

Comprehensive Overview of Preterm Developmental Supportive Care: Narrative Review

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Abstract: *Background:* Preterm infants face significant health challenges due to the underdevelopment of their organ systems. The neonatal intensive care unit (NICU) is considered a stressful environment, which can disrupt self-regulation and maturation. Developmental supportive care strategies have been shown to enhance neurodevelopmental outcomes in neonates by mimicking intrauterine conditions, reducing stress, and providing appropriate sensory stimulation. Nursing interventions, particularly developmental care, are essential in improving neonatal health, with nurses playing a pivotal role in implementing these strategies.

Aim: This article aimed to provide a comprehensive narrative synthesis of recent research on the impact of developmental supportive care on the health outcomes of preterm infants.

Methods: An extensive literature search was conducted across PubMed, Scopus, Web of Science, Google Scholar, and the Cochrane Library. Quantitative studies, quasi-experimental research, observational studies, and meta-analyses of randomized clinical trials published in English within the past decade were included, with a particular emphasis on studies from the last five years.

Results: The findings indicated that the application of developmental supportive care strategies in the neonatal intensive care unit significantly improved health outcomes for preterm infants, as reported in previous studies.

Conclusion: This narrative overview demonstrated that developmental supportive care effectively contributes to the management and enhancement of preterm infants' health. The study recommends promoting and standardizing these practices in neonatal intensive care units, conducting a collective review of developmental supportive care techniques, and establishing training programs to improve health outcomes for preterm infants and identify effective interventions.

Keywords: Developmental supportive care, preterm care, neuroprotective strategies, neonatal intensive care unit.

INTRODUCTION

Preterm newborns are those born early with short gestation before completing 37 weeks. Preterm newborns are defined as infants born before completing 37 weeks of gestation [1]. Approximately 15 million preterm infants are born each year worldwide, and they account for 75% of perinatal fatalities and 50% of long-term morbidity. Preterm birth significantly increases the risk of neonatal mortality and morbidity [2,3]. Due to underdeveloped organ systems and, in some cases, congenital abnormalities, preterm infants experience numerous health complications. These complications frequently involve the gastrointestinal, circulatory, and central nervous systems, necessitating admission to the neonatal intensive care unit (NICU) [4,5].

The uterine environment offers essential protection and support, minimizes fetal stress, and promotes the maturation of the fetal nervous system. Because of premature birth and immature organ development, preterm infants are exposed to numerous stressors that

may impede healthy brain development [6]. Most hospitalized infants experience fear and pain during medical procedures. Non-pharmacological pain management measures, such as deep breathing, help reduce children's fear and discomfort [7]. Promoting the development and adoption of modern aspects that focus entirely on determining tension in preterm infants would permit nurses to execute more accurate actions tailored to the specific needs of each infant [8].

Developmental supportive care (DSC) strategies in NICUs are designed to improve neurodevelopmental outcomes in preterm neonates by simulating intrauterine conditions, minimizing stress, providing appropriate sensory stimulation, and promoting optimal growth and development, and developmental supportive care strategies for preterm neonates include environmental noise reduction, light reduction, smell and taste stimulation, non-nutritive sucking (NNS), Kangaroo mother care (KMC), and postural support [9-11].

Developmental care addresses the essential needs of infants and adapts the NICU environment to provide appropriate care. This approach encourages its integration into clinical policies to support optimal brain

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development in infants [12]. The stress reduction strategy was developed as a sensory activity map for preterm infants, providing user-friendly information to optimize sensory development and reduce stress. This approach is based on the interconnectedness of the infant's senses and the importance of stimulating them at appropriate times to promote optimal growth in preterm infants in the NICU [13].

Nurses' knowledge required to support the development and well-being of preterm infants can be effectively enhanced and knowledge decay mitigated through interactive learning using mobile applications [14]. The use of electronic nursing documentation is also a key factor in ensuring accurate information and increasing the time efficiency of nursing staff [15]. Health outcomes can be significantly improved by advancing nursing care through fostering more humanistic and supportive relationships [16]. A developmental care model, along with its key elements, has been established, particularly for preterm infants. Evidence suggests that implementing this model in the NICU can enhance developmental outcomes for preterm infants when applied by nurses [17]. There is a need to increase awareness of the positive effects of implementing developmental supportive care for premature infants, and to emphasize the importance of a more integrated, comprehensive, and multidisciplinary approach that incorporates the various components of developmental supportive care, which may lead to more effective interventions and improved outcomes for this vulnerable population [18,19].

These development measures, along with standard procedures, have been highlighted in many studies as emphasizing the importance of providing educational programs for nursing staff to enhance their knowledge and practices related to pain management [20], intravenous infusion for preterm infants [21], endotracheal suction procedures for preterm infants [22], nasogastric tube for preterm infants [23], neonatal parenteral nutrition [24], and physiotherapy [25]. This article aims to highlight and provide a comprehensive narrative synthesis of the most recent research on the impact of developmental supportive care on the health of preterm infants.

RESEARCH METHODOLOGY

This approach enables a comprehensive analysis of the physiological, developmental, and psychological effects of developmental supportive care interventions

for preterm neonates through a narrative synthesis [26,27].

