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The Effect of Watching Infant Video With or Without Smelling an Infant-Scented Hat With Infant Scent on Anxiety, Milk Volume, Stress, and Attachment in Mothers of Hospitalized Infants in the Neonatal Intensive Care Unit: A Randomized Controlled Trial

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ABSTRACT

Background and Aims: An infant's unique scent can significantly foster a deep emotional connection between mother and baby. This study aimed to determine the effect of watching infant video with or without smelling an infant-scented hat on anxiety and breast milk volume (primary outcomes), stress and mother-infant attachment (secondary outcomes) in mothers with hospitalized infants in the neonatal intensive care unit (NICU).

Methods: In this randomized controlled trial, 78 mothers were allocated to three groups using block randomization: intervention group 1 (infant-scented hat plus video), intervention group 2 (video only), and a control group (plain hat). The intervention lasted 5 days. All mothers received training on breast pumping and recording their milk volume. Data were analyzed using analysis of covariance.

Results: Compared with the control group, both interventions led to significant improvements in state anxiety (Group 1: adjusted mean difference [AMD] = −16.40, 95%CI: −24.56 to −8.24, $p < 0.001$; Group 2: AMD = −13.83, 95%CI: −21.26 to −6.40, $p < 0.001$), trait anxiety (Group 1: AMD = −11.54, 95%CI: −16.29 to −6.80, $p < 0.001$; Group 2: AMD = −11.57, 95%CI: −15.87 to −7.26, $p < 0.001$), and perceived stress (Group 1: AMD = −2.11, 95%CI: −3.67 to −0.56, $p = 0.004$; Group 2: AMD = −1.86, 95%CI: −3.39 to −0.33, $p = 0.001$). Milk volume (mL) in Group 1 was significantly higher than in the control group (Day 3: MD = 37.85, 95%CI: 4.13 to 71.56, $p = 0.023$; Day 4: MD = 49.13, 95%CI: 9.73 to 88.53, $p = 0.010$; Day 5: MD = 80.55, 95%CI: 34.85 to 126.26, $p = 0.001$). On Day 5, milk volume in Group 2 was significantly higher than in the control group (MD = 51.05, 95%CI: 5.17 to 96.93, $p = 0.024$). Mother–infant attachment scores were significantly higher in Group 1 compared with the control group (MD = 3.56, 95%CI: 0.93 to 6.19, $p = 0.004$).

Abbreviations: AMD, adjusted mean difference; ANCOVA, analysis of covariance; CI, confidence interval; ITT, intention-to-treat; MAS, mother–infant attachment scale; PSS, perceived stress scale; STAI, state-trait anxiety inventory.

Conclusion: Scent-infused materials and infant video exposure during NICU hospitalization may reduce maternal anxiety and stress, enhance milk production, and improve attachment, supporting development of targeted NICU interventions.

1 | Introduction

The first moment when parents hold their children in their arms is one of the most meaningful experiences in a parent's life. This first physical contact also marks the beginning of receiving childhood chemical signals and olfactory communication [1]. The olfactory cues emitted by infants and/or mothers are essential for establishing the mother-infant interaction during birth [2]. The positive impact of an infant's scent is particularly noticeable for children under 1-year-old. A mother's ability to recognize her baby's scent results from spending time with the infant, leading her to prefer her child's scent over other babies [3]. In this regard, a study by Hierl et al. (2021) showed that mothers could smell the scent of themselves and their infants without exception [4]. This ability to smell scent develops within a day or even a few hours after birth, and it has been observed that a mother's ability to recognize scent decreases on the fourth and fifth days after birth and improves again on the eighth day. This decline in the ability to smell scent is associated with an increase in the mother's depression scores on those days [3, 5].

The aroma of a baby stimulates parts of the mother's brain related to reward. This phenomenon is connected to motherhood, as there is no activation of the dopaminergic areas in women who do not have children. This targeted activation of the neural reward system may strengthen caregiving and attachment. Based on the idea that body odor helps in mother-infant bonding, it is hypothesized that mothers who have difficulty bonding with their children may show selective disorders in recognizing and preferring their baby's scent compared to healthy mothers [3, 6]. A study by Croy et al. (2019) showed that mothers with psychological disorders are less likely to prefer the scent of their infants. Given that the smell of a baby is generally perceived as very pleasant, consciously recognizing the infant's scent could provide an additional therapeutic approach for mothers experiencing attachment issues [3]. In addition, infant scent influences the maternal oxytocin system to affect milk production. Odor cues from the infant activate olfactory pathways and hypothalamic neurons, triggering oxytocin release into both blood and cerebrospinal fluid, with elevated levels reported in emotion- and stress-related brain regions (e.g., amygdala) [7, 8]. Oxytocin facilitates the milk-ejection reflex, promotes relaxation [6], and stimulates prolactin secretion from the anterior pituitary, which drives milk synthesis—thus directly linking infant scent exposure to the milk production cycle [7]. Mothers rapidly learn to prefer their own infant's scent, and stronger olfactory bonding predicts greater attachment. Scent-exchange interventions (e.g., cloths with maternal or infant scent) improve mother–infant engagement, bonding, and breastfeeding initiation, highlighting translational applications of olfactory communication in perinatal care [9].

According to studies, the amount of milk secreted in mothers is 15 cc on the first day, 500–600 cc daily from days 4 to 7, and 1000 cc daily after 1 week, or 150–200 ml/kg/day [10, 11]. It is recommended that mothers who cannot breastfeed their infants look at pictures of their children and smell their clothes during the pumping process [11, 12].

