ISSN: 1607-8322, e-ISSN: 2220-5799 | Anaesthesia, Pain & Intensive Care
Vol 29(6); September 2025 | DOI: 10.35975/apic.v29i6.2927

ORIGINAL RESEARCH | **PAIN MANAGEMENT**

Comparison of the effect of listening to the white noise, lullaby, and nature sounds on pain during intravenous line insertion in premature neonates in the neonatal intensive care unit

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ABSTRACT

Background & objectives: Intravenous (IV) line insertion in neonates has always been a painful and disturbing experience for the neonate as well as the operator. Various methods have been described by the researchers to keep the neonates comfortable during this procedure. This study was conducted to compare the effect of listening to white noise, lullabies, and nature sounds on pain during IV line insertion in the premature infants hospitalized in the Neonatal Intensive Care Unit (NICU).

Methodology: In this clinical trial study, 110 premature infants admitted to the NICU were selected by the convenience sampling method and were placed into four groups: e.g., lullaby, nature sound, white noise, and control groups, with 4 blocks. Interventions: the pain of each infant was measured at three steps: before, during the insertion of the intravenous line, and 5 minutes after it. The Neonatal Infant Pain Scale (NIPS) was used to measure pain. The findings were analyzed with SPSS version 23 software. Non-parametric tests such as the Kruskal-Wallis test, Chi-square test, and the Bonferroni post-hoc test were employed. A statistical significance level of $P < 0.05$ was considered for all tests.

Results: The results showed that the pain during IV-line insertion in the white noise group was significantly less than in the other groups, and significantly more in the control group than in the other groups. The pain in the nature sound group was significantly lower than in the lullaby sound group. After 5 minutes of IV-line insertion in premature infants, the pain level was the lowest in all groups. Pain in the control group was 4.34 times ($P < 0.001$), and in the lullaby group was 0.87 times higher than white noise ($P < 0.001$); the nature sound was different from white noise. It had no meaning. The results showed that the pain estimation of the four groups during the intervention was lower than before. Also, the pain before the intervention was 0.75 times higher than 10 min after the intervention ($P = 0.003$).

Conclusion: Listening to white noise and the sounds of nature as one of the bio-behavioral solutions has an effect on pain reduction during intravenous line insertion in neonates hospitalized in the NICU, and the application of these simple and effective methods by the nurses working in the NICUs is recommended.

Abbreviations: NICU**:** Neonatal Intensive Care Unit, NIDCAP: Newborn Individualized Developmental Care and Assessment Program, NIPS: Neonatal Infant Pain Scale, IV: Intravenous

Keywords: Critical care; Intravenous; Nature sound; Neonate; NIPS; Non-pharmacological; Pain; Premature infants; Sound; White noise

Citation: Nickchehre S, Rasuli M, Shoghi M. Comparison of the effect of listening to white noise, lullaby, and nature sounds on pain during intravenous line insertion in premature neonates in the neonatal intensive care unit. Anaesth. pain intensive care 2025;29(6):607-615. **DOI:** 10.35975/apic.v29i6.2927

Received: May 09, 2024; **Revised:** October 26, 2024; **Accepted:** January 01, 2025

1. INTRODUCTION

The advancements in technology and medical care have significantly increased the survival chances of premature and severely ill infants.[1] This improvement is largely attainable through the hospitalization of newborns in specialized neonatal care units (NICU) and the implementation of frequent diagnostic and therapeutic procedures. Newborns admitted to NICUs often undergo painful procedures.[2] Reports indicate that infants born at 24 to 42 weeks of gestation, experience an average of 98 painful procedures within the first 14 days of their life. In most cases, these painful interventions are performed without the implementation of pharmacological and non-pharmacological pain relief measures for the newborn.[3,5]

Premature infants often experience heightened sensitivity to pain due to their immature nervous systems and physiological systems.[6] This sensitivity not only complicates their immediate medical care but also raises concerns about potential long-term neurodevelopmental consequences related to unrelieved procedural pain.[7] Consequently, there is a pressing need for effective strategies that can alleviate pain without resorting solely to pharmacological interventions, which may carry risks of adverse side effects in this vulnerable population.[8]

