

Effects of maternal tobacco smoking on breast milk composition and infant development: a literature review

Abstract

Several research studies highlight the importance of breastfeeding. Breast milk is a necessary nutrient for infants as it provides everything they need during the most vulnerable stage of their lives. It contains antibodies that protect newborn babies against viruses, bacteria, and various kinds of illnesses that their undeveloped immune constitution cannot fight alone. Mothers are also encouraged to live a healthy lifestyle in order to produce good quality milk; they are advised to eat healthily to improve their ability to lactate properly. Thus, it is suggested that engaging in hazardous vices, mainly smoking, during the nursing period, may adversely impact upon the yield of breast milk and will lead to an unhealthy reaction in the infants. It is reported by the Centers for Disease Control and Prevention's National Center of Health Statistics, that about 12% of women actively smoke during pregnancy, and that some of them try to quit unsuccessfully. Many women relapse back to their smoking habits, which causes drastic alterations to the composition of breast milk (2018). Smoking tobacco does not only attenuate the protective properties of breast milk, but also affects the baby's well-being. The specific pathophysiological mechanisms which underpin these adverse effects are still nebulous and warrant further research in the field. This literature review is a narrative synthesis of previous studies which were primarily scoped to the deleterious effects of tobacco on breast milk composition, the mother's lactating process, and the development of the infant. A comprehensive search of the up-to-date, evidence-based literature was performed, and a meta-analysis of the results was conducted to come up with an appropriate conclusion. Previous studies have suggested that nicotine alters the quality of breast milk, and although the results are generally inconclusive, there are also recurrent themes which have emerged from these studies: nicotine smoking while breastfeeding can cause lactation issues among mothers, and the nicotine transferred through breast milk leads to a disruption in infants' sleeping patterns. Previous studies have shown that breastfeeding mothers who smoke tobacco have increased levels of nicotine in their milk. The milk concentration of nicotine is three times higher than non-smokers plasma concentration. Also, the quantity of breast milk produced is less, and the lactation period is much shorter than usual. Smoking is very hazardous and dangerous to an infant's health. It changes not only the milk's taste but also its composition by reducing the essential protective properties required for the survival of the baby. It also affects how the infant responds to breastfeeding. It is advisable for breastfeeding mothers to abstain from nicotine smoking for the safety and overall wellbeing of their child.

Keywords: breast milk, smoking, pregnancy, nicotine, regular cigarette smokers, tobacco, mothers

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The effects of nicotine in breast milk

According to the World Health Organization,¹ tobacco smoking is responsible for more than seven million deaths per year, six million of which are the result of direct smoking, while nearly a million are through second-hand smoke. Tobacco smoking represents a significant threat to public health, and has been acknowledged as an epidemic mainly because non-smokers are also at risk. Approximately, 250 million women smoke daily, and although more than half of this number succeed in quitting during pregnancy, at least 50- 80% experience a relapse during the first six postnatal months.² The hazardous effects of nicotine are conferred upon the infant through passive smoking as well as breastfeeding. The direct and passive dangers of cigarette smoke cannot be overstated; indeed, it is a deadly combination of over five thousand and three hundred harmful compounds. Second-hand smoke is a combination of the combusting tobacco mixed with the smoke that is exhaled by the user. This mixture is comprised of

a plethora of harmful compounds such as hydrocarbon, ethers, nitro compounds, nitrites, anhydrides, amides, nitrogen oxides, alcohols, phenols, esters, amines, N-nitrosamines, amides, imides, lactams, lactones, aldehydes, carboxylic acids, ketones, N-heterocyclics, carbohydrates, and metals.³ However, the most critical element in tobacco smoke is nicotine due to its highly addictive properties.⁴ There are over seventy different carcinogens located in tobacco smoke, and many have yet to be assessed by the IARC (International Agency for Research on Cancer) Monographs program. All these toxic chemicals were identified to cause cancer in the human body.⁵