Research demonstrates that premature infants admitted to neonatal intensive care units (NICUs) are frequently deprived of critical maternal sensory stimuli, including physical contact, vocal interaction, and olfactory cues from their mothers [13–15]. Although parents today have better access to the NICU and can spend long periods by their infants' sides, the experience of an unfamiliar environment, the alarm sounds of machines, and the specific conditions of the unit can still lead to an increase in parental anxiety. On the other hand, the fragile and immature appearance of the infant, along with the parents' initial mental image of their baby and other concerns during hospitalization in the NICU, are factors that contribute to anxiety and distress in parents. All these factors damage the family and significantly increase stress and anxiety, particularly among mothers [16]. In one study, it was shown that these factors disrupt the parental role and hinder the proper interaction between mother and infant, creating challenges that pose difficulties for parents and affect the growth and development of the infant [17]. Nowadays, some NICUs use live video visitation services (VVS) such as "AngelEye," which allow parents to observe their infant virtually. This technology helps parents feel closer and more emotionally connected when they cannot be physically with their baby. The benefits of using VVS include reduced parental anxiety, increased feelings of closeness, and improved milk production when mothers observe their babies while pumping. However, there are challenges with using this technology that need to be addressed to utilize its benefits effectively [18]. Additionally, parents, especially mothers who have the most contact with their infants, require interventions that reduce their anxiety and stress, teach them how to interact appropriately with their infants, and help them adapt to the challenges of the NICU environment.

Despite advances in NICU care and family-centered approaches, there is limited evidence on integrated multisensory interventions that simultaneously support maternal well-being, lactation, and mother–infant bonding. Most previous work examines either olfactory cues or audiovisual support in isolation, often over short durations, with unclear feasibility for routine NICU use [3, 11, 12, 14]. There is a critical need to evaluate whether a combined sensory–audiovisual intervention delivered across multiple days can produce sustained improvements in maternal anxiety, stress, milk production, and attachment, and whether such an approach is scalable in busy NICU settings. To address this gap, we evaluated the effect of watching an infant video with or without smelling an infant-scented hat on anxiety and breast milk volume (primary outcomes) and maternal stress and mother–infant attachment (secondary outcomes) in mothers with hospitalized infants in the NICU.

2 | Study Hypotheses

1. Mothers in the intervention groups (video alone and video with smelling an infant-scented hat) will demonstrate significantly lower levels of anxiety and stress and higher

level of breast milk volume and mother–infant attachment compared to the control group.

2. The combined intervention (video with smelling an infant-scented hat) will result in significantly greater improvements in anxiety, breast milk volume maternal stress and mother–infant attachment compared to the video-alone intervention.

3 | Methods

3.1 | Study Design and Participants

This randomized controlled trial was conducted in accordance with CONSORT guidelines [19, 20] and enrolled 78 mothers of infants admitted to the NICU at two teaching hospitals, Al-Zahra and Taleghani, in Tabriz, Iran.

The inclusion criteria for the study were as follows: not taking any psychotropic medication (no psychological problems or anxiety disorders) in the mother, an Apgar score above 7, no intracranial hemorrhage in the infant, stable general condition of the infant, infant's weight above 1000 grams, first-time admission to the NICU, gestational age between 28 and 34 weeks, no congenital anomalies in the infant, and the mother being in the breastfeeding period between the 3rd and 5th days after delivery.

The study's exclusion criteria were conditions that prevent intervention on the infant (such as intracranial hemorrhage, delay in motor or neurological development, etc.), readmission during the data collection process, and parents lacking literacy.

3.2 | Sample Size

The sample size was calculated using G-Power based on the anxiety variable from Farrokhian et al. [16], taking $m1 = 10.89$ and $m2 = 8.66$, with an assumed 25% reduction in anxiety score due to the intervention. $SD1 = SD2 = 2.95$; α (two-sided) $= 0.05$; power $= 0.95$. This yielded a required sample size of 24 per group. Accounting for potential attrition, the final sample size is 26 participants per group.

Sampling began after obtaining ethical approval from the Ethics Committee and registration in the Clinical Trial Registration Center (IRCT20120718010324N82). The researcher visited the NICU units of Al-Zahra and Taleghani educational hospitals in Tabriz and screened hospitalized infants and their mothers based on eligibility criteria. If both the infant and mother met the criteria, informed written consent was obtained from the parents, and questionnaires on maternal and infant characteristics, as well as the Spielberger State-Trait Anxiety Inventory, the Cohen Perceived Stress Scale, and the Maternal Attachment Scale, were completed through interviews with the mothers. Before the intervention began, mothers were trained on how to express milk and record the volume of milk expressed. This training included instructions on using breast pumps and proper milk expression techniques. To accurately measure the expressed milk volume, 10 mL syringes were provided to help mothers easily record the amount of milk.

4 | Randomization

Participants were randomly assigned to three groups, including two intervention groups and one control group, using the Randlist software. Random allocation was performed through random block randomization with block sizes of 6 and 9 and an allocation ratio of 1:1:1. To conceal allocation, the type of intervention was written on a piece of paper and placed inside opaque, consecutively numbered envelopes. The envelopes were opened in order of participant entry into the study, and the type of intervention received was determined. Random allocation and allocation concealment were carried out by an individual not involved in participant recruitment or data collection.

5 | Intervention

In the Intervention Group 1: A cotton, soft, thin, and washable hat, identical for all infants and sized to fit each infant's head, was gently placed on the infant's head by the researcher. Before taking the infant's scent sample, the infant's body was gently and carefully wiped with a clean towel. To prevent the transfer of the researcher's scent to the baby's hat, several precautions were taken. The hat was washed with a fragrance-free, baby-safe detergent and dried thoroughly. The researcher also avoided wearing any strong scents during the preparation and handling of the hats. To minimize contamination and prevent the absorption of environmental odors, the hat was stored in a zip-lock plastic bag (for no more than 2 h). As in the Kara study (2019), the infant's nurse placed the hat on the infant's head for 12 to 24 h to absorb the infant's scent and then put it in a zip-lock bag [11].

The hat, now impregnated with the infant's scent, was promptly delivered (within 2 h) to the mother and the infant's family members visiting the hospital. The researcher recorded a 2-min video of the infant for each mother, showing the infant's face and limbs while in the NICU. The video was also handed over to the mother and family members. During the breast-pumping session, the mother smelled the hat containing the infant's scent while simultaneously watching the infant's video and expressing breast milk. The mother recorded the amount of milk expressed in the daily milk monitoring form provided by the researcher. The same procedure was repeated every time milk was expressed throughout the day. The intervention lasted 5 days, and a new hat was provided to the mother daily. The mother continued to smell the hat and watch the video for up to 24 h after receiving the last hat while recording the milk she expressed.