Nurses play a crucial role in managing pain and providing comfort to premature neonates hospitalized in the NICU, particularly during painful procedures such as peripheral intravenous line insertion.[9] In recent years, non-pharmacological interventions have garnered considerable attention in the context of neonatal pain management.[10,11] Among these, auditory stimuli—such as white noise, lullabies, and nature sounds—have been investigated for their potential calming effects.[12] White noise, characterized by a consistent sound that masks other auditory stimuli, can promote a sense of security and calm in infants, reminiscent of the sounds they would have heard in utero.[13] Similarly, lullabies (Human sound), often transmitted through maternal voices or recorded music, have been shown to elicit positive emotional responses and assist in emotional bonding, which can be beneficial in a clinical setting.[14,15] Nature sounds, known for their natural rhythms and associations with tranquility, may further enhance relaxation and promote a soothing environment for these infants.[16,17]

In the context of comparing the effects of listening to white noise, lullabies, and nature sounds, nurses are responsible for the implementation of these sound interventions as part of a holistic approach to pain management.[18,19] They assess the individual needs of each neonate and determine the most appropriate auditory stimuli based on the infants' responses and preferences. By utilizing soothing sounds, nurses can help to create a calmer and more supportive environment, which can potentially reduce the perception of pain and anxiety during these invasive procedures.[20,21]

Despite the promising rationale for using auditory stimuli in pain management, the literature remains fragmented and underexplored, particularly in regard to the comparative efficacy of different sound types during painful procedures.[22] Existing studies tend to focus on single modalities rather than conducting side-by-side comparisons of white noise, lullabies, and nature sounds in the context of procedural pain in premature neonates.[23] The lack of comprehensive evidence regarding the direct effects of auditory stimuli on pain perception in this unique population represents a significant gap in the current body of knowledge.[24] This study aimed to address this gap by comparing the effects of listening to white noise, lullabies, and nature sounds on pain during intravenous line insertion in premature neonates hospitalized in a NICU.

2. METHODOLOGY

110 premature neonates participated in this study. This study was a randomized clinical trial to assess the effects of different auditory stimuli on pain perception during intravenous line insertion in premature neonates. Inclusion criteria were; Apgar score higher than five in the fifth minute after birth, no receipt of analgesics during iv line insertion and at least 3 hours prior, absence of debilitating conditions and anatomical defects of the limbs (arms and legs), absence of underlying diseases and extensive surgeries causing pain (such as abdominal surgeries, etc.), birth weight of 1000 grams or more, No have chest tube, have experienced intravenous line insertion at least once before starting study, Having a damaged IV line that needs to be replaced, Attempts to insert an intravenous line more than once were considered as an exclusion

Table 1: Scoring and interpretation for the NIPS [16]

Observation	Score	interpretation
Facial expression	0	Relaxed
	1	Grimace
Cry	0	No cry
	1	Whimper (mild moaning or intermittent)
	2	Vigorous crying or silent cry (based on facial movements if intubated)
Breathing pattern	0	Relaxed
	1	Change in breathing (irregular, increased, gagging, breath holding)
Arms	0	Relaxed
	1	Flexed/extended (tense straight arms, rigid and/or rapid extension)
Legs	0	Relaxed
	1	Flexed/extended (tense straight legs, rigid and/or rapid extension)
State of arousal	0	Sleeping/awake (quiet, peaceful, settled)
	1	Fussy (alert, restless, and thrashing)
NIPS score interpretation		0–1: no pain; 2: mild pain; 3–4: moderate pain; 5–7: severe pain

Lawrence J., Alcock D., Kay J., McGrath P. J. The development of a tool to assess neonatal pain. Journal of Pain and Symptom Management. 1991;6(3):p. 194. doi: 10.1016/0885-3924(91)91127-U.

criterion. The NICU department of Sarem Hospital in Tehran was the site where the research was conducted. This hospital has a level 3 neonatal intensive care unit (NICU) that includes 12 active NICU beds and 8 active post-NICU beds.

The researcher, after obtaining the necessary permissions (Ethical code: 1402-3-3-26639) to conduct the study, explained the study objectives to the parents and, following the acquisition of informed written consent from both parents, enrolled the neonates in the study. Participants were selected based on inclusion criteria with a convenience method and randomly assigned into four groups using 4-block randomization method: Group A (lullaby), Group B (nature sounds), Group C (white noise), and Group D (control group). All 4-state modes were determined and placed in envelopes. After selecting the neonates, the researcher asked a mother to draw one envelope, thereby determining the sequence of participant selection (for example: A-D-C-B).