Current research reveals a gap, as it has predominantly focused on isolated interventions of DSC rather than a wide range of interventions that enhance DSC for preterm infants [18,19]. To improve the quality and effectiveness of care provided to preterm infants, further studies are needed to address various aspects of DSC, including environmental management and individualized care practices. As a starting point, the review question was identified: What are the health outcome indicators associated with developmental supportive care interventions for preterm infants in the NICU? The inclusion criteria were established to ensure that only studies published in the last 10 years (2015-2025), with particular focus on those from the most recent five years, investigating one or more interventions among identified DSC strategies — including environmental noise reduction, light reduction, olfactory and gustatory stimulation, non-nutritive sucking, kangaroo care, and postural support — and their impact on health outcomes were included.

Articles published in English were considered eligible. A comprehensive search was conducted to include quantitative studies, randomized controlled trials (RCTs), quasi-experimental studies, observational studies, and meta-analyses of randomized clinical trials. The literature search was carried out across multiple databases, including PubMed, Scopus, Web of Science, Google Scholar, and the Cochrane Library, using specific keywords such as neonatal intensive care unit (NICU), preterm neonates, developmental care, neurodevelopmental support, physiological effects, oxygen saturation (SpO₂, SaO₂), respiratory stability, weight gain, stress reduction, pain management, sleep protection, noise and light reduction in NICU, olfactory and gustatory stimulation, breastfeeding scent, non-nutritive sucking, pacifiers, kangaroo care, skin-to-skin contact, postural support, positioning, and containment. Following the search, relevant references were compiled, and duplicates were removed. All pertinent studies were selected, data were extracted, and results were synthesized and summarized.

The analyzed data included paper titles, aims, methodologies, results, conclusions, and recommendations. During the title screening phase, 323 studies were retrieved, and after removing duplicates, 299 remained. Titles and abstracts were reviewed, resulting in 134 articles. Articles failing to meet the selection criteria were excluded, leaving

twenty-eight articles that met eligibility criteria and were included in this study.

RESULT

The twenty-eight included studies were thoroughly reviewed and categorized into eight intervention types: four studies focused on noise reduction interventions, three studies on light reduction interventions, including two studies that combined both noise and light reduction.

Regarding olfactory stimulation, three studies were identified, with only one study investigating combined olfactory and gustatory stimulation. Non-nutritive sucking interventions were addressed in two studies, kangaroo care interventions in four studies, and tactile stimulation interventions in four studies.

Finally, seven studies examined the effects of supported positioning and posture on premature infants.

DISCUSSION

Effect of Reducing Noise Levels on Premature Baby

Environmental noise levels in the NICU exceeded the recommendations of the American Academy of Pediatrics. They were associated with adverse effects on the vital signs and sleep patterns of preterm infants [28]. A study showed that the use of earmuffs in premature infants significantly reduced stress scores and RR, but did not have a significant effect on other physiological parameters, such as HR, SpO₂, and BP [29]. The 'quiet time protocol' is an intervention implemented to enhance the sleep quality of infants. This protocol involves reducing light and sound, minimizing patient handling, and educating staff about the adverse effects of noise. Such measures are crucial for the neurodevelopment of preterm infants, as they help stabilize physiological parameters and reduce stress [30].

Another study demonstrated that enhancing and regulating the environment for preterm neonates improved their physiological functions by reducing fluctuations in HR, RR, and SpO₂ [31]. In the same context, the study reported that clustered care significantly improved the sleep behaviors of preterm neonates by promoting longer periods of both quiet and active sleep. The findings also emphasized the importance of encouraging nurses to adopt cluster care practices [32].

Effect of Reducing Lighting and Vision Levels on Premature Baby

The French Neonatal Society recommends implementing gradual changes in lighting within NICUs and avoiding rapid increases in light intensity, as abrupt changes have the strongest influence on infants' physiological stability. Continuous exposure to bright light can negatively impact the growth and development of preterm infants [33]. A study found that combining ear protectors and eye covers was beneficial in alleviating pain associated with venipuncture in preterm infants and suggested this approach as an effective non-pharmacological method for pain relief during painful procedures in this population [34]. Other interventions demonstrated that the use of earplugs and eye covers effectively decreased physiological parameters, including RR, HR, systolic and diastolic blood pressure, and SaO₂, as well as behavioral responses in preterm infants exposed to crowded and brightly lit NICU environments [35]. Regarding the effects of a light-darkness cycle, the study found that exposure to a regulated light-dark cycle had a positive impact on infants' weight gain and reduced the length of their stay in the NICU. Infants in the experimental group who experienced the light/dark cycle showed greater weight increases and shorter hospitalization durations compared to those in the control group [36].