In the Intervention Group 2, a video of the infant was provided to the mother and family members in the hospital. The mother watched the video of her infant while expressing milk and recorded the amount of milk expressed in the daily milk monitoring form. This process was repeated every time milk was expressed throughout the day. The intervention lasted 5 days, and five videos were provided to the mother, one per day. The mother continued to record the milk expressed for up to 24 h after receiving the last video. In the control group, the mothers received a plain hat without the infant's scent. The mothers recorded the amount of milk they expressed daily in the milk monitoring form starting from the admission of their infant to the NICU and continued for 5 days.

The infant video used in Intervention Groups 1 and 2 was standardized across participants. Each mother received a video of her own infant lasting exactly 2 min. The infant video was recorded in the NICU while the infant was awake and calm, depicting the face and limbs, without audio. The video was presented to the mother during the breastfeeding/pumping session and was identical in length and content for all sessions. Videos were shown without disrupting the hospital routine, and mothers were instructed to watch them passively during pumping.

6 | Measures to Prevent Contamination Bias

To minimize contamination, all interventions (video sessions and scented hats) were administered individually at the participant's bedside, not in group settings. The video content was shown to each mother privately, ensuring that other mothers in the unit could not see or hear the intervention content. The infant-scented hats were provided individually in sealed, opaque envelopes labeled only with the participant's study code, so the content was not visible to others. Nursing and medical staff providing routine care were not informed of participants' group assignments. They were instructed to avoid discussing the study details with patients and to refer any questions to the research team. This helped prevent unintentional disclosure of intervention details to control group participants. Also, at enrollment, all participants were verbally instructed and provided with written information requesting that they do not discuss the details of their study procedures with other mothers in the unit, as this could affect the study results. They were encouraged to direct any questions or curiosity about the study to the research team. Throughout the study period, research staff regularly liaised with ward nurses and unit managers to monitor for any signs of contamination, such as mothers asking about interventions they had not received or discussing study procedures with each other. No significant instances of contamination were reported.

7 | Data Collection Tools

For data collection in the research, the following questionnaires were used: Mother and Infant Demographic Questionnaire, Daily Milk Monitoring Form, Spielberger State-Trait Anxiety Inventory, Perceived Stress Scale and Maternal Attachment Questionnaire.

Mother and Infant Demographic Information Form: The researchers created this form based on literature and articles [21–24]. It includes 15 questions regarding the mother's age, education level, birth weight, height, head circumference, chest circumference, gender, birth age, birth type, diagnosis, infant feeding, breastfeeding status, and whether the mother received breast pumping education during pregnancy.

Daily Milk Monitoring Form: The researchers developed this form so the mother could record the amount of milk she expressed daily.

The State-Trait Anxiety Inventory (STAI) is a scale used to assess anxiety levels, developed by Spielberger and colleagues in 1970 for individuals aged 14 and older. This scale consists of the State Anxiety Scale (20 questions) and the Trait Anxiety Scale (20 questions), making up 40 items. Each question is scored between 1 and 4. The total score ranges from a minimum of 20 to a maximum of 80, with higher scores indicating a higher level of anxiety and lower scores indicating a lower level of anxiety. The response options for the State Anxiety Scale include: (1) Never, (2) Sometimes, (3) Often and (4) Almost always. The response options for the Trait Anxiety Scale include: (1) Rarely, (2) Sometimes, (3) Often and (4) Almost always. In the State Anxiety Scale, items 1, 2, 5, 8, 10, 11, 15, 16, 19, and 20 are reverse scored. In the Trait Anxiety Scale, items 21, 26, 27, 30, 33, 36, and 39 are reverse scored. Internal consistency coefficients for the scale have ranged from 0.86 to 0.95, while test-retest reliability coefficients have ranged from 0.65 to 0.75 over a 2-month interval [25]. In Mahram's study, the reliability of the research tool for the normal group (600 people) was 0.90 according to Cronbach's alpha, while it was estimated in the standard group (130 persons) as 0.94 [26].

The Perceived Stress Scale (PSS) was designed by Cohen and colleagues in 1983. It is used to assess the degree to which situations in an individual's life are evaluated as stressful, determining how they have felt over the past 10 weeks. This tool includes 14 questions, scored on a 5-point Likert scale: 0 = Never, 1 = Rarely, 2 = Sometimes, 3 = Most of the time, 4 = Always. Seven questions (4, 5, 6, 7, 9, 10, 13) are reverse-scored. The total score is derived from the sum of all responses, with a score range of 0–56, and a higher score indicates greater perceived stress [27]. This tool was validated in Iran in a study by Mansouri and colleagues, where its reliability was confirmed with a Cronbach's alpha of 0.85 [28].

The Maternal Attachment Scale (MAS) is a questionnaire comprising 19 items completed by the mother or the person who spends the most time with the child. This scale, designed by Condon and Corkindale (1998), is intended for children aged 0 to 36 months. The scale measures three factors: Attachment quality (questions 3, 4, 5, 6, 7, 10, 14, 18, 19), Lack of hostility (questions 1, 2, 15, 16, 17) and Enjoyment of interaction (questions 8, 9, 11, 12, 13). The total attachment score is obtained by summing the scores of these three subscales. A higher score indicates stronger maternal attachment to the child. The scoring of items on this scale varies; some items are 5-point Likert scale, while others are 4-point. For example, items 1–3 have five response options. In Condon and Corkindale's study, the scale's internal consistency was found to be 0.78, with a score range from 19 to 95 [29]. In Iran, Zeynali conducted a psychometric study, reporting the reliability of the full scale as 0.69 [30].