In the intervention groups, auditory stimuli (white noise, lullabies, and nature sounds) were played from 5 min before the intravenous line insertion until 5 min after the procedure. Neonates were positioned under a warmer according to Newborn Individualized Developmental Care and Assessment Program (NIDCAP) guidelines, based on the selected envelope. The chosen sound was played through two small speakers placed 20 centimeters from each side of the neonate's head. The volume of the audio was set at approximately 45 decibels. The researcher performed all venous cannulation of the neonates, while a colleague monitored the vital signs and responses of the neonates. Data were meticulously recorded by another colleague who assessed pain with the NIPS scale (Table 1) at 3 time points: 5 min after listening to music (before intervention), during the IV-line placement, and five min after its completion. It is worth noting that these three individuals remained constant throughout the study.

A standard 24-gauge IV catheter was used for all IV insertions. All neonates in 4 groups received routine care, including swaddling and the administration of a few drops of 24% sucrose solution. In the control group, an IV line was inserted according to routine practices without additional interventions, and pain assessment was conducted as mentioned earlier. After successful access, a small amount of fluid was injected into the vein to confirm patency, and the catheter was secured

2.1. Sample size

In this study, we chose the power of the test to be 80 (resulting in $Z\_(1-\beta)=1.28$) and the type I error to be 1 percent ($Z\_(\alpha/2)=2.58$). Considering the effect size of one sample required in the control group, it was approximately 35 infants, and in each intervention group. Considering a 10% probability of attrition, the sample size was 38 in the control group and 24 in each intervention group. Using 4-block sampling effectively prevents the issue of unequal group sizes resulting from random draw, because the randomization is constrained within each block, ensuring balanced group assignment across the entire sample.

The demographic information collected about the neonates included gestational age, current age, gender, weight, and height, Apgar scores at the 1st and 5th min of admission, heart rate, respiratory rate, and blood pressure. To assess pain, the Neonatal Infant Pain Scale (NIPS), developed by Lawrence et al. (1993), was used. NIPS is a behavioral scale applicable for assessing pain in both term and preterm neonates.[25] The NIPS includes six behavioral indicators (facial expression, crying,

Table 2: Comparative demographic characteristics of premature infants hospitalized to the NICU

Demographic Characteristics		Control (n = 38)	Rain Sound (n = 24)	Lullaby Sound (n = 34)	White Noise (n = 25)	Test Results
Gender	Female	18 (47.4)	9 (37.5)	5 (20.8)	13 (50)	χ 2=5.596 df=3 *P=0.133
	Male	20 (52.6)	15 (62.5%)	19 (79.2)	12 (50)	
Infant age (days)	Less than 7	29 (76.3)	15 (62.5)	10 (41.7)	14 (58.3)	Kruskal-Wallis H=15.623 **P <η 0.001**
	7 - 14	7 (18.4)	9 (37.5)	14 (58.3)	8 (33.3)	
	≥14	2 (5.3)	0	0	2 (8.3)	
	Max-Min	1-32	3-12	3-13	1-16	
	Mean ± SD	4.49 ± 0.04	6.04 ± 2.49	7.25 ± 2.64	6.42 ± 3.98	
Weight (grams)	1000-1500	14 (36.8)	30 (4.2)	11 (45.8)	14 (58.3)	Kruskal-Wallis H =17.444 **P <η 0.001**
	1000-2000	15 (39.5)	16 (66.7)	11 (45.8)	9 (37.5)	
	≥ 2000	9 (23.7)	7 (29.1)	2 (8.2)	1 (4.2)	
	Mean ± SD	1686.53 ± 432.29	1828.63 ± 258.81	1486.132 ± 3184.28	1460 ± 371.80	
	Max-Min	2500-1000	2320-1000	2000-1000	2500-1000	
Cause of Hospitalization	Respiratory	22 (57.9)	15 (62.5%)	14 (58.3)	12 (50)	**P=0.109
	Preterm	11 (28.9)	3 (12.5)	2 (8.3)	9 (37.5)	
	Cyanosis	5 (13.2)	6 (25)	8 (33/3)	3 (12.5)	
Number of Twins	Single	27 (71.1)	21 (87.5)	19 (79.2)	14 (5.83)	χ 2=5/870 df=3 *P= 0.123
	Twin	11 (38.9)	3 (12.5)	5 (20.8)	10 (41.7)	
Apgar at 5 min Total	Less than 7	10 (26.3)	24 (100)	24 (100)	8 (33.3)	Kruskal-Wallis H = 21/203 P< η 0.001
	Less than 7	28 (73.7)	0 (0)	0 (0)	16 (66.7)	
	More than 7	28 ()	73.7%	0	0%	
	Mean ± SD.	7/50 ± 1/15	8.54 ± 0.50	8.80 ± 0.65	7.25 ± 1.02	
	Max-Min	6-9	8-9	7-9	6-9	
Apgar at 9 min	Less than 7	1 (2.6)	24 (100)	24 (100)	37 (97.4)	Kruskal-Wallis H = 17/322 P< η 0.001
	More than 7	37 (97.4)	0 (0)	0 (0)	0 (0)	
	Mean ± SD..	8.74 ± 1.17	9.54 ± 0.50	9.21± 0.50	8.54 ± 1.02	