Effect of Smell and Taste Stimulation on Premature Baby

Stimulation of breast milk taste and smell in premature neonates, when combined with tube feeding, demonstrates positive neurodevelopmental effects for preterm infants and their families, serving as a simple and cost-effective intervention [37]. The study recommends the routine use of breastfeeding-related olfactory stimulation for premature neonates in NICUs. It emphasizes the need to enhance nurses' education regarding this intervention, due to the importance of continuous olfactory stimulation in improving physiological indices HR, SpO₂, and RR and reducing distress-related behavioral responses [38]. This finding was supported by another study, which demonstrated that olfactory stimulation using maternal milk reduced fluctuations in both SpO₂ and HR before and after blood draws in preterm infants. It also showed that this intervention had a soothing effect as a non-pharmacological method during stressful procedures [39]. Results also showed that olfactory and gustatory stimulation for preterm infants improved oral and motor

Table 1: Summary of the Reviewed Research

DSC	Study title	Study design	Population (sample size)	Study aims	Intervention applied	Study results	Conclusions and Recommendations
Noise Reduction	"Effect of Using Earmuffs on Physiological Parameters and Stress Levels of Premature Infants: A Randomised Controlled Trial." [29]	RCT	One hundred preterm infants were divided into a study group and a control group, with fifty infants in each group.	To study whether stress and physiological measures were impacted following the implementation of noise management through the placement of earplugs on preterm infants in the NICU.	Intervention using earplugs for infants, in which the study group of infants used earplugs twice daily, while the control group did not receive earplugs, to evaluate the effect of noise reduction on preterm infants.	A decrease in stress and RR was noted in the study group, thus the use of earplugs was found to be effective for these two outcomes; however, it did not have a significant effect on other measures such as HR, SpO ₂ , or BP in infants.	The stress levels and RR of premature babies can be reduced by using appropriately fitted earplugs. The use of earplugs is recommended to decrease distress.
	"Interventional Effect of Quiet Time Protocol on the Physiological Parameters of Premature Neonates Admitted to the Neonatal Intensive Care Unit." [30]	Quasi-Experimental study.	Sixty-two preterm infants in the NICU were divided into intervention and control groups, with thirty-one infants in each group.	To evaluate the physiological parameters of preterm infants in the NICU and the extent to which they are affected by the quiet time protocol.	Using the 'quiet time protocol' by reducing noise and light exposure, including moving the neonate to a separate room, reducing lighting, minimizing movements and conversations, minimizing alarms, placing an incubator cover, and silencing phones, with monitoring physiological variables.	HR and RR were reduced with quiet time in the NICU, but these changes were not statistically significant. However, a significant improvement in SaO ₂ was observed with the implementation of quiet time practices.	The quiet time protocol has been shown to improve SaO ₂ and promote the growth of preterm infants without adversely affecting physiological parameters. Its adoption is therefore recommended for the care of preterm infants.
	"Effect of Earmuffs on Physiological Parameters of Preterm Neonates Nursed in Incubators: A Before-and-After." Study." [31]	Crossover Study by Non-Randomized.	Sixty preterm infants	To determine whether the physiological parameters of preterm infants (HR, RR, and SpO ₂) are affected by the use earplugs	The HR, RR, and SpO ₂ of 60 stable preterm infants were monitored both while using earmuffs in incubators and when earmuffs were not used.	The use of earmuffs resulted in significant reductions in cases of hypoxia, tachypnea, and tachycardia compared to the control phase; additionally, earmuff use improved stability in HR and SpO ₂ .	Earmuffs have been shown to stabilize physiological parameters; therefore, they may improve stability and health outcomes in preterm infants.
	"Effect of Clustered Nursing Care on Sleep Behaviors of the Preterm Neonates Admitted to the Neonatal Intensive Care Unit." [32]	Clinical Trial	Sixty neonates were equally divided between the control and intervention groups.	To examine whether sleep patterns are affected by the application of clustered nursing care for preterm infants in NICUs.	Clustered care involves performing multiple tasks (such as diaper replacement, abdominal girth measurement, axillary thermometry, and mouth care) during a single session rather than separately, in comparison to traditional care.	Cluster care intervention group experienced longer durations of quiet and active sleep compared to the control group, while the control group demonstrated longer periods of quiet wakefulness, increased alertness, and more frequent crying.	Clustered nursing care significantly improved the duration of both quiet and active sleep in preterm infants in the NICU. It is recommended to standardize clustered care practices and provide education for nurses.
Noise and Light Reduction	"Effect of eye shield and ear muffs on pain intensity during venous blood sampling in premature infants: a clinical trial study." [34]	Clinical Trial Study	A total of 148 preterm infants were equally divided into four groups, with 37 babies in each group.	To study whether pain intensity was affected by the use of ear muffs and eye shields during venous blood sampling in preterm infants.	Four groups were randomly assigned: one group received an eye shield, another group received ear muffs, a third group received both interventions, and the control group underwent routine blood collection. The interventions lasted for 15 minutes before and after blood draw.	There was a marked difference in pain ratings during and after blood sampling among the groups, with the lowest pain intensity observed in the group that received both ear muffs and eye shields.	Earplugs and eye protectors used in combination were found to more effectively reduce pain during venous blood collection. It is therefore recommended to use ear muffs and eye shields to suppress pain during this procedure.
	"Effect of Earplugs and Eye Cover on Physiological and Behavioural Responses among Preterm Infants in	Quasi-Experimental design.	A total of 120 preterm infants were divided into three equal groups of 40: one group	To examine whether behavioural and physiological responses are influenced when preterm infants wear eye patches	Preemies in the earplug and eye cover groups wore them for two hours each morning and afternoon to reduce noise and bright light, while the control group received	Preemies' behavioural and physiological responses (RR, HR, SaO ₂ , systolic and diastolic blood pressure during and within five minutes after interventions were	Preemies' behavioural and physiological responses were reduced by the use of eye patches and earplugs when the NICU was crowded and brightly lit. This