8 | Data Analysis

All statistical analyzes were performed using SPSS (IBM Corp., Armonk, NY, USA), version 26.0. All analyzes presented in this study were pre-specified and the outcomes were defined as primary or secondary outcomes a priori in the trial registration. The Kolmogorov-Smirnov test was used to assess the normality of quantitative data, and all data followed a normal distribution. To compare the groups' characteristics regarding the mother and neonate, one-way analysis of variance (ANOVA), chi-square, chi-square trend, and Fisher's exact tests were applied. One-way ANOVA was used to compare the groups concerning state and trait anxiety, maternal milk volume, maternal attachment, and perceived stress before the intervention. After the intervention, between-group comparisons were performed using analysis of covariance (ANCOVA) for all outcomes. Baseline values of each outcome were included as covariates in the respective models to adjust for potential baseline imbalances and improve statistical precision. For milk volume, which was measured repeatedly on days 3, 4, and 5, separate ANCOVA models were conducted for each time point, with baseline milk volume (day 1) as the covariate. Adjusted mean differences (AMD) with 95% confidence intervals were calculated for each comparison. All analyzes followed the intention-to-treat principle and the reporting guidance of Assel et al. (2018) [31]. A two-tailed p-value < 0.05 was considered statistically significant for all analyzes. All tests were two-sided [32, 33].

Post-hoc power analysis was conducted using G-Power software (version 3.1). Based on the observed effect sizes, sample size, and significance level of $\alpha = 0.05$, the achieved statistical power was calculated for the outcomes.

9 | Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Tabriz University of Medical Sciences (approval number: IR.TBZMED.REC.1402.946). Written informed consent was obtained from all participants prior to enrollment. Participants were assured of the confidentiality of their data and informed that they could withdraw from the study at any time without affecting their right to receive standard care. The trial was registered with the Iranian Registry of Clinical Trials (IRCT registration number: IRCT20120718010324N82).

10 | Results

Participant registration was conducted from April 20 to July 20, 2024. A total of 100 neonates and their mothers were evaluated. Of these, 22 individuals were excluded before random allocation for various reasons, including refusal to participate, failure to meet inclusion criteria, exacerbation of infection, and physiological instability. Ultimately, 78 participants remained, with 26 mothers and neonates in Intervention Group 1, 26 in Intervention Group 2, and 26 in the Control Group (Figure 1). Table 1 shows no statistically significant difference between the three groups regarding maternal and neonatal characteristics ($p > 0.05$).

After the intervention, the mean score for state anxiety in the first intervention group (adjusted mean difference (AMD): −16.40; 95% confidence interval (CI): −24.56 to −8.24; $p < 0.001$) and the second intervention group (AMD: −13.83; 95% CI: −21.26 to −6.40; $p < 0.001$) was significantly lower than the control group. However, there was no statistically significant difference between the first and second intervention groups (AMD: −2.56; 95% CI: −10.21 to 5.08; $p = 0.80$). Additionally, the mean score for trait anxiety in the first intervention group (AMD: −11.54; 95% CI: −16.29 to −6.80; $p < 0.001$) and the second intervention group (AMD: −11.57; 95% CI: −15.87 to −7.26; $p < 0.001$) was significantly lower than the control group, but no statistically significant difference was found between the two intervention groups (AMD: 0.02; 95% CI: −4.75 to 4.80; $p > 0.99$) (Table 2). Baseline state anxiety and baseline trait anxiety were measured at enrollment. Significant differences in these baseline measures were detected across the three groups. To mitigate potential bias from these imbalances, all primary analyzes used ANCOVA with baseline state anxiety and baseline trait anxiety as covariates.

Regarding the volume of breast milk, there was no statistically significant difference between the study groups on the first and second days ($p > 0.05$). The amount of breast milk expressed by mothers in the first intervention group on the third day (AMD: 37.85; 95% CI: 4.13 to 71.56; $p = 0.023$) and the fourth day (AMD: 49.13; 95% CI: 9.73 to 88.53; $p = 0.010$) was significantly higher than the control group. However, there was no statistically significant difference between the second intervention group and the control group, nor between the two intervention groups ($p > 0.05$). The amount of expressed breast milk on the fifth day in the first intervention group (AMD: 80.55; 95% CI: 34.85 to 126.26; $p = 0.001$) and the second intervention group (AMD: 51.05; 95% CI: 5.17 to 96.93; $p = 0.024$) was significantly higher than the control group. However, no statistically significant difference was found between the first and second intervention groups ($p > 0.05$) (Table 3).

The mean perceived stress score in the first intervention group (AMD: −2.11; 95% CI: −3.67 to −0.56; $p = 0.004$) and the second intervention group (AMD: −1.86; 95% CI: −3.39 to −0.33; $p = 0.001$) was significantly lower than the control group. However, there was no statistically significant difference between the first and second intervention groups (AMD: −0.25; 95% CI: −1.80 to 1.29; $p = 0.97$) (Table 2).

The mean maternal attachment score in the first intervention group was significantly higher than in the control group (AMD: 3.56; 95% CI: 0.93 to 6.19; $p = 0.004$). However, there was no statistically significant difference between the second intervention group and the control group or between the first and second intervention groups ($p > 0.05$) (Table 2).

Post-hoc power analysis revealed that with our sample size of 26 participants per group and the observed effect sizes for outcome, the achieved statistical power was > 0.99 for all outcomes. This indicates that the study had adequate power to detect the observed effect.

11 | Discussion

The study showed that both types of interventions reduced state and trait anxiety and perceived stress, while maternal attachment significantly increased. Additionally, the combined intervention of smelling an infant-scented hat and watching a video of the infant may provide additional benefits to breast milk production.

In this study, watching a video of the baby with or without smelling an infant-scented hat significantly reduced both state and trait anxiety in mothers. Akbaş et al. (2019) investigated the relationship between NICU hospitalization duration and parental anxiety levels using the State-Trait Anxiety Inventory.