P < 0.05 is considered significant

arms, legs, and state of arousal) and one physiological parameter (breathing pattern) used to evaluate and estimate the intensity of pain. The total score of this tool ranges from 0 to 7, with a higher score indicating greater pain. A score of 0-2 is interpreted as mild or no pain, a score of 3-4 as mild to moderate pain, and a score of more than 4 as severe pain.

2.2. Statistical analysis

The research data were analyzed using SPSS software version 23 after collection. For descriptive analysis of the data, frequency distribution tables, means, and standard deviations were utilized. Due to the non-normality of the data, non-parametric tests such as the Kruskal-Wallis test, Chi-square test, and the Bonferroni post-hoc test were employed. A statistical significance level of $p < 0.05$ was considered for all tests.

3. RESULTS

The mean age and the mean weight of the infants in all four groups are given in Table 2. The four groups studied had statistically significant differences in terms of infant age ($P < 0.001$), infant weight ($P < 0.001$), and Apgar scores at 5th ($P < 0.001$) and 9th ($P < 0.001$) min, but no significant differences were observed between other demographic variables of infants in the four groups ($P < 0.05$) (Table 2).

The results of the Kolmogorov-Smirnov test showed that the pain variable was not normal before the intervention ($P < 0.001$), during the intervention ($P < 0.001$), and 10 min after the intervention ($P < 0.001$), so nonparametric tests were used for analysis.

Table 3: Estimated average pain of premature infants admitted to NICU in the groups

Group/Time		Mean ± SD	Results of Bonferroni Post Hoc Tests
Groups	**Control**	4.91 ± 0.08	P (Control/ Nature Sound) < 0.001 P (Control/Lullaby) < 0.001 P (Control/White noise) < 0.001 P (Rain sound/Lullaby) < 0.001 P (Nature sound/White noise) < 0.001 P (White noise/Lullaby) < 0.001
	Nature Sounds	1.45 ± 0.10	
	Lullaby Sound	2.13 ± 0.10	
	White Noise	0.40 ± 0.10	
Time	**Before Intervention**	2.80 ± 0.08	P (Before/During) = 0.26 P (Before/10 min after) < 0.001 P (During/10 min after) < 0.001
	During Intervention	2.53 ± 0.08	
	10 minutes after intervention	1.34± 0.08	

The results of the mixed ANOVA test on the data with repeated measures revealed significant effects for group (P < 0.001, F = 476.533), time (P < 0.001, F = 85.248), and the interaction effect of time and group (P < 0.001, F = 28.771). As shown in Table 2, the estimated mean pain during the three time points assessed in the white noise group was significantly lower than in the other groups, while in the control group, it was significantly higher than in the other groups (P < 0.001). The pain level in the nature sounds group was significantly lower than in the lullaby sound group (P < 0.001). The results also indicated that the pain estimates in all four groups during the intervention period were lower than those before the intervention (P = 0.026). The pain of infants five minutes after the intervention was significantly lower compared to during the intervention (P < 0.001) and also significantly lower than before the intervention (P < 0.001). It is worth noting that for conducting the mixed ANOVA test with data from two-way repeated measures, the variables of infants' age, weight, 5-minute Apgar score, and 9-minute Apgar score were controlled as confounding variables (Table 2).

The pain levels of premature infants in the control group were 4.34 times higher (P < 0.001), and in the lullaby sound group, they were 0.87 times higher than in the white noise group (P < 0.001). There was no significant difference between the nature sounds and white noise. The pain before the intervention was 0.75 times higher than five minutes after the intervention (P = 0.003) (Table 3).

The results of the mixed analysis of variance test in two-way repeated measures data showed that the effects of group (P < 0.001, F=476.533), time (P < 0.001, F=85.248), and the interaction effect of time and group (P < 0.001, F=28.771) were significant. As can be seen in Graph 1, the average pain estimate at the three times studied was significantly lower in the white noise group than in the other groups and significantly higher in the control group than in the other groups (P < 0.001).

