Journal of Multidisciplinary Healthcare

Dovepress
Taylor & Francis Group

Open Access Full Text Article

REVIEW

Implementation and Strategy in Developmental Care Practice in Infants with Congenital Heart Disease in Intensive Care Unit: Scoping Review

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Abstract: Congenital Heart Disease (CHD) is a common congenital heart defect in infants. This condition has a higher risk of developmental disorders. The majority of infants with CHD require long-term care in intensive care units, but infants only focus on getting medical care so that developmental care is rarely practiced. This review aims to determine the implementation and strategies in the practice of developmental care for infants with CHD in intensive care units. The study design used a scoping review with a literature search using five primary databases including Scopus, PubMed, Sage Journals, ScienceDirect, and Taylor & Francis. The inclusion criteria were English-language articles, articles with experimental research types, and participants of infant patients with CHD that discussed the effectiveness of implementing developmental care interventions and their implementation strategies. Based on the search results, we analyzed 13 relevant articles. There are several developmental care interventions for infants with CHD that we classified into physiological subsystems (massage therapy, Kangaroo Care (KC), exclusive breastfeeding, and nutritional care); cognitive, motor, and sensory subsystems (early physical therapy, tummy time, oral feeding, and physiotherapy); parent-infant interaction subsystems (Skin-to-Skin Contact (SSC), nutritional risk management, and nutritional training and support); and environmental management subsystems (infant accompaniment). The strategies in implementing the intervention include aspects of health workers (experience, training, and licensing); aspects of intervention protocols; and aspects of intervention methods and models (socialization, strict supervision, and the Plan-Do-Study-Act (PDSA) model). The implementation and strategies of developmental care practices have been proven to improve development in infants with CHD.

Plain Language Summary: This literature review describes various developmental care interventions for infants with CHD in intensive care along with strategies for their implementation. These interventions and strategies can help address developmental issues that often occur due to CHD. Researchers obtained 13 research articles that discussed the effectiveness of developmental care interventions for infants with CHD. Developmental care interventions for infants with CHD can be carried out in physiological aspects (massage therapy, KC, exclusive breastfeeding, and nutritional care); cognitive, motor, and sensory aspects (early physiotherapy, tummy time, oral feeding, and physiotherapy); parent-infant interaction aspects (SSC, nutritional risk management, and nutritional training and support); and environmental management aspects (infant accompaniment). These interventions have been shown to improve development and shorten the length of stay in infants with CHD. Previous studies have also shown effective strategies for implementing developmental care including improving aspects of health workers, intervention protocols, and intervention methods and models.

Keywords: congenital heart disease, developmental care, infant, infant development

Received: 7 January 2025
Accepted: 17 March 2025
Published: 24 May 2025

Introduction

Congenital Heart Disease (CHD) is a congenital heart disorder that causes disturbances in heart function.[1] This disorder is associated with anatomical abnormalities in the right atrium, left atrium, right ventricle, or left ventricle that can occur simultaneously.[2] CHD consists of acyanotic CHD and cyanotic CHD. Atrial Septal Defect (ASD) and Ventricular Septal Defect (VSD) are types of acyanotic CHD and Transposition of the Great Arteries and Tetralogy of Fallot are the most common types of cyanotic CHD.[3] CHD occurs in millions of infants each year and is the most common disorder worldwide.[4] The incidence of CHD in infants is around 8 to 12 per 1000 live births with 10–15% (1.2–1.7 per 1000) included in the critical CHD group.[5]

In infants, CHD is usually characterized by symptoms of bruising, signs of heart failure, lung infection, palpitations, and chest pain, whereas older children tend to experience fatigue, palpitations, chest pain, and syncope.[1] In infants, whether or not they have undergone heart surgery, they often experience several disorders such as swallowing dysfunction, digestive and absorption disorders, and gastrointestinal disorders which can cause growth and development problems.[3,6] Therefore, infants with CHD are at higher risk for developmental disorders. In addition, CHD also has negative short- and long-term impacts on neurodevelopmental function, decreased exercise capacity, impaired exercise performance, and quality of life due to lower levels of health.[7]

Half of the infants with CHD experience defects in neurodevelopment.[8] Neurodevelopmental disorders are the most common morbidity in infants with CHD, where neurodevelopment is a term that encompasses cognitive function, executive function, social interaction, communication, attention, and emotional function.[9,10] Disturbed neurodevelopment is related to biological and environmental factors, especially during infants being treated in the intensive care unit, which has a negative impact on brain development during critical periods.[11] The majority of infants with CHD require long-term care in the pediatric intensive care unit or cardiac intensive care unit (CICU) because of their poor heart condition.[12] Infants who are treated in intensive care units consist of several conditions, including infants with cyanotic CHD or acyanotic CHD, have undergone catheterization, or have undergone heart surgery.[13]