Even though several reports have unearthed the damaging effects of tobacco smoking on the fetus and newborn babies, numerous mothers consistently smoke during pregnancy and especially while breastfeeding. Smoking mothers typically started smoking at a younger age, are less educated and have a generally lower socioeconomic status. They are unaware of the destructive effects

of tobacco smoke on their developing child. The Centers for Disease Control and Prevention⁶ reported that smoking during pregnancy results in low birth weight, premature infants, fetal developmental problems, and a high risk of pregnancy-related complications such as placental abruption. Mothers are encouraged to exclusively breastfeed their infants for the first six months which helps to protect them against acute and chronic disorders and spare them from a higher risk of diarrheal illness and pneumonia and is considered superior to any other type of formula.⁷ According to the 2008 official statement from the American Academy of Pediatrics, exclusive breastfeeding for at least four months compared with feeding intact cow milk protein formula decreases the cumulative incidence of atopic dermatitis and cow milk allergy in the first two years of life.⁸ Despite the importance of breastfeeding however, many mothers stop as early as three months. This underscores the importance of continuously promoting breastfeeding as every mother's public health responsibility as well as strictly recommending it across health centers.⁹

Methods

This literature review employed a narrative synthesis approach regarding the influence of tobacco smoking on the process of lactation, the composition of breast milk, and the development of the newborn. The strategy was to utilize the categorized narrative review of the literature to allow access to high-quality results for discussion. A comprehensive search for articles published only in the English language was conducted on PubMed, MEDLINE, and Science Direct databases. To ensure quality data, the research articles reviewed had to meet specific inclusion and exclusion criteria which included: a peer-reviewed research article, publications not more than twenty years old, published in the English language, name of the authors indicated, a topic relevant to the study and must have been from the above-stated search engines. It is noteworthy to emphasize that there are limited published pieces of evidence on this matter. A total of 62 eligible studies were screened, 36 of which met the inclusion criteria.

Discussion

I. 1. Levels of nicotine and cotinine metabolite in breast milk of regular smokers

Studies have shown that when mothers breastfeed and smoke simultaneously, the fetus absorbs high amounts of nicotine compared to tobacco smoke exposure from the environment.¹⁰ A study by Calvares demonstrates that nicotine has a longer half-life in milk than serum (2016). When teratogen is consumed via breastfeeding, it is absorbed by the baby's liver and converted into cotinine, a major metabolite that has a much longer half-life (20hrs) than nicotine (2hrs). Hence, nicotine and cotinine are both present in the baby's blood and can cause an elevated fetal heart rate.¹¹ Also, the elimination of nicotine and cotinine in babies takes four times longer than in adults.¹² Studies have also shown that the breastfed infant population of tobacco smoking moms have cotinine in the baby's urine. The cotinine levels are ten times higher in those babies compared to babies that are formula-fed and exposed to passive smoke exposure from the environment.¹³

An experimental study conducted by Melena & Yourshaw, & Morgan¹⁴ established evidence that nicotine is not stored in the breast milk of smokers; instead, cotinine is. Cotinine stays in the mother's breast milk due to its longer-half life, but nicotine quickly disappears. After smoking one cigarette, the nicotine started disappearing quickly from the mother's breast milk and reached a peak concentration at

about 30 to 60 minutes after smoking. Contrary to nicotine, cotinine was still seen in the mother's breast milk after 12 hours from refraining from smoking. Usually, regular cigarette smokers are not satisfied with just one cigarette. So, cotinine builds up and peaks in the mother's breast milk. Maternal regular smokers may build up enough residual cotinine over time, leading to consistently elevated levels of cotinine, even when they consume a low number of cigarette.¹³