The pain level in the nature sounds group was significantly lower than in the lullaby group (P < 0.001). The results also showed that the pain estimates of the four groups during the intervention were lower than before (P = 0.026). The pain of the infants was significantly lower 5 min after the intervention than during the intervention (P < 0.001) and before the intervention (P < 0.001). It should be noted that in order to perform the mixed analysis of variance test in two-way repeated measures data, the variables of infant age, infant weight, 5-min Apgar and 9-min Apgar were controlled as confounding variables.

Table 4: The effect of intervention on pain in premature infants admitted to NICU

Effect	Parameter	B	Confidence Interval	P
Group Effect	Control	4.34	4.01−4.67	<0.001
	Nature sounds	0.16	0.01−0.31	0.504
	Lullaby sound	0.87	0.54−1.20	<0.001
	White Noise	Baseline		
Time Effect	Before intervention	0.75	0.36−1.13	0.003
	During intervention	0.45	0.25−0.65	0.067
	10 minutes after intervention	Baseline		

P < 0.05 is considered significant

The pain level of premature infants in the control group was 4.34 times (P < 0.001) and 0.87 times higher in the lullaby sound than in the white noise (P < 0.001), and there was no significant difference between the nature sound and the white noise. Also, the pain before the intervention was 0.75 times higher than 5 min after the intervention ($P = 0.003$) (Table 3).

The group and time effects of pain on the neonates are given in Table 4.

4. DISCUSSION

The results of the current study show that the average pain levels of the infants decreased during and after the intervention. However, in the control group, the pain during the intervention significantly increased compared to before, and 5 min after the intervention, it remained higher than prior to the intervention. Based on the results of our study, infants exposed to all three types of sounds experienced less pain compared to the control group at the three time points—before, during, and 5 min after the IV placement. It can be concluded that listening to lullabies, white noise, and nature sounds effectively reduces the pain of the participating infants. In various studies, the effect of these three types of sounds has been examined separately with a control group. In studies, the positive effect of lullaby on reducing pain in infants and children during invasive procedures such as vaccination,[27] reducing anxiety, and a sense of closeness between mother and infant. Fancourt and Perkins (2018) have shown in a study consistent with the present study, that there was a significant difference between the control and experimental groups, indicating the effect of the mother's voice on reducing pain in infants during arterial blood sampling.[28] In another study on the effect of lullaby with the mother's voice on physiological responses, following endotracheal tube suction in premature infants, they concluded that lullaby in the mother's voice in caring for premature infants can have a significant effect on the physiological responses of infants and the level of pain.[29] Another study showed that lullabies played during invasive interventions for premature infants reduced pain scores. which was consistent with the results of the present study.[30] Previous studies also showed that the mother's voice produced similar results.[31-33]

Other studies have shown that musical sounds have a positive effect on reducing pain during invasive procedures in infants.[34,35] Studies on the effects of nature sounds are very few, and most studies have considered the above sounds as sounds of musical types. In a study consistent with the present study, which used nature sounds, the results showed that nature sounds are an effective non-pharmacological method for reducing pain, reducing crying time, and improving vital signs. The sound of nature is a monotonous sound that consists of different environmental sounds with different frequencies, such as wind blowing through trees, waterfalls, rain, or ocean waves. It is a whispering and constantly monotonous sound, so it resembles the sound of a mother's womb. It has been proven that babies are influenced and calmed by the mother's heartbeat before birth and are calmed by hearing this familiar sound and rhythm after birth.[36]

Studies on the effect of white noise on infant pain have been based on the premise that white noise is a familiar sound for infants, and most studies have shown a positive effect of white noise on pain and a sense of calm in infants.[13,37,38] The effect of white noise in shortening the period of adaptation of infants to the outside world during the postpartum period has been investigated.[39] White noise is a uniform auditory stimulus without rapid changes in intensity and is usually similar to nature sounds such as the sea or rain. When exposed to white noise in the womb, the infant can hear its mother's heartbeat, blood flow in large vessels, and the sounds of uterine and digestive tract movements.[37] Since premature infants are familiar with these sounds, white noise therapy may be more effective in reducing pain symptoms. Several studies have investigated the effects of auditory stimuli such as white noise on premature infants. The results showed a reduction in stress and unstable vital signs, improved physiological function, and neurobehavioral development in premature infants.