Intensive care settings can be traumatic for families and infants with CHD due to exposure to stress that causes increased pain, physiological instability, impaired attachment to parents, behavioral disorganization, and impaired brain development.[14] While in intensive care, the majority of infants are focused on medical care such as surgical intervention or other medical interventions rather than developmental care, which has an increasing impact on impaired neurodevelopmental function.[7] Currently, care that can support the developmental period during while infants with CHD are in intensive care units has not received much attention.[10] Inadequate developmental care, especially in motor aspects, in infants with CHD can increase the risk of cardiovascular complications.[6]

Care that can support and protect the baby's brain both before and after heart surgery is needed because it can create an environment that supports brain development.[8] Developmental care is a neuroprotective treatment for premature babies which is generally applied in the NICU.[9] Developmental care has been recognized as an important factor in efforts to optimize infants development.[15] Developmental care includes physiological subsystems; cognitive, motor, and sensory subsystems; parent-infant interactions; environmental management; and care according to developmental stages.[9]

The impact of CHD on long-term neurodevelopment is increasingly recognized as an area of concern.[16] However, developmental care is often only applied to premature infants who do not have CHD because premature infants are considered to have a high risk of developmental delays, which are actually also experienced by infants with CHD.[17] Infants with CHD have a three to four times greater risk of experiencing developmental delays,[18] but the majority of infants with CHD are focused only on medical care, so developmental care is rarely practiced in intensive care units.[19] In nursing, developmental care performed on infants with CHD is one of the efforts to provide holistic nursing care. This holistic nursing has an important role in optimizing the results of care for infants with CHD.

However, developmental care for infants with CHD has not been integrated into intensive care due to concerns about the implementation of several interventions that can disrupt the hemodynamic stability of the infant and the safety of medical equipment attached to the infant's body.[20] This is also related to the lack of specific developmental care guidelines specifically for infants with CHD and the lack of clear strategies from both hospitals and health workers in practicing developmental care for both premature infants and infants with CHD.[21] Research related to developmental

care practices conducted on infants with CHD is also still very limited. Therefore, this review was conducted to describe existing studies related to the implementation and strategies in practicing developmental care for infants with CHD in intensive care units and its impact on infant development. This review can be a reference for health workers, parents, and hospitals to implement developmental care in addition to medical care for infants with CHD.

Materials and Methods

Study Design

The research design used is a scoping review. Scoping review is one of the methodological techniques that can produce quality information by conducting a comprehensive quality assessment and has a comprehensive conceptual scope in explaining relevant research results.[22] There are several stages in conducting an article review, including identifying research questions, formulating keywords for article searches, determining research article criteria, identifying several sources of information, determining relevant literature that meets the criteria, extracting and mapping articles, and reporting the results of article analysis.

Eligibility Criteria

The selection of literature used in this review was based on the PRISMA Extension for Scoping Review (PRISMA-ScR) method (Figure 1).[23] In this review, we did not register the protocol because this review applies an iterative methodology