I. 2. Tobacco smoke and its adverse effects on lactation

Mothers who smoke are observed to produce a decreased quantity of milk, often with shorter lactation periods.¹⁵ Moreover, because of the difficulty in quitting cigarettes, these mothers decide to wean their infants sooner, thereby increasing the risk of mastitis, amongst other problems.¹⁶ Lactating mastitis is characterized by inflammation of the mammary gland that is commonly seen in women who wean their infants too soon. The milk starts accumulating and stops flowing due to an infection usually caused by *Staphylococcus aureus* and *Staphylococcus albus*.¹⁷ Nicotine intake also affects women's hormonal levels, which is often associated with diminished lactation. Also, this teratogen in mother's blood significantly affects the prolactin level – the hormone responsible for stimulating the healthy growth of mammary glands.¹⁸ Smoking women have also been shown to have high amounts of somatostatin levels immediately after breastfeeding, in contrast to non-smokers. Sachs, in an experiment (2013) explored the effects of epinephrine upon the mammary glands. He speculated that epinephrine affects the mammary glands by depleting the amount of circulating oxytocin, making it problematic to release the milk from the breast of mothers who smoke.

I. 3. Alterations seen in the composition of breast milk and taste due to tobacco usage

When the mother smokes, so does the child. The breast milk of smoking mothers is flavored with tobacco, resulting in the effects of nicotine on the developing brain. This exposes the baby to flavors that seem desirable early on in life. Research proves that babies and infants develop taste and preferences according to the taste they experienced through breastfeeding.¹³ Mothers who smoke during the prenatal period give birth to newborn babies with lower birth weights by 150-250 g in contrast to babies of non-smokers.¹⁹ This may be due to the lower amount of lipid content demonstrated in the breast milk of smoking women. The breast milk of smoking mothers has also been shown to have about 23% lower lipid content, compared to that of non-smoking mothers.²⁰ Furthermore, decreased amounts of omega-3 fatty acids have been observed in the breast milk of women who smoke. The harmful nicotine teratogen is passed on to the baby through the mother's milk and reduces the baby's appetite, resulting in the baby's unwillingness to feed.¹⁴ A study conducted by Winiarska-Mieczan²¹ discovered that smoking confers a higher concentration of heavy metals in breast milk, especially the classified Group 1 carcinogen cadmium. This metal is very toxic and dysregulates the metabolism of magnesium, iron, copper, zinc, and selenium. These microelements are crucial for fetal and infant development.²² There is also a reduction of iodine content seen in smoking mother's breast milk. This deficiency of iodine in fetal and infant development is linked to brain damage, declined motor function, and very low cognitive functionality.²³ Evidence also suggests that there is an overall decrease in the levels of cytokines, notably - Tumor Necrosis Factor Alpha (TNF- α), in the breast milk of smoking women. TNF is essential for babies and adults since it helps against trauma and infections.²⁴ Researchers have illustrated that the use of tobacco during breastfeeding alters the milk composition and attenuates its protective properties against infections

as well as its role in stimulating the full potential development of the infant. Regardless, breast milk of a nicotine user is preferred over formula milk since the harmful effects of exposure to nicotine are outweighed by numerous benefits of breastfeeding.²⁵ As stated by the American Academy of Pediatrics²⁶ women who continue breastfeeding even though they are not able to quit smoking, show a lower predilection for respiratory illnesses, compared to those who smoke and bottle feed their infant.