According to the results of the present study, the average pain estimate at the three times studied was significantly lower in the white noise group than in the other groups, and significantly higher in the control group than in the other groups. The pain in the nature sound group was significantly lower than in the lullaby sound group. Few previous studies reported no significant effect of white noise during other procedures, such as heel lancet and pain after surgery.[40] These discrepancies may be related to differences in procedure type, intervention methods, or pain assessment tools. Our study demonstrated that, among the auditory interventions, white noise was notably more effective in reducing pain levels during and after the intravenous line placement when compared to the control group. This aligns with existing literature that suggests white noise may create a soothing auditory backdrop that masks disruptive environmental sounds, promoting a sense of security and comfort in infants. While lullabies and nature sound also contributed to pain alleviation, white noise demonstrated a more pronounced effectiveness in our results. Further exploration of different types of white noise (e.g., varying frequencies or volumes) could provide additional insights into optimizing its use for pain relief. Incorporating white noise machines into neonatal care could be a straightforward and cost-effective strategy to improve comfort for premature infants during invasive procedures.

5. LIMITATIONS

As with any study, the findings are subject to limitations, such as the small sample size and the specific conditions under which the study was conducted. Future research should consider a larger cohort and varied NICU settings to examine the broader applicability of these findings.

6. CONCLUSION

In conclusion, our study highlights that white noise is a particularly effective auditory intervention for managing pain in premature infants, offering a practical approach for clinicians in the NICU. By integrating white noise into routine care, healthcare professionals can enhance the comfort and emotional well-being of these vulnerable patients, further contributing to improved health outcomes. Continued research into the diverse applications of auditory stimuli in neonatal care will be essential for optimizing pain management strategies.

7. Data availability

The numerical data generated during this research is available with the authors.

8. Conflict of interest

All authors declare that there was no conflict of interest.

9. Funding

The study utilized the hospital resources only, and no external or industry funding was involved.

10. Authors' contribution

SN: literature search, data collection, write manuscript draft

MS: design, Literature search, data collection

MR: corresponding author, statistical analysis, manuscript editing.

11. REFERENCES

1. Batey N, Henry C, Garg S, Wagner M, Malhotra A, Valstar M, et al. The newborn delivery room of tomorrow: emerging and future technologies. Pediatr Res. 2024;96(3):586-94. PubMed DOI: 10.1038/s41390-022-01988-y
2. Barzegari A, Akbarian Rad Z, Nikbakht H, Qalehsari M, Jafarian Amiri S, Zabihi A, et al. Frequency and pain intensity of painful procedures in premature infants hospitalized in the neonatal intensive care unit. J Educ Health Promot. 2024;13(1):467. PubMed DOI: 10.4103/jehp.jehp_1042_24
3. Cruz M, Fernandes A, Oliveira C. Epidemiology of painful procedures performed in neonates: a systematic review of observational studies. Eur J Pain. 2016;20(4):489-98. PubMed DOI: 10.1002/ejp.757
4. Rodrigues AC, Guinsburg R. Pain evaluation after a non-nociceptive stimulus in preterm infants during the first 28days of life. Early Hum Dev. 2013;89(2):75-9. PubMed DOI: 10.1016/j.earlhumdev.2012.08.002
5. Onianwa P, Alonge T, Otegbayo J, Ike E, Chukura F, Are O, et al. Pain as 5th vital sign: impact of pain assessment training program on Nigerian nurses' knowledge of pain management. Int J Nurs Midwifery. 2017;9(11):129-35. DOI: 10.5897/IJNM2017.0283
6. Bouza H. The impact of pain in the immature brain. J Matern Fetal Neonatal Med. 2009;22(9):722-32. PubMed DOI: 10.3109/14767050902926962
7. Grunau R, Holsti L, Peters J. Long-term consequences of pain in human neonates. Semin Fetal Neonatal Med. 2006;11(6):268-75. PubMed DOI: 10.1016/j.siny.2006.02.007
8. Chen X, Li R, Xiong A, Luo B. A review and bibliometric analysis of global research on non-pharmacologic management for neonatal and infant procedural pain. Medicine. 2024;103(48):e40552. PubMed DOI: 10.1097/MD.0000000000040552
9. Gimbler-Berglund I, Ljusegren G, Enskär K. Factors influencing pain management in children. Nurs Child Young People. 2008;20(10):21-4. PubMed DOI: 10.7748/paed2008.12.20.10.21.c6901
10. Weng Y, Zhang J, Chen Z. Effect of non-pharmacological interventions on pain in preterm infants in the neonatal intensive care unit: a network meta-analysis of randomized controlled trials. BMC Pediatr. 2024;24(1):9. PubMed DOI: 10.1186/s12887-023-04488-y
11. Bergomi P, Chieppi M, Maini A, Mugnos T, Spotti D, Tzialla C, et al. Nonpharmacological techniques to reduce pain in preterm infants who receive heel-lance procedure: A randomized controlled trial. Res Theory Nurs Pract. 2014;28(4):335-48. PubMed DOI: 10.1891/1541-6577.28.4.335
12. Shen M, Ding X, Fu L, He H, Chen S, Hu Y, et al. Comparative effectiveness of multi-sensory interventions for reducing pain among premature infants: A systematic review and network meta-analysis. Int J Nurs Stud. 2024;:104947. PubMed DOI: 10.1016/j.ijnurstu.2024.104947
13. Cetinkaya S, Yavas Celik M, Ozdemir S. Effect of white noise on alleviating the pain of new-born during invasive procedures. J Matern Fetal Neonatal Med. 2022;35(8):1426-32. PubMed DOI: 10.1080/14767058.2020.1755652