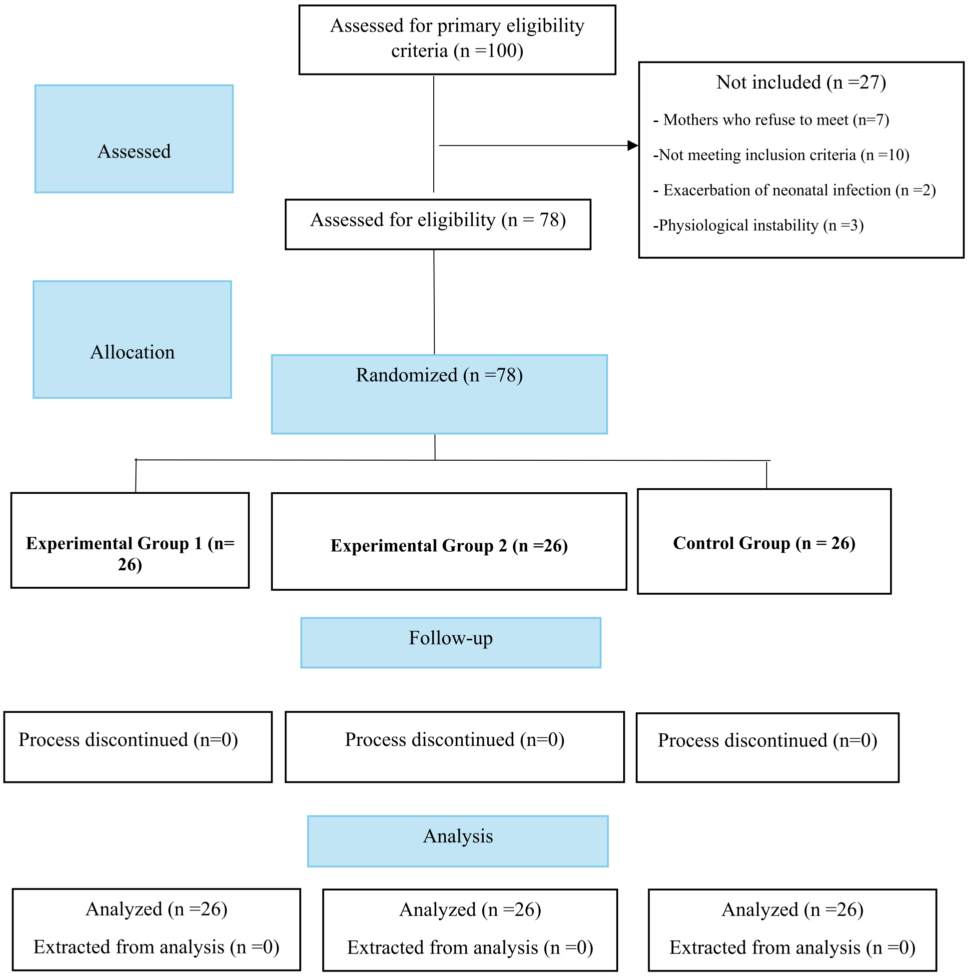

FIGURE 1 | Flowchart of the study.

Their findings revealed a positive correlation between length of infant hospitalization and both state and trait anxiety scores in mothers, with longer NICU stays associated with progressively higher anxiety levels [34].

Gaskin et al. found that smelling the baby's clothes while expressing milk had a calming effect on mothers and reduced their anxiety [35]. In her study, Kara examined the impact of the baby's scent on maternal anxiety and milk volume. The results showed that the baby's scent could help reduce maternal anxiety, and milk volume, and breastfeeding self-efficacy increased [11]. Tekin, in his study, assessed state and trait anxiety levels and breastfeeding success in mothers whose infants were hospitalized in the NICU. The results indicated that maternal companionship and participation in NICU care could reduce anxiety and increase breastfeeding success [36].

In this study, watching a video of the baby with and without the baby's scent significantly reduced the perceived stress in mothers. These results are consistent with those of Guttmann et al.'s study. In their research, using bedside cameras (webcams) for infants hospitalized in the NICU and remote monitoring by parents led to lower stress scores for the parents [37]. Rhoads et al. examined the outcomes of using webcams in the NICU environment. Forty-two parents of hospitalized infants in the NICU who were eligible for the study participated. Stress, anxiety, and attachment were measured at different time points (baseline, 1 week, and 2 weeks after starting the use of webcams). The results showed that there was no significant relationship between anxiety or attachment and the time spent observing the infant via the webcam. However, there was a relationship between the parents' stress levels and the duration of infant observation at three different times. Qualitative data revealed that parents preferred to be physically present with their infants [38]. Xu et al. investigated how smelling the baby's scent affects maternal responses to acute stress. They found that the baby's scent could increase sympathetic nervous system activity in mothers. These findings suggest that the baby's scent might help increase oxytocin levels and, in turn, improve mothers' responses to their infants in stressful conditions [39]. GÖRAL's study examined the effectiveness of nursing educational and supportive interventions in reducing stress in mothers of premature infants in the NICU. Sixty-two mothers were divided into two groups (intervention and control). The intervention group received various training sessions, including skin-to-skin contact and kangaroo care. The results showed that, after the intervention, the mothers' stress levels in the intervention group were significantly lower than those in the control group [40]. Abdeyazdan et al. conducted a study to reduce the stress levels of families in the NICU by implementing a planned intervention program (family support program). This program included training, caregiving procedures, emotional support, and kangaroo care. The results showed that, in the intervention group, the mothers' stress levels significantly decreased [41].

Research has shown that oxytocin (OT) is associated with stress-related disorders such as depression, anxiety disorders,

TABLE 1 | Baseline characteristics of participants by the study groups.