	Neonatal Intensive Care Unit." [35]		received earplugs, one group received eye covers, and one group served as the control.	and earplugs in the NICU.	standard care only.	improved by the application of eye patches and earplugs.	intervention is recommended for implementation during peak hours in crowded and brightly lit NICUs.
Light Reduction	"Effect of a light-darkness cycle on the body weight gain of preterm infants admitted to the neonatal intensive care unit." [36]	Randomized Multicentric clinical trial,	A total of 294 preterm infants were randomly divided into an experimental group of 150 (exposed to a light/darkness cycle) and a control group of 144 (exposed to constant bright light).	To examine whether the weight gain and timing of early discharge of preterm infants are affected by the implementation of a light/dark cycle in the NICU.	Experimental group was exposed to light/dark cycle shifts (dark from 19:00 to 07:00 and light from 07:00 to 19:00), while the control group remained under continuous bright light.	In the light-dark cycle group, infants gained weight earlier and had a shorter length of hospital stay compared to the continuous-bright-light group.	Preterm infants given an light/dark cycle showed improved physiological development, earlier weight gain, and shorter hospital stays; these findings suggest that further research is warranted.
Olfactory And Gustatory Stimulation	"Effect of Continuous Olfactory Stimulation Using Breast Milk on Physiological Indices and Behavioral Responses of Preterm Neonates." [38]	Quasi-Experimental design.	Sixty preterm infants were equally assigned to an olfactory stimulation group (n = 30) and a control group (n = 30).	To examine whether behavioural and physiological reactions are affected by continuous olfactory stimulation with maternal milk in preterm infants.	Ongoing olfactory stimulation with maternal milk was compared to a control group without stimulation, and the physiological and behavioral responses of newborns were examined over several days.	Ongoing olfactory stimulation with maternal milk improved behavioural and physiological indicators in the study infants compared to the control group.	Preemies' physiological and behavioral parameters were found to improve with breast milk smell, suggesting that it should be routinely provided in the NICU.
	"Effect of Olfactory and Gustatory Stimulations on Preterm Neonates' Feeding Progression and Sniffing Away Feeding Tube." [40]	Quasi-Experimental design.	Sixty preterm infants, with thirty assigned to the study group and thirty to the control group.	To determine whether the feeding progression and tube sniffing are affected by smell and taste stimulation in preterm infants.	Smell and taste stimulation were administered to preterm infants in the NICU using maternal breast milk provided both before and during tube feeding, and the outcomes were compared to those of traditional care without sensory stimulation.	Preterm infants who received smell and taste stimulation were faster in having the feeding tube removed and achieved full oral intake earlier. They also showed an increase in milk intake and weight compared to the control group.	Smell and taste stimulation was found to improve preterm neonates' feeding progression without causing harm. It is recommended that NICU policies and care guidelines include this intervention.
	"Analgesic effect of maternal human milk odor on premature neonates: a randomized controlled trial." [41]	Prospective, Randomized, Controlled, and double blinded.	33 neonates, with 17 in the control group while 16 were assigned to the breast milk odor group.	To examine the analgesic impact of the odor of breast milk on preterm infants, a standardized olfactory stimulation technique was used.	During venipuncture, neonates were randomly assigned to either a group exposed to the odor of mother's milk or a control group with an odor-free diffuser.	Infants exposed to breast milk odor during venipuncture demonstrated decreased pain responses, indicating greater analgesia and shorter crying times than the control group.	Exposure to breast milk odor during venipuncture has been shown to relieve pain through standardized olfactory stimulation. This non-pharmacological intervention is recommended for pain management in the NICU.
	"Effects of breast milk and vanilla odors on premature neonate's heart rate and blood oxygen saturation during and after venipuncture." [39]	RCT	135 preterm infants were divided equally into 3 groups: vanilla odor, control, and mother's milk odor.	To investigate whether vital signs, such as HR and SpO ₂ , were affected by the use of vanilla or breast milk odors during and after venipuncture.	Infants were exposed to the respective odors for five minutes before venipuncture and for thirty seconds afterward, with HR and SpO ₂ monitored using a calibrated pulse oximeter.	In comparison to the control group, the odor of mother's milk significantly reduced HR and SpO ₂ variability during and after venipuncture, whereas vanilla odor did not affect these vital signs.	The fluctuations in SpO ₂ and HR during and after venipuncture in preterm infants were reduced by the presence of maternal breast milk odor. NICU nurses can utilize the scent of breast milk as a soothing intervention during and after this procedure.