14. Bekar P, Efe E. Effects of mother-sung lullabies on vaccination-induced infant pain and maternal anxiety: A randomized controlled trial. J Pediatr Nurs. 2022;65:e80-e6. PubMed DOI: 10.1016/j.pedn.2022.03.003

15. Zahadatpour Z, Edraki M, Ardekani S. Impact of Lullabies on Changes in Heart Rate during Tubal Tracheal Suction in Premature Infants. Iranian Nurs Sci Association. 2018;5(5). Full Text

16. Saadatmand V, Rejeh N, Heravi-Karimooi M, Tadrisi S, Zayeri F, Vaismoradi M, et al. Effect of nature-based sounds' intervention on agitation, anxiety, and stress in patients under mechanical ventilator support: A randomised controlled trial. Int J Nurs Stud. 2013;50(7):895-904. PubMed DOI: 10.1016/j.ijnurstu.2012.11.018

17. Mohseni H, Ramezani M, Saki A, Poor-Alizadeh N. Comparison of the Effect of the White Noise and Sound Reduction on Behavioral Responses of Premature Infants Under Noninvasive Ventilation: A Clinical Trial. J Perinat Neonatal Nurs. 2025. PubMed DOI: 10.1097/JPN.0000000000000902

18. Kahraman A, Gümüş M, Akar M, Sipahi M, Yılmaz H, Başbakkal Z. The effects of auditory interventions on pain and comfort in premature newborns in the neonatal intensive care unit; a randomised controlled trial. Intensive Crit Care Nurs. 2020;61:102904. PubMed DOI: 10.1016/j.iccn.2020.102904

19. Zulaikha F, Sureskiarti E, Herlina N, Hindun S, Handayani M. The Effect of Auditory Stimulation Theraphy for Baby's Pain Scale. Indones J Glob Health Res. 2021;3(2):185-92. Full Text

20. Cong X, McGrath J, Delaney C, Chen H, Liang S, Vazquez V, et al. Neonatal nurses' perceptions of pain management: survey of the United States and China. Pain Manag Nurs. 2014;15(4):834-44. PubMed DOI: 10.1016/j.pmn.2013.10.002

21. Bruene D. Neonatal Pain Management. Pain Manag Nurs. 2025;26(2):e224.

22. Frickmann F, Urman R, Siercks K, Burgermeister G, Luedi M, Lersch F. The effect of perioperative auditory stimulation with music on procedural pain: a narrative review. Curr Pain Headache Rep. 2023;27(8):217-26. PubMed DOI: 10.1007/s11916-023-01138-x

23. Ting B, Tsai C, Hsu W, Shen M, Tseng P, Chen D, et al. Music intervention for pain control in the pediatric population: A systematic review and meta-analysis. J Clin Med. 2022;11(4):991. PubMed DOI: 10.3390/jcm11040991

24. Hüppi P, Filippa M. Multisensory stimuli and pain perception in the newborn. Pediatr Res. 2024;95(3):603-4. PubMed DOI: 10.1038/s41390-023-02833-6

25. Lawrence J, Alcock D, McGrath P, Kay J, MacMurray S, Dulberg C. The development of a tool to assess neonatal pain. Neonatal Netw. 1993;12(6):59-66. PubMed