Variables	Group 1 ($n = 26$) Mean ± SD	Group 2 ($n = 26$) Mean ± SD	Control ($n = 26$) Mean ± SD	p
Mother's age (Year)	28.11 ± 4.15	28.73 ± 5.03	28.84 ± 5.37	0.845[a]
Gestational age (week)	31.38 ± 2.07	31.84 ± 1.84	31.96 ± 1.79	0.519[a]
Postnatal age (day)	3.73 ± 0.91	3.80 ± 0.89	3.65 ± 0.84	0.823[a]
Birth weight (gr)	1680.57 ± 581.59	1782.11 ± 597.37	1731.41 ± 573.98	0.820[a]
Birth length (cm)	42.00 ± 4.00	42.03 ± 3.97	42.80 ± 3.81	0.707[a]
Head circumference (cm)	29.07 ± 2.59	29.65 ± 2.52	29.57 ± 2.50	0.675[a]
Chest circumference (cm)	27.11 ± 2.56	27.76 ± 2.53	27.57 ± 2.50	0.635[a]
	***n* (%)**	***n* (%)**	***n* (%)**	***p* value**
Mother's education level				0.406[b]
Elementary	1 (3.8)	6 (23.1)	6 (23.1)	
High school	4 (15.4)	2 (7.7)	2 (7.7)	
Diploma	13 (50.0)	11 (42.3)	13 (50.0)	
University	8 (30.8)	7 (26.9)	5 (19.2)	
Diagnosis of the baby				0.396[c]
Respiratory distress	22 (84.6)	21 (80.8)	22 (84.6)	
Hyperbilirubinemia	1 (3.8)	3 (11.5)	3 (11.5)	
Intrauterine growth retardation (IUGR)	3 (11.5)	0 (0.0)	1 (3.8)	
Congestive heart disease (CHD)	0 (0.0)	1 (3.8)	0 (0.0)	
Cleft palate	0 (0.0)	1 (3.8)	0 (0.0)	
Type of delivery				> 0.99[d]
Cesarean section	22 (84.6)	17 (65.4)	22 (84.6)	
Vaginal	4 (15.4)	9 (34.6)	4 (15.4)	
General condition of the baby				0.689[c]
Good	10 (38.5)	13 (50.0)	12 (46.2)	
Average	15 (57.7)	12 (46.2)	11 (42.3)	
Bad	1 (3.8)	1 (3.8)	3 (11.5)	
Baby's gender				0.398[d]
Female	18 (69.2)	14 (53.8)	15 (57.7)	
Male	8 (30.8)	12 (46.2)	11 (42.3)	
Nutritional status				0.826[c]
Breast milk	17 (65.4)	20 (76.9)	19 (73.1)	
Formula	1 (3.8)	1 (3.8)	2 (7.7)	
Donated milk	8 (30.8)	5 (19.2)	5 (19.2)	
Baby feeding method				> 0.99[d]
Oral	5 (19.2)	6 (23.1)	5 (19.2)	
Enteral	21 (80.8)	20 (76.9)	21 (80.8)	
Breast feeding education				
Yes	26 (100)	26 (100)	26 (100)	
No	0 (0.0)	0 (0.0)	0 (0.0)	
Number of pregnancies				0.960[c]
1	18 (69.2)	16 (61.5)	17 (65.4)	
2	4 (15.4)	6 (23.1)	6 (23.1)	
> 3	4 (15.4)	4 (15.4)	3 (11.5)	
Number of births				0.370[d]
1	20 (76.9)	17 (65.4)	17 (65.4)	

(Continues)

TABLE 1 | (Continued)

	n (%)	*n* (%)	*n* (%)	*p* value
> 2	6 (23.1)	9 (34.6)	9 (34.6)	
Number of live babies				0.988[c]
1	15 (57.7)	14 (53.8)	14 (53.8)	
2	7 (26.9)	8 (30.8)	9 (34.6)	
> 3	4 (15.4)	4 (15.4)	3 (11.5)	

Note: Group 1: The hat and video recipient group, Group 2: The video recipient group; Group 3: Control.
[a]One Way ANOVA.
[b]Chi square for trend.
[c]Fisher's Test.
[d]Chi square.

and post-traumatic stress disorder (PTSD) and plays an essential role in stress regulation. The hypothalamus, the command center of the endocrine system, and the hippocampus, a key area in regulating mood and anxiety, are functionally interconnected. The hypothalamus sends OTergic neurons to the hippocampus, which has high levels of OT receptors and regulates the secretion of glucocorticoids, the primary stress hormones. High levels of glucocorticoids during chronic stress can lead to hippocampal atrophy, while OT protects hippocampal neurons from the toxic effects of glucocorticoids. Therefore, OT exerts anti-stress effects by modulating neural circuits in the hippocampus, amygdala, and prefrontal cortex. Following an increase in endogenous OT levels, the mother's cortisol levels decrease, which in turn leads to reduced anxiety, negative mood, and stress in the mother [42, 43].

In this study, smelling an infant-scented hat and watching a baby video led mothers to experience greater attachment to their infants. Schäfer and Croy emphasize the importance of odors in parent-child bonding during infancy and throughout the entire developmental period [44]. On the other hand, maternal interaction and skin-to-skin contact with the infant lead to increased OT secretion, which promotes maternal attachment to the child and fosters emotional bonding, positively influencing the infant's growth [43]. In a clinical trial by ŞAHİN and colleagues, 54 mothers and infants were divided into three groups: the baby scent group, the baby scent and visual stimulus group, and the control group. During the intervention, measurements of cortical and breast oxygenation were taken. Results showed that the effect of baby scent and visual stimuli on oxygenation was significantly higher in the intervention groups than in the control group. However, no significant changes were observed in milk volume or mother-infant bonding scores. These findings suggest that baby scent and visual stimuli can be considered strategies to reduce the adverse effects of mother-infant separation [45]. Gibson and colleagues conducted a systematic review to explore using web cameras in the NICU to enhance parent-child bonding. They found that using cameras increased parents' sense of closeness to their infants, improved responsiveness, and reduced stress and anxiety. Web cameras were concluded to be a valuable complement to family-centered care approaches [46]. Using bedside cameras, Patel and colleagues examined emotional bonding between parents and infants in the NICU through remote infant viewing (RIV). Parents could view live videos of their infants 24 h from any location with internet access. The study showed that remote viewing could strengthen emotional bonding, particularly during visitation restrictions, such as during the COVID-19 pandemic [47]. Dunham and colleagues explored the mother-infant bonding (MIB) process through virtual visits (VV) for infants hospitalized in the NICU. Virtual visits enabled mothers to continuously access live one-way webcam feeds of their hospitalized infants, facilitating the MIB process in the NICU [18]. Kaynak and colleagues study found that mothers who interacted with their infants via video calls had significantly higher attachment levels [48]. Similarly, Psychogiou and colleagues showed that for mothers who underwent cesarean sections and whose infants were transferred to the NICU, video calls provided the opportunity to see their infants as soon as possible, which led to increased maternal bonding [49].