Non-Nutritive Sucking (NNS)	"The analgesic effect of non-nutritive sucking on neonates during invasive procedures." [43]	Experimental design	Sixty-four newborns were randomly assigned in equal numbers to two groups.	To evaluate the effectiveness of NNS in providing analgesia to neonates undergoing painful procedures.	NNS was provided to the treatment group, while traditional care was given to the control group, and neonates' pain was monitored and compared between the two groups.	The infants who received NNS (treatment group) experienced significantly less pain compared to the group that received traditional care (control group).	NNS was found to reduce neonatal pain during painful interventions. It is recommended to promote NNS in clinical practice, educate staff, and integrate NNS into care protocols.
	"Effects of pacifier use on transition to full breastfeeding and sucking skills in preterm infants: a randomized controlled trial." [44]	RCT	70 preemies were divided into two groups: 34 in the pacifier group and 36 in the control group.	To examine how pacifiers influence preterm infants' breastfeeding and sucking abilities.	The control group did not receive pacifiers, but the pacifier group used pacifiers until full breastfeeding was established, with infants being monitored throughout the intervention.	Pacifier use was shown to accelerate the onset of full breastfeeding and shorten the time to discharge compared to the control group. Additionally, the sucking skills of infants who used pacifiers improved significantly.	Pacifiers have been shown to improve sucking skills, accelerate the achievement of full breastfeeding, and shorten hospital stay in preterm infants; therefore, their use is recommended.
Kangaroo Care	"The effect of kangaroo mother care in improvement of weight gain and vital signs stability in preterm and critically ill neonates." [46]	Case-control study	88 neonates were divided into two groups: group 1 received KMC, while group 2 did not receive KMC.	Assess the influence of kangaroo care on weight gain and vital signs in severely ill preterm infants.	Group 1 received KMC through skin-to-skin contact, whereas group 2 did not receive KMC.	Group 1 that received KMC demonstrated higher Temp, lower RR approaching normal values, and greater weight gain than the group that did not receive KMC.	KMC promotes vital signs and physiological stability as well as weight gain in preterm and severely ill neonates. It is recommended to support KMC by highlighting its benefits and techniques and by assisting mothers to initiate it early.
	"The efficacy of Kangaroo-Mother care to the clinical outcomes of LBW and premature infants in the first 28 days: A meta-analysis of randomized clinical trials." [47]	Meta-Analysis of Randomized Clinical Trials (Rcts)	Seventeen randomized controlled trials involving 17,668 participants were included; fourteen studies focused on low birthweight infants, while three studies focused on preterm infants.	To examine how Kangaroo-Mother Care (KMC) improves health outcomes for preterm infants and low birth weight infants.	The analysis examined the effects of KMC on low birth weight infants and preterm neonates.	KMC was found to significantly reduce mortality, shorten the length of hospital stay, and lower the rates of sepsis and hypothermia among preterm infants with low birth weight.	KMC significantly reduced hypothermia, sepsis, length of hospitalization, and mortality rates among preterm and low birth weight infants. The findings suggest the need to standardize KMC clinical protocols and to conduct larger, randomized clinical trials.
	"Longer duration of kangaroo care improves neurobehavioral performance and feeding in preterm infants: a randomized controlled trial." [48]	RCT	120 preterm infants were divided into three groups: forty received KMC for 60 minutes per day, forty received traditional care, and forty received KMC for 120 minutes per day.	To investigate whether vital signs, neurobehavioral function, stress responses, and effective breastfeeding were affected by KMC in preterm infants.	KMC was administered for either 60 or 120 minutes per day, while the control group received usual care, for a minimum of 7 days. Neurobehavioral performance and physiological parameters, such as RR, HR, Temp, and SpO ₂ , were recorded before and after KMC.	Compared to the control group, both KMC groups showed reduced stress reactions and increased attention, regulation, and breastfeeding effectiveness. The group receiving 120 minutes of KMC demonstrated better SpO ₂ and Temp control than the group receiving 60 minutes of KMC.	Preemies who received longer durations of KMC achieved full oral feeding earlier and showed better neurobehavioral development, thermal stability, breastfeeding outcomes, and higher SpO ₂ levels. Prolonged KMC was therefore recommended, and further research was suggested to support these findings.
	"Effect of Kangaroo Care and Oral Sucrose on Pain in Premature Infants: A Randomized Controlled Trial." [49]	RCT	Sixty-four preterm infants were included, with thirty-two receiving kangaroo care and thirty-two receiving oral sucrose.	To examine whether pain relief during heel prick procedures was enhanced by oral sucrose and kangaroo care for preterm infants.	Preterm infants in the first group received KMC, while those in the second group received oral sucrose. Both groups were assessed for SpO ₂ , HR, and pain responses during and two minutes after heel stick exposure.	KMC outperformed oral sucrose in reducing pain among preterm infants undergoing heel stick.	Kangaroo Mother Care has been shown to be more effective in soothing pain in preterm infants during heel stick procedures, and this simple, natural technique is recommended for pain management in this population.

