxidants can reduce breast milk's ability to protect babies from cell damage and infection. In addition to nutritional effects, exposure to cigarette smoke also affects the immunological components of breast milk (Macchi et al., 2021). Breast milk is rich in immunological factors such as secretory immunoglobulin A (sIgA), lactoferrin, and lysozyme, which play a role in protecting babies against gastrointestinal and respiratory infections (Ariwidiani, 2025). Research shows that mothers exposed to cigarette smoke have lower levels of sIgA and lactoferrin in their breast milk than mothers who are not exposed (Nguyen et al., 2020). This decrease in immunological factors has the potential to increase infants' susceptibility to infectious diseases, especially in the early period of life when the infant's immune system is not yet mature.

Another important finding in this study was the role of breastfeeding patterns as the strongest determinant of breast milk quality. Mothers who practised exclusive breastfeeding had a higher proportion of good breast milk quality compared to mothers with non-exclusive breastfeeding patterns (Muluneh, 2023). These results are consistent with the literature, which states that exclusive breastfeeding supports the stability of breast milk composition, increases breast milk production, and maintains the balance of nutritional and immunological components (Victora et al., 2021). Exclusive breastfeeding patterns are also associated with more optimal breastfeeding frequency and duration, which physiologically stimulate milk production through a positive feedback mechanism between the baby's suckling and the secretion of the hormones prolactin and oxytocin. A study by (Morrow-Howell et al., 2017). emphasises that consistent and exclusive breastfeeding plays an important role in maintaining the quality and quantity of breast milk. In the context of exposure to cigarette smoke, exclusive breastfeeding can act as a partial protective factor by increasing lactation efficiency and maintaining breast milk composition (Nakijoba et al., 2025). From a broader environmental perspective, the results of this study also need to be understood in the context of exposure to non-tobacco air pollution. The South Sumatra region, including Musi Banyuasin, periodically experiences forest and land fires that produce fine particulates and harmful aromatic compounds (Bramante et al., 2023). reported that environmental pollutants such as PM2.5 and PAHs can be detected in breast milk and potentially affect its quality (Bramante et al., 2023). This condition indicates that breastfeeding mothers in the region face multiple exposures that can have a cumulative effect on breast milk quality.

The results of this study are consistent with studies Fernández-Cao et al. (2022) which emphasises that breast milk quality is a reflection of the complex interaction between maternal diet, environmental exposure and maternal health status(Thanhaeuser et al., 2022). Therefore, interventions to improve breast milk quality

cannot focus on just one factor, but must include a holistic approach that involves controlling exposure to cigarette smoke, increasing support for exclusive breastfeeding, and improving the home environment.

From a public health perspective, the findings of this study have important implications for strengthening promotional and preventive programmes at the primary health care level. Community health centres play a strategic role in providing education about the dangers of cigarette smoke to breastfeeding mothers and infants, as well as in encouraging the implementation of smoke-free homes. Studies show that family- and community-based interventions are more effective in reducing exposure to second-hand smoke than individual approaches alone (Thanhaeuser et al., 2022).

In addition, integrating smoking cessation counselling with maternal and child health programmes can provide dual benefits, namely protecting breastfeeding mothers and improving the health of all family members(Benowitz & Fraiman, 2017). emphasises that primary health care-based smoking cessation interventions are effective when accompanied by family and community support (*Nature Reviews Cardiology*). In this context, the involvement of husbands and other family members is key to the success of efforts to control exposure to tobacco smoke.

The limitations of this study should be considered when interpreting the results. The cross-sectional design does not allow for direct causal conclusions, and the relatively small sample size may affect the generalisability of the results. However, the use of a mixed-methods approach and data triangulation strengthens the validity of the findings and provides a rich contextual picture of the conditions of breastfeeding mothers in the study area. Further research is recommended using a longitudinal design and broader biomarker measurements to evaluate the long-term impact of exposure to cigarette smoke on breast milk quality and infant health

CONCLUSION

This study demonstrates that cigarette smoke exposure is significantly associated with reduced breast milk quality among breastfeeding mothers in the working area of the Balai Agung Health Center, Musi Banyuasin Regency. Both direct exposure and household smoking were shown to negatively affect breast milk quality, highlighting the critical role of the domestic environment in maternal and infant health.

Among the factors examined, breastfeeding patterns emerged as the strongest determinant of breast milk quality. Mothers who practiced exclusive breastfeeding were significantly more likely to produce good-quality breast milk compared to those who did not, even in the presence of environmental risk factors. This finding underscores the protective role of exclusive breastfeeding against adverse environmental exposures.

These results emphasize the importance of integrating smoke-free home promotion with breastfeeding support programs at the primary healthcare level. Strengthening family involvement, particularly in reducing household smoking behaviors, alongside sustained education on exclusive breastfeeding, is essential to protect breast milk quality and optimize infant health outcomes.

RECOMMENDATIONS

Public health policies should prioritize the protection of breastfeeding mothers and infants from cigarette smoke exposure by strengthening the implementation of smoke-free home initiatives and enforcing smoke-free regulations at the community level. Primary health centers are encouraged to integrate routine counseling on smoking cessation for family members with breastfeeding education and maternal nutrition programs, ensuring that exclusive breastfeeding is consistently promoted as a protective factor for breast milk quality. In addition, collaboration between health authorities, local governments, and community leaders is essential to improve compliance with smoke-free policies and to support sustainable behavior change. Regular monitoring of breastfeeding practices and environmental smoke exposure at the primary care level is recommended to inform evidence-based interventions aimed at safeguarding breast milk quality and infant health.

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