Kerr and colleagues conducted a qualitative study to examine the views of parents and healthcare staff on the impact of technology that transmits live images of infants in the NICU to the mother's bedside through a webcam in the post-delivery care environment. The study included 33 parents and 18 nurses working in the NICU, who were purposively selected. Data were collected through individual, paired, and small-group interviews. The results showed that the opinions about this technology were generally positive. The benefits of this technology included a sense of closeness and increased responsiveness, improved mental health, physical recovery, and the involvement of family and friends, all of which supported the process of early bonding and the transition to parenthood [50]. In their study, Aftyka et al. found that electronic photos or videos of infants hospitalized in the NICU emphasized the importance of effective communication between parents and medical staff. However, this method cannot replace skin-to-skin contact for creating emotional bonds between parents and infants. Ultimately, NICU units should look for strategies to minimize the impact of separation on parents' experiences and emotional bonding in similar situations in the future [51].

In this study, the intervention involving watching videos of infants combined with the baby's scent increased the mothers' milk volume. Weber et al. showed that video visits through the FamilyLink program, allowing parents to observe their infants remotely, had a positive impact on breastfeeding and parents' emotions during the hospitalization of their infants, helping to improve family experiences [52]. Turhan and Özkan studied the effect of watching videos of infants on mothers with infants

TABLE 2 | Comparison of anxiety, stress and maternal attachment among study groups.

Variable	Control ($n = 26$) Mean (SD)	Video ($n = 26$) Mean (SD)	Hat and video ($n = 26$) Mean (SD)	Difference between groups p	Comparison of two groups: Hat and video with control	Comparison of two groups: Video with control	Comparison of two groups: Hat and video with video
State anxiety					MD (%95 CI)[a]; p	MD (%95 CI)[a]; p	MD (%95 CI)[a]; p
Baseline	45.42 (13.83)	53.61 (8.85)	58.57 (9.65)	0.001	−13.15 (−20.61 to −5.70); < 0.001	−4.96 (−12.41 to 2.49); 0.291	−8.19 (−15.64 to −0.74); 0.027
After intervention	35.69 (8.45)	41.57 (14.91)	57.42 (10.46)	< 0.001	−16.40 (−24.56 to −8.24); < 0.001	−13.83 (−21.26 to −6.40); < 0.001	−2.56 (−10.21 to 5.08); 0.800
Trait anxiety							
Baseline	41.11 (10.88)	52.61 (8.38)	52.11 (10.26)	0.001	−11.00 (−17.70 to −4.29); < 0.001	0.500 (−6.20 to 7.20); > 0.99	−11.50 (−18.20 to −4.79); < 0.001
After intervention	33.65 (6.63)	39.69 (7.92)	51 (9.71)	< 0.001	−11.54 (−16.29 to −6.80); < 0.001	−11.57 (−15.87 to −7.26); < 0.001	0.02 (−4.75 to 4.80); 1.00
Stress							
Baseline	21.80 (4.51)	23.65(7.76)	23.92 (2.62)	0.313	−2.11 (−5.77 to 1.54); 0.412	−0.26 (−3.92 to 3.39); > 0.99	−1.84 (−5.50 to 1.81); 0.529
After intervention	19.92 (2.81)	20.84 (3.82)	22.80 (2.02)	< 0.001	−2.11 (−3.67 to −0.56); 0.004	−1.86 (−3.39 to −0.33); 0.012	−0.25 (−1.80 to 1.29); 0.970
Maternal attachment							
Baseline	71.83 (4.29)	71.48 (5.58)	71.63 (4.03)	0.965	0.19 (−2.98 to 3.37); > 0.99	−0.15 (−3.32 to 3.02); > 0.99	0.34 (−2.83 to 3.52); 0.991
After intervention	72.58 (5.72)	70.89 (3.94)	68.90 (4.57)	0.001	3.56 (0.93 to 6.19); 0.004	2.08 (−0.54 to 4.71); 0.161	1.48 (−1.15 to 4.11); 0.435

Note: One-way analysis of variance was used to compare the groups before the intervention, and ANCOVA was used to examine the differences between the groups after the intervention.
[a]Mean difference (95% confidence interval).

TABLE 3 | Comparison of amount of milk among study groups.

Variable	Hat and video ($n = 26$) Mean (SD)	Video ($n = 26$) Mean (SD)	Control ($n = 26$) Mean (SD)	Difference between groups *p*	Comparison of two groups		
					Hat and video with control MD (%95 CI)[a]; *p*	Video with control MD (%95 CI)[a]; *p*	Hat and video with video MD (%95 CI)[a]; *p*
First day	24.57 (26.34)	26.19 (28.30)	17.57 (14.56)	0.388	7 (−9.15 to 23.15); 0.647	8.61 (−7.54 to 24.77); 0.482	−1.61 (−17.77 to 14.54); > 0.99
Second day	78.30 (52.56)	80.88 (47.89)	55.11 (31.44)	0.198	13.77 (−7.79 to 35.33); 0.325	14.17 (−7.47 to 35.82); 0.304	−0.40 (−21.81 to 21.01); 1.00
Third day	138.23 (56.82)	134.73 (69.72)	91.11 (46.03)	0.001	37.85 (4.13 to 71.56); 0.023	32.21 (−1.62 to 66.05); 0.067	5.63 (−27.84 to 39.11); 0.968
Fourth day	199.30 (70.95)	181.73 (68.13)	141.15 (54.96)	0.001	49.13 (9.73 to 88.53); 0.010	29.47 (−10.07 to 69.02); 0.203	19.65 (−19.46 to 58.78); 0.532
Fifth day	262.50 (99.97)	235.00 (63.18)	173.26 (43.65)	0.001	80.55 (34.85 to 126.26); 0.001	51.05 (5.17 to 96.93); 0.024	29.50 (−15.88 to 74.88); 0.310

Note: One-way analysis of variance was used to compare the groups before the intervention, and ANCOVA was used to examine the differences between the groups after the intervention.
[a]Mean difference (95% confidence interval).