Tactile Stimulation	"Effectiveness of tactile stimulation on neurobehavioral development and the physiological parameters among neonates in NICU." [50]	Pre test-post test design	50 neonates, with 25 in the experimental group and 25 in the control group.	To examine how physiological and neurobehavioral functions are affected by tactile stimulation in preterm infants in the NICU.	The experimental group received tactile stimulation, while the control group received usual care. Neurobehavioral responses were assessed before and after tactile stimulation.	The experimental neonates' physiological and neurobehavioral parameters were significantly improved after tactile stimulation. This intervention positively affected HR and Temp.	Neonates' tactile stimulation was found to support physiological and neurobehavioral functions in the NICU. Further studies are recommended.
	"Effect of Tactile Stimulation on Neonatal Stress During Invasive Procedures at NICUs of Port Said." [52]	Quasi-Experimental design	A total of 130 neonates were included in the study.	To examine whether neonatal stress associated with invasive procedures was reduced by tactile stimulation in the NICU.	A structured tactile stimulation procedure was applied to neonates, alongside the assessment of stress scales before, during, and after the invasive procedure, both with and without tactile stimulation.	Invasive procedures with and without tactile stimulation differed significantly in behavioral, physiological, and motor parameters. Tactile stimulation was found to significantly reduce neonatal stress in the NICU.	Tactile stimulation has been shown to reduce stress in neonates during painful procedures in the NICU. Providing health education and conducting additional research are recommended.
	"The effect of gentle human touch during endotracheal suctioning on procedural pain response in preterm infant admitted to neonatal intensive care units: a randomized controlled crossover study." [53]	Randomized controlled crossover study	Thirty-four preterm neonates	To assess the effect of gentle human touch on procedural pain responses in preterm neonates during endotracheal suctioning.	Endotracheal suctioning was associated with the gentle human touch technique, by positioning the neonate in a fetal-like posture, with one hand gently placed around the infant's head and the other hand supporting the bottom.	Neonates undergoing suctioning with the application of gentle human touch showed significantly reduced mean pain scores.	The use of gentle human touch to manage pain during endotracheal suctioning in neonates is recommended to be routinely implemented in the NICU as a non-pharmacological technique to reduce pain.
	"Impact of Tactile Stimulation on Neurobehavioral Development of Premature Infants in Assiut City." [51]	Quasi-Experimental design.	Fifty preterm infants, with twenty-five assigned to the study group and twenty-five to the control group.	To examine whether neurobehavioral functions were affected by tactile stimulation of preterm infants.	Study infants were given tactile stimulation, while control infants received traditional care, and neurobehavioral functions were assessed.	Neurobehavioral functions of preemies were significantly enhanced in the study group compared to the control group, with a significant difference observed between the two groups.	Neurobehavioral development was enhanced by tactile stimulation of preterm infants. It is recommended that this intervention be routinely provided to stable infants in NICUs, and that additional health education and research be conducted to support its implementation.
Supported Positioning and Posture	"Nesting Technique: The Effects on Preterm Cardiorespiratory Indicators." [54]	RCT	Sixty preterm infants were randomly assigned to four groups: right lateral, control, prone, and supine, with fifteen infants in each group.	To examine whether cardiorespiratory indices in the right lateral, supine, and prone positions were affected by nesting intervention in preterm infants.	Nesting was performed for the preterm infants in their four groups, and SpO ₂ , RR, and HR were recorded prior to and after exposure; the outcomes were then compared.	Nesting in the right lateral, supine, and prone positions was associated with improvements in SpO ₂ , RR, HR, and Temp after three days of intervention.	Nesting was shown to improve the regulation of cardiopulmonary function in preterm infants; the authors suggested that it should be implemented with optimal positioning in the NICU.
	"Impact of a short period of prone versus supine nursing in preterm neonates less than 32 weeks on weight gain: A prospective observational study." [57]	Prospective observational study	The sample consisted of 22 preterm neonates.	To investigate whether weight gain was affected by the supine versus prone positions of preterm infants born before 32 weeks of gestation.	Infants were placed in the prone position for three days and in the supine position for another three days, except during feeding and for the half-hour afterwards; weight was recorded daily.	In the prone position, infants gained weight more effectively compared to the supine position, but the difference was not significant.	Preterm infants gained more weight in the prone position than in the supine position; therefore, the use of the prone position for stable infants, under observation, has been suggested to conserve energy.
	"Efficacy of nesting on physiological parameters	Experimental pretest-posttest control	Sixty preterm infants, with thirty	To examine how physiological measurements in experimental and	Nesting was performed for the preterm infants, and measurements of	In experimental infants, there were significant improvements in physiological	Nesting improved preterm infants' Temp, SpO ₂ , RR, HR, and weight in the NICU.