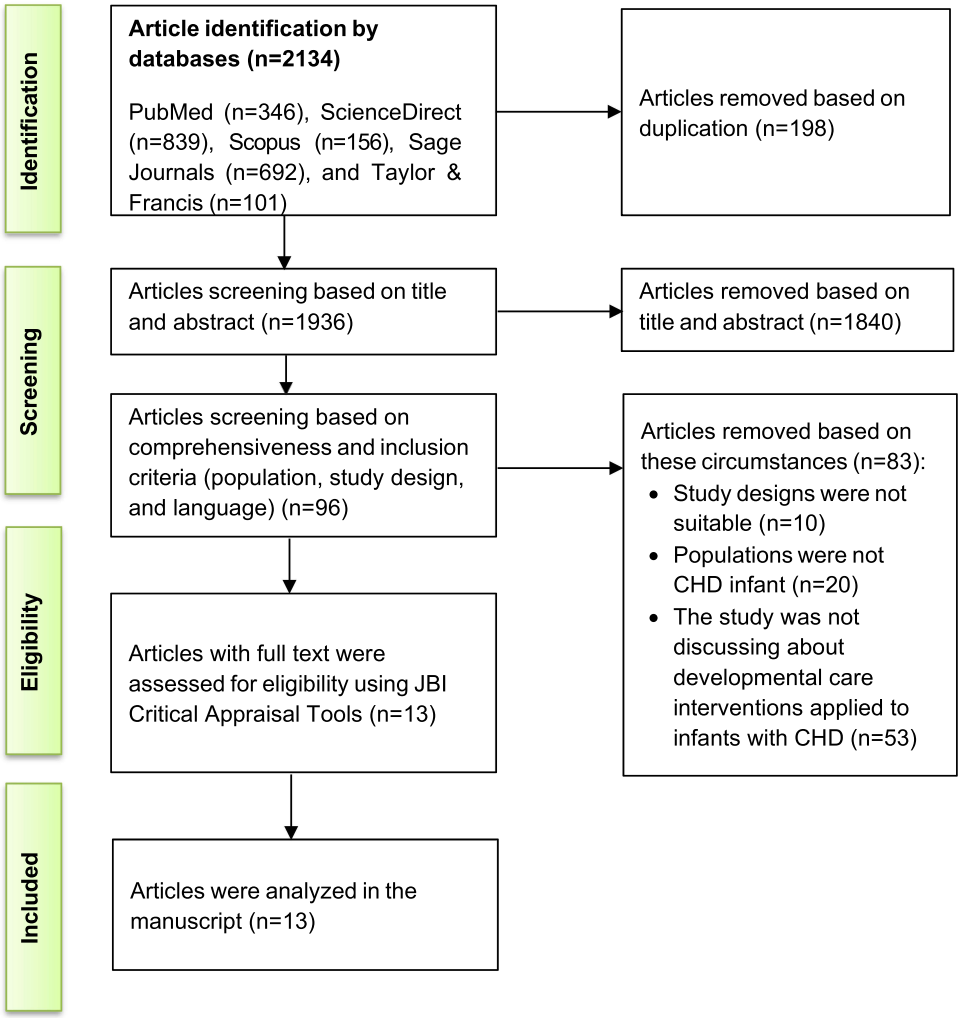

Figure 1 PRISMA Flowchart.
Notes: PRISMA figure adapted from Page MJ, McKenzie JE, Bossuyt PM et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.[24]

and evolves over time to improve the process of identifying gaps in the literature. Although without protocol registration, we ensure that the study plan and inclusion and exclusion criteria remain focused on the initial objectives of the study and do not change during the review process. This aims to reduce selection bias or unauthorized modifications during the study. The process flow of this review has also been described in detail to ensure transparency throughout the process and make it easier for readers or other researchers to understand the review process.

The research questions and eligibility criteria in this review used the PCC (Population, Concept, Context) approach as follows.

P (Population): infants with CHD

C (Concept): developmental care

C (Context): intensive care unit

In the article search process, there are selection criteria that include inclusion criteria and exclusion criteria. The inclusion criteria in the literature used include infant patients with CHD, English-language articles, articles with experimental research types (clinical trials, randomized controlled trials, cohort studies, quasi-experimental, case reports), and articles that focus on discussions related to developmental care interventions in infants with CHD and their implementation strategies. Although translation tools are increasingly sophisticated, in this review the authors focused on using English-language articles to minimize the potential for inaccuracies in other language translations that could affect the results of analysis and interpretation. The exclusion criteria for this article review include articles with review research types and research protocols. This literature review does not include restrictions on the year of publication because research articles discussing the application of developmental care to infants with CHD are very limited so that the study search is comprehensive.

Data Collection and Analysis

Search Strategy

Literature search to obtain this review article used five primary databases including Scopus, PubMed, Sage Journals, ScienceDirect, and Taylor & Francis. In searching literature databases such as Scopus and PubMed and on publisher platforms such as Sage Journals, ScienceDirect, and Taylor & Francis, the authors conducted a systematic search using structured queries and specific search parameters. The article search applied selection criteria that included inclusion criteria and exclusion criteria. The keywords used in searching for articles were "CHD infant", "congenital heart disease", "developmental care", and "infant development". Each term used was verified by MeSH (Medical Subject Headings) and synonyms were used to find all possible relevant articles. The authors used the Boolean operators "AND" and "OR" on each syllable to trim or expand the search results.

Study Selection and Quality Appraisal

The authors selected studies that met the eligibility criteria that had been determined. The literature was selected by eliminating duplicate articles and articles that did not meet the inclusion criteria. Articles obtained from all databases used were screened by checking the title, abstract, and full text to find articles that were relevant to this review article. After the process was carried out, the authors conducted an analysis for each article. The authors assessed the articles using the Joanna Briggs Institute (JBI) critical assessment checklist.

The assessment based on the JBI critical assessment checklist consists of 13 questions for randomized control trial design articles, 11 questions for cohort study design articles, 9 questions for quasi-experimental study design articles, and 8 questions for case report design articles.[25] Each question has four answer choices "yes", "no", "not applicable", and "unclear". The author calculates the critical assessment score based on the number of "yes" answers divided by the total number of "unclear", "no", and "yes" answers, except for the answer "not applicable". After conducting the assessment, the author eliminates articles that have a JBI score < 70%. When there were differences in the selection results, the first and second authors made a joint decision based on the results of the review. During the process, we did not experience any differences of opinion regarding the eligibility of the study.