26. Sarhangi F, Mollahadi M, Ebadi A, Matinzadeh Z, Tadrisi S. Validity and reliability of neonatal infant pain scale in neonatal intensive care units in Iran (2010). Pak J Med Sci. 2011;27(5):1087-91. Full Text

27. Baik-Schneditz N, Pichler G, Schwaberger B, Mileder L, Avian A, Urlesberger B. Peripheral intravenous access in preterm neonates during postnatal stabilization: feasibility and safety. Front Pediatr. 2017;5:171. PubMed DOI: 10.3389/fped.2017.00171

28. Azarmnejad E, Sarhangi F, Javadi M, Rejeh N, Amirsalari S, Tadrisi S. The effectiveness of familiar auditory stimulus on hospitalized neonates' physiologic responses to procedural pain. Int J Nurs Pract. 2017;23(3):e12527. PubMed DOI: 10.1111/ijn.12527

29. Pouraboli B, Rayyani M, Hosseini F, Dehghan M. Effects of Mothers Lullaby on Physiological Responses in Premature Infants Receiving Endotracheal Suctioning. 2019;5(4):11-17;. Full Text

30. Tekgündüz K, Polat S, Gürol A, Apay S. Oral glucose and listening to lullaby to decrease pain in preterm infants supported with NCPAP: a randomized controlled trial. Pain Manag Nurs. 2019;20(1):54-61. PubMed DOI: 10.1016/j.pmn.2018.04.008

31. Kurdahi Badr L, Demerjian T, Daaboul T, Abbas H, Hasan Zeineddine M, Charafeddine L. Preterm infants exhibited less pain during a heel stick when they were played the same music their mothers listened to during pregnancy. Acta Paediatr. 2017;106(3):438-45. PubMed DOI: 10.1111/apa.13666

32. Azarmnejad E, Sarhangi F, Javadi M, Rejeh N. The effect of mother's voice on arterial blood sampling induced pain in neonates hospitalized in neonate intensive care unit. Glob J Health Sci. 2015;7(6):198-204. PubMed DOI: 10.5539/gjhs.v7n6p198

33. Chirico G, Cabano R, Villa G, Bigogno A, Ardesi M, Dioni E. Randomised study showed that recorded maternal voices reduced pain in preterm infants undergoing heel lance procedures in a neonatal intensive care unit. Acta Paediatr. 2017;106(10):1564-8. PubMed DOI: 10.1111/apa.13944

34. Caparros-Gonzalez R, de la Torre-Luque A, Diaz-Piedra C, Vico F, Buela-Casal G, Dowling D, et al. Listening to relaxing music improves physiological responses in premature infants. Adv Neonatal Care. 2018;18(1):58-69. PubMed DOI: 10.1097/ANC.0000000000000448

35. Tang L, Wang H, Liu Q, Wang F, Wang M, Sun J, et al. Effect of music intervention on pain responses in premature infants undergoing placement procedures of peripherally inserted central venous catheter: A randomized controlled trial. Eur J Integr Med. 2018;19:105-9. DOI: 10.1016/j.eujim.2018.03.006

36. Karakoç A, Türker F. Effects of white noise and holding on pain perception in newborns. Pain Manag Nurs. 2014;15(4):864-70. PubMed DOI: 10.1016/j.pmn.2014.01.002

37. Alemdar D. Effect of recorded maternal voice, breast milk odor, and incubator cover on pain and comfort during peripheral cannulation in preterm infants. Appl Nurs Res. 2018;40:1-6. PubMed DOI: 10.1016/j.apnr.2017.12.001

38. Azizi A, Ghafoorpoor Yazdi P, Azizi A, Ghafoorpoor Yazdi P. White noise: applications and mathematical modeling. In: Computer-Based Analysis of the Stochastic Stability of Mechanical Structures Driven by White and Colored Noise. SpringerBriefs in Applied Sciences and Technology. Springer, Singapore; 2019. p. 25-36. Abstract

39. Pietrzak J, Kurdyś P, Surówka Ł, Obuchowicz A. Stosowanie urządzeń wytwarzających biały szum u niemowląt i małych dzieci w ocenie ich rodziców. Pediatr Med Rodz. 2019;15(3):291-6. DOI: 10.15557/PiMR.2019.0049

40. Alemdar D, Özdemir F. Effects of covering the eyes versus playing intrauterine sounds on premature infants' pain and physiological parameters during venipuncture. J Pediatr Nurs. 2017;37:e30-e6. PubMed DOI: 10.1016/j.pedn.2017.06.016