among preterm babies admitted at tertiary care hospital Karad." [55]	group study	assigned to the experimental group and thirty to the control group.	control groups were affected by nesting in preterm infants.	SpO ₂ , RR, HR, Temp, and weight were recorded over five days.	measurements of SpO ₂ , RR, HR, and Temp, while weight did not show a marked difference.	
"Effect of Different Positions on Gastric Residual Volume of Preterm Neonates at Neonatal Intensive Care Unit." [58]	Quasi-experimental design	Sixty preterm infants were included, with thirty assigned to the positioning intervention group and thirty to the traditional care control group.	To examine whether gastric residual volume is affected by different positions of preterm infants in the NICU.	Study infants who received gavage nutrition were positioned in multiple positions—prone, right lateral, and supine—and then had their gastric residual volume assessed and compared. In contrast, control infants received traditional care after feeding.	The prone position was associated with the lowest gastric residual volume, followed by the right lateral position, while the supine position showed the highest gastric residual volume.	The gastric residual volume was lower in the prone position, followed by the right-side position, which helped preterm infants tolerate feeding. It is suggested to provide education about these positions and to conduct further studies.
"Comparison of the Effects of Supine and Prone Positions on Oxygen Saturation and Vital Signs in Premature Infants: A Crossover Clinical Trial." [59]	Crossover clinical trial	Twenty-two preterm infants were divided into two groups, Group 1 and Group 2.	To investigate whether vital signs and SaO ₂ were affected by the prone and supine positions in preterm infants.	Newborns were divided into two groups: group 1 with supine for 3 hours and next prone for 3 hours, while group 2 was the inverse procedure. Fifteen-minute intervals, SaO ₂ , RR and HR were measured.	The prone position of infants was associated with a marked increase in SaO ₂ , and a decrease in RR and HR compared to the supine position.	Infants achieved better regulation when positioned in the prone rather than the supine position with respect to HR, RR, and SaO ₂ ; therefore, the prone position is recommended to enhance physiological stability, with careful monitoring and consideration of the newborn's condition, and should not be used at home.
"Effect of positioning on physiological parameters on low birth weight preterm babies in neonatal intensive care unit." [56]	Experimental design with control group	40 preemies, with 20 assigned to the nesting (experimental) group and 20 to the traditional wrapping (control) group.	To assess infants' SaO ₂ , RR, axillary Temp, and HR before and sixty minutes after nesting	SaO ₂ , RR, HR, and Temp were monitored in the experimental group both before and 60 minutes after nesting; the same parameters were measured in the control group before and 60 minutes after traditional care, over a period of five days.	Nesting greatly enhanced and regulation of infants' Temp, and lowered and regulation their mean HR and mean RR. No significant difference in SpO ₂ was observed post-intervention.	Nesting was found to enhance and regulate preterm infants' physiological functions. the study recommended the implementation of nesting in NICUs with more research.
"The effects of flexed (fetal tucking) and extended (free body) postures on the daily sleep quantity of hospitalized premature infants: A randomized clinical trial." [60]	Randomized Clinical Trial	Thirty-two premature infants.	To compare the daily sleep duration of preterm infants between fetal positioning (flexed) and free posture (extended).	Over a 12-hour period each day for four days, infants were assigned to one of four conditions: free body posture in supine or lateral positions, or facilitated fetal tucking in supine or lateral positions; all sessions were recorded on video.	Babies in facilitated fetal tucking posture and lateral position, had longer sleep durations than in an extended posture or supine position.	Infants slept longer and were less awake with flexed posture and lateral position. The study highlighted the importance of this intervention and the potential for integrating it into routine care in the NICU, and suggested further research.

function, accelerated the initiation of oral feeding, increased milk intake, enhanced weight gain, reduced adverse effects, and shortened the time required to achieve complete oral feeding (faster time to aspirating a feeding tube). The study recommended implementing educational programs for nurses and incorporating these interventions into NICU policies [40].

Another study investigated the soothing effect of maternal milk odor stimulation on preterm infants during blood draws and proposed this approach as a

non-pharmacological pain management strategy in the neonatal unit, as it was found to reduce the duration of crying following blood collection [41].

Effect of Non-Nutritive Sucking on Premature Baby

Non-nutritive sucking (NNS) is a simple intervention that facilitates the development of swallowing, breathing, and sucking coordination, while also supporting the maturation of the nervous system. Safe oral feeding requires the harmonious integration of

these functions [42]. NNS has been utilized in NICUs and has been shown to effectively reduce pain in neonates during painful procedures such as venipuncture. The study emphasized the importance of educating healthcare providers about the benefits and proper techniques of NNS in neonatal care [43]. The use of pacifiers in premature infants has been shown to accelerate the development of sucking ability, facilitate an earlier transition to exclusive breastfeeding, and reduce hospitalization duration, highlighting the significance of this intervention in the NICU [44].

Effect of Kangaroo Care on Premature Baby

The concept of Kangaroo Mother Care (KMC) originated in the early 1970s, with a focus on immediate skin-to-skin contact between mother and newborn immediately after birth. This practice later became known as "skin-to-skin contact," "Kangaroo Care," or "Kangaroo Mother Care (KMC)," and has been associated with numerous benefits for both mothers and their infants [45]. In a study, KMC was associated with improved vital signs, including a significant increase in body temperature (Temp), normalization of RR and HR after one hour of KMC, as well as increased weight gain and a statistically significant improvement in Apgar scores among the KMC group compared to the group without KMC. These findings support the role of KMC in promoting the stability and health of both preterm and full-term newborns [46].

A meta-analysis including 17 studies and 17,668 subjects highlighted the importance of KMC in reducing neonatal mortality, hypothermia, and sepsis, as well as decreasing the average length of hospital stay. The analysis also identified KMC as an effective and low-cost strategy for both mothers and infants [47]. It was also concluded that extended KMC was highly effective in promoting earlier achievement of full oral feeding and improving neurological function, thermal regulation, breastfeeding success, and SpO₂ in preterm infants in the NICU [48].

Similarly, two researchers reported that administering KMC was more effective than oral sucrose in alleviating pain during heel pricks in preterm infants, providing a non-pharmacological approach to managing distressing procedures in the NICU [49].