I. 4. Infant development disturbed by tobacco exposure through breast milk

Maternal tobacco smoke exposes the baby to problems such as respiratory tract infections and otitis media. Nicotine found in breast milk increases the infant's blood pressure and may predispose to development of hypertension and cardiovascular disease in later life. Nicotine exposure also exhibits cardiac arrhythmias, such as bradycardia and tachycardia, and also cardiac cycle irregularity.² There is also a worrisome association between maternal smoking during pregnancy and breastfeeding, and a higher risk of early age leukemia (EAL).²⁷ Also, infants of mothers who smoke during breastfeeding are at 50% higher risk of infantile colic.² One particularly notable change was of the infants' sleeping pattern. Sleep is the most persistent activity among infants in the first few months of their lives, as it plays a significant role in their mental and physical development. After their mothers' recent nicotine intake through cigarette smoking, they spend less time sleeping during the period after they were breastfed. The time they spend on sleeping appears to be longer and better during the days when the mothers temporarily abstain from smoking. It was suggested that the higher the dose of nicotine transferred to the infant, the more significant sleep disruption the baby is likely to experience.²⁸ The higher the nicotine dose supplied to the infant through the breast milk, the less time the infant spends actively sleeping compared to infants of non-smokers.²⁹ The PGO waves (ponto-geniculo-occipital), elements that are central to active sleep maintenance, are directly overpowered by nicotine – which is why an individual's sleeping pattern, be it an infant or an adult, is altered.²⁸

Breastfeeding can reduce the risk of respiratory tract infections in infants, such as asthma and wheezing, but this reduction is lost when the mother smokes tobacco and breastfeeds.^{5,29} A study conducted by Stepan and Wilkerson documented evidence of mothers who smoked and breastfed their infants; the infants displayed a lower respiratory rate after feeding. Furthermore, the exposure to tobacco smoke through breast milk inhibits proper lung development and alters the lung structure.³⁰ There are also concerns of a higher incidence of Sudden Infant Death Syndrome (SIDS), as “maternal smoking accounts for more than 100,000 fetal and perinatal death” in the United States.¹⁴ Nicotine exposure appears to be the second most remarkable factor parents need to consider for possible SIDS, after sleeping positions.³¹ Breastfeeding is essential for newborns since it has been shown to protect the babies from (SIDS). Despite this, if the mother is a smoker, then this protection is lost. Mothers who smoke and breastfeed expose their babies to huge risks such as SIDS.^{14,30,32} Breastfeeding also reduces the risk of problems that manifest in later life, such as obesity, glucose intolerance, coronary heart disease, and diabetes mellitus. Maternal smoking during breastfeeding exposes the infant to metabolic complications in which manifest in adult life.³³ Furthermore, tobacco smoke exposure through breast milk affects the development of an infant's brain, which may cause learning deficits that persist through adulthood. The child demonstrates memory

deficits and difficulty in learning and memorizing information. During adolescence, the child exhibits signs of long-term memory loss.^{13,34}

Conclusion

Smoking tobacco is very harmful to the fetus and the developing infant. United States birth statistics from 2002 reveal that 10% of complicated births were premature, 20% were characterized by low birth weights, 8% resulted in preterm infant deaths, and 35% were attributable to SIDS caused by maternal smoking.³⁵ Evidence suggests that tobacco smoking during breastfeeding is linked with a disrupted infantile sleeping pattern, reduced breast milk production and an overall shorter lactation period. Breastfeeding is highly recommended for infants due to the benefits of mitigating risk factors for metabolic disorders, cardiac rhythm disorders, otitis media, respiratory infections, anemia, digestive disorders, and SIDS. In contrast, when the mother smokes and breastfeeds, the milk loses many of its beneficial properties and exposes the infant to the aforementioned complications. The infant is also at high risk of colic, early age leukemia, sleep disorders, and smoking later in life because of the exposure to tobacco taste through breast milk. Regardless, breast milk of mothers who smoke is highly recommended over formula milk due to the benefits of the milk. All mothers are advised to feed their babies with breast milk for a minimum of 6 months after birth and to continue longer than a year if possible, so that the infant can take advantage of all the nutrients for their future development. Mothers who struggle with smoking cessation should try having longer intervals between breastfeeding and smoking since nicotine does not stay in the breast milk after 2hrs, but its metabolite cotinine does (>12hrs). Further research is required to determine the effects cotinine has prenatally and postnatally. Mothers who smoke are highly cautioned to be careful with tobacco use during pregnancy and breastfeeding.

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Conflicts of interest

Authors declare that there is no conflict of interest.

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