hospitalized in the NICU, and their findings showed that, on the third day after delivery, the milk volume of mothers in the intervention group was significantly higher than that of the control group [53]. Another similar study found that mothers who observed their infants via webcam in the NICU experienced increased feelings of control and closeness, as well as an increase in both the frequency of milk expression and the amount of milk produced [54]. Taşkın's study suggests that the baby's scent is a stimulating factor for the lactation process. This process is recognized as a natural mechanism in the mother-child relationship, where the scent of the baby's body can trigger hormonal responses in the mother, thereby increasing milk production. This sensory connection strengthens the emotional bond between mother and infant and plays a crucial role in breastfeeding and meeting the infant's nutritional needs [55]. White Traut and colleagues studied the effects of auditory, tactile, visual, and vestibular interventions, comparing the psychological well-being of mothers, infant behaviors, and the levels of OT and cortisol in the saliva of mothers and infants. The study found that smelling the lotion scent of infants by the mother had the most significant impact on the mothers' OT levels [56]. Thus, OT, produced in specific neurons in the hypothalamus, is transported to the posterior pituitary gland, where it is released in response to physiological needs such as uterine contractions and breastfeeding. After OT release, prolactin secretion increases, enhancing milk production and breastfeeding success. On the contrary, pain, anxiety, and stress in the mother can lead to a decrease or even cessation of breastfeeding [43, 44].

Our findings show that both Intervention Group 1 and Intervention Group 2 led to improvements in anxiety and stress compared with the control group, but there were no statistically significant differences between Intervention Group 1 and Intervention Group 2 for any outcome. This indicates that the scent component did not produce an incremental benefit above video exposure alone in this NICU setting. Several explanations are plausible: the odor cue may have been insufficiently potent, the exposure duration may have been inadequate, or the study may have been underpowered to detect small additive effects. Additionally, any potential scent effect could be masked by the strong impact of watching a video of the infant. To adequately evaluate an additive scent effect, future work could use a factorial randomized design, test different scent intensities and exposure timings, and ensure sufficient sample size to detect interactions between scent and video components.

12 | Strengths and Limitations of the Study

In this study, essential principles related to clinical trials were followed, including random allocation and allocation concealment. Standardized and reliable tools were used to assess anxiety, perceived stress, and maternal attachment, ensuring accurate measurements. Additionally, the study employed multiple interventions and simultaneously engaged both olfactory and visual senses, enhancing the effectiveness of the intervention. The sample was carefully selected from mothers with infants in the NICU, and the use of precise inclusion and exclusion criteria helped ensure homogeneity, which supports the generalizability of the results. Despite randomization, this study has several limitations. First, the sample size was relatively small and the intervention duration was short, with no long-term follow-up, which limits our ability to assess the durability of the observed effects. Second, although randomization was performed, significant baseline differences in state and trait anxiety were observed between groups. This is likely attributable to the moderate sample size and the inherent variability of these psychological measures. While we adjusted for these differences using ANCOVA, the possibility of residual confounding cannot be entirely excluded. Future studies with larger sample sizes and stratification by baseline anxiety levels would help address this limitation. Third, the sample consisted only of mothers of infants in the NICU, which may limit generalizability to mothers of healthy infants or those not in NICU care. Fourth, we did not measure or control for potential confounding variables such as NICU length of stay, mechanical ventilation status, and the level of mother-infant contact. These factors have been shown in previous research to influence maternal stress and anxiety and milk production [57, 58]. The absence of these variables in our analysis means that we cannot rule out their potential impact on the observed outcomes. Future studies should include these variables to better isolate the specific effects of olfactory and video interventions. Despite these limitations, the findings provide preliminary evidence warranting replication and broader investigation in diverse populations.

12.1 | Clinical Implications of the Findings

The results of this study can aid in designing supportive interventions for mothers in the NICU, such as using newborn's scent and videos to reduce perceived anxiety and stress and enhance maternal attachment. These findings could also contribute to the education of midwives and medical staff about the importance of olfactory and visual stimuli for newborns and their impact on mothers, encouraging them to adopt these interventions. By reducing maternal anxiety and increasing attachment, improvements in clinical outcomes for preterm infants can be expected. Additionally, using olfactory and visual interventions could help increase maternal milk production and facilitate the breastfeeding process, benefiting the health of the infants. Ultimately, it can be concluded that the findings of this study could improve the care of premature infants and potentially lead to the development of new clinical protocols in the NICU.

13 | Conclusion

The results of this study indicate that olfactory and visual stimuli positively impact perceived anxiety and stress, increase maternal attachment, and may contribute to higher breast milk production among mothers of infants admitted to the NICU. Given that mothers of preterm infants face significant psychological and emotional challenges, these non-pharmacological interventions could serve as a practical therapeutic approach to improving their mental and emotional well-being, ultimately leading to better clinical outcomes for the infants in the NICU. These results highlight the significance of olfactory and visual cues as sensory prompts that enhance the bond between mother and infant while alleviating maternal stress and anxiety. Consequently, these strategies are suggested to be integrated into neonatal care initiatives as an easy and effective approach.

Author Contributions

Shahla Shafaati Laleh: conceptualization, investigation, software, writing – original draft, data curation, project administration. **Sevil İnal:** conceptualization, validation, visualization, writing – review and editing. **Mohammadbagher Hosseini:** conceptualization, investigation, visualization, writing – review and editing. **Shirin Hasanpoor:** conceptualization, supervision, writing – review and editing. **Hamideh Nikzad:** conceptualization, investigation, writing – original draft, project administration. **Mojgan Mirghafourvand:** conceptualization, funding acquisition, writing – review and editing, visualization, validation, methodology, formal analysis, supervision, resources.

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Ethics Statement

Ethical approval was obtained from the Ethics Committee of Tabriz University of Medical Sciences (Code: IR.TBZMED.REC.1402.946), and the study was registered with the Clinical Trial Registration Center (IRCT20120718010324N82).

Consent

Informed written consent was obtained from all participants. All methods were carried out following relevant guidelines and regulations.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The datasets generated and/or analyzed during the current study are not publicly available due to limitations of ethical approval involving the patient data and anonymity but are available from the corresponding author at reasonable request.

Transparency Statement

The lead author Mojgan Mirghafourvand affirms that this article is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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