Effect of Tactile and Touch Stimulation on Premature Baby

Preterm and sick babies may react negatively in several ways and may not always tolerate being

handled. Touch serves as a crucial foundation for complex and individualized communication between the infant and their parent or caregiver [11].

A study demonstrated that tactile stimulation in the NICU led to improvements in both physiological and neurobehavioral functions in newborns[50]. Another study emphasized the role of tactile stimulation in reducing stress and cortisol levels, thereby enhancing the adaptation of preterm infants to the NICU environment through non-pharmacological methods that support neurobehavioral development [51].

A study demonstrated that tactile stimulation alleviated stress associated with invasive procedures in neonates, showing significant improvements in behavioral, physiological, and motor parameters among those who received tactile stimulation. Thus, it is considered an effective method for reducing stress during painful interventions in the NICU [52].

A study recommended the application of gentle human touch by NICU nurses as an effective non-pharmacological pain management strategy, after demonstrating that gentle human touch administered during endotracheal suctioning of preterm infants significantly reduced pain levels [53].

Effect of Postural Support and Supported Positioning on Premature Baby

Postural support in the NICU, which involves positioning the infant's extremities in flexion to simulate the fetal position while permitting movement, has been shown to provide greater comfort, enhance neuromuscular development, and reduce both stress and the risk of postural deformities in preterm infants [10].

A study demonstrated that the application of nesting combined with right lateral, supine, and prone positioning in the NICU significantly benefited cardiorespiratory indicators in preterm newborns, such as RR, HR, Temp, and SpO₂ after three days of intervention [54].

Similar study reported that the use of nesting intervention significantly regulated the physiological parameters of preterm infants, including HR, Temp, SpO₂, RR, and weight in the NICU [55].

In the same context, an experimental study found that the application of nesting intervention significantly improved and stabilized the physiological markers of preterm infants in the NICU, resulting in raised and

stabilized Temp and normalized RR and HR [56]. A study showed a trend toward greater weight gain in the prone position compared to the supine position; however, this difference was not statistically significant. It suggested that the prone position with monitoring in healthy infants may help conserve energy and improve behavioral regulation [57].

Researchers found that the gastric residual volume was reduced when preterm infants were placed in the prone position, which decreased gastroesophageal reflux and improved feeding tolerance in preterm infants [58]. Another study found that the prone position significantly enhanced SaO₂, improved the stability of HR and RR, and emphasized the importance of proper positioning in premature infants [59]. A randomized clinical trial found that preterm infants slept longer and spent less time awake with a flexed posture and lateral positioning [60].

SIGNIFICANCE OF THE STUDY

As prematurity rates continue to rise, this narrative review highlights the importance of understanding preterm developmental supportive care. It summarizes the major themes and significant findings in this area, including improving neurodevelopment, overall health, and morbidity; enhancing family well-being; reducing costs and the burden on the healthcare system; and better supporting at-risk preterm neonates.

CONCLUSION

Providing developmental supportive care (DSC) significantly improves neurodevelopmental outcomes by incorporating strategies such as noise reduction, light exposure control, effective management of neonatal pain, Kangaroo-Mother Care, tactile stimulation, and gustatory and olfactory stimulation. Based on the study's findings, the researcher strongly recommends promoting, generalizing, and standardizing developmental supportive care practices within neonatal intensive care units (NICUs). Furthermore, an educational program should be implemented to train healthcare providers on the impact of DSC on preterm infant health outcomes. This program should utilize modern and interactive technologies, focusing on identifying appropriate interventions to improve both physiological and behavioral responses in premature infants.

Future Scope: While this review demonstrates that developmental supportive care is a promising

intervention for preterm infants, further research is warranted to clarify the long-term effects of these interventions. Additionally, investigations should explore the differential impacts on premature neonates based on specific application methods, assess the influence of varying intervention durations on growth and development, and evaluate how combining multiple developmental supportive care strategies can synergistically optimize outcomes for newborns.

LIMITATION OF THE STUDY

This narrative overview was intended to synthesize and condense the existing literature on preterm developmental supportive care. It is possible that some relevant papers were missed, which could introduce bias or result from selective publication in the literature.

Narrative reviews often do not employ a systematic standard for including papers, such as explicit analytical criteria or structured and rigorous methodologies [26,27].

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DISCLOSURE

The author asserts the absence of any competing interests.

ABBREVIATIONS

NICU	= Neonatal Intensive Care Unit
DSC	= Developmental Supportive Care
Temp	= Temperature
HR	= Heart Rate
RR	= Respiratory Rate
BP	= Blood Pressure
SpO ₂	= SpO ₂ , Oxygen Saturation
KMC	= Kangaroo-Mother Care
RCT	= Randomized Controlled Trial
NNS	= Non-Nutritive Sucking

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DATA AVAILABILITY

Every piece of data appears in the paper text and tables.

AUTHOR CONTRIBUTION

AHS helped conceptualize it. HSAH researched literature. HSAH and AHS wrote the rough draft. AHS and HSAH edited the manuscript. All writers reviewed and approved the manuscript. Each author holds that the manuscript is honest and meets authorship guidelines.

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