Data Extraction and Analysis

In this study, the authors analyzed 13 articles. Extraction and analysis of articles were carried out using a matrix table consisting of the author's name, year of article, country, research objectives, research samples, research methods, interventions (settings, developmental care practices, strategies used), and outcomes on child development. All articles reviewed were primary studies with randomized controlled trial, cohort study, quasi-experimental, and case report designs. This review used several articles with relevant cohort study and case report designs because articles related to developmental care interventions specifically for infants with CHD are very limited and we have ensured that the research supports the aim of this review in exploring the developmental impact of developmental care interventions in infants with CHD and strategies in their implementation.

The data analysis process was carried out by identifying and presenting all data obtained from each article finding into a predetermined matrix table After obtaining the data, the author analyzed and explained each finding based on the type of developmental care intervention applied to infants with CHD along with its strategies. The author categorized each intervention found in the reviewed research articles into four developmental care subsystems including the physiological subsystem; cognitive, motor, and sensory subsystems; parent-infant interaction subsystem; and environmental management subsystem. The author also categorizes strategies in implementing developmental care into health worker aspects, intervention protocol aspects, and intervention method and model aspects.

Results

Study Selection

The literature search process began with the identification of articles from several databases and obtained 2134 articles. All articles were screened based on duplicate articles, titles, and abstracts so that the number of findings became 96 articles. Furthermore, the author re-screened the articles based on the inclusion criteria and obtained 13 articles. The author assessed the quality of the articles using the JBI critical assessment checklist. Based on the results of the JBI assessment, the author used 13 articles to be analyzed in this review because they had good quality with a JBI score of more than 75% (Table 1). The article selection process in this literature review is shown using the PRISMA flow diagram (Figure 1).

Table 1 JBI Critical Appraisal Results

Study	Design	JBI Critical Appraisal Tool
(Haseba et al, 2018)[26]	Retrospective and randomized controlled trial	10/13 (77%)
(Uzark et al, 2022)[27]	Randomized controlled trial	11/13 (84%)
(Fourdain et al, 2021)[28]	Retrospective controlled cohort study	9/11 (82%)
(Harrison et al, 2020)[29]	Two-group randomized controlled trial design	12/13 (92%)
(Gazzolo et al, 2000)[30]	Quasi experimental study	8/9 (88%)
(Harrison et al, 2019)[8]	Randomized controlled trial	10/13 (77%)
(Newcombe & Fry-Bowers, 2017)[31]	Randomized controlled trial	11/13 (84%)
(Medoff-Cooper et al, 2016)[32]	Prospective cohort study	10/11 (91%)
(Huang et al, 2024)[33]	Quasi experimental study	8/9 (88%)
(Yuruk & Cetinkaya, 2024)[5]	Randomized controlled trial	11/13 (84%)
(Steltzer et al, 2016)[34]	Retrospective cohort study	9/11 (82%)
(Janz-Robinson et al, 2015)[35]	Retrospective population-based cohort study	9/11 (82%)
(Vikhe et al, 2024)[16]	Case report	7/8 (87%)

Study Characteristic

In the 13 articles found, there were 6 RCTs, 4 cohort studies, 2 quasi-experimental studies, and 1 case report analyzed and had a population of infants with CHD (Table 1). The articles analyzed came from various countries including America (n=6), Japan (n=1), Canada (n=1), Italy (n=1), China (n=1), Turkey (n=1), Australia (n=1), and India (n=1). All participants (n=2043) in the articles analyzed in this literature review were infant patients with CHD (acyanotic CHD: 1838, cyanotic CHD: 56, and Complex Congenital Heart Disease (CCHD): 149) in the intensive care unit who were in pre-cardiac surgery (n=226) and post-cardiac surgery (n=1817) conditions. The articles analyzed had the largest sample of 1473 respondents,[35] and the smallest sample of 1 respondent.[16]

Developmental Care Practice

There are 13 articles that conduct research on the effectiveness of several developmental care interventions in infants with CHD as an effort to support their development. Based on the category of developmental care interventions for infants with CHD, there are 4 articles on the physiological subsystem,[29–31,34] 5 articles on the cognitive, motor, and sensory subsystem,[16,26–28,32] 3 articles on the parent-infant interaction subsystem,[5,8,33] and 1 article on the environmental management subsystem.[35] Various details of developmental care interventions in these categories can be seen in (Table 2).[5,8,16,26–35]

Table 2 Categories of Developmental Care Practice

Categories	References
Physiological subsystem	
Massage therapy	(Harrison et al, 2020)[29]
Kangaroo Care (KC)	(Gazzolo et al, 2000)[30]
Exclusive breastfeeding	(Steltzer et al, 2016)[34]
Nutritional care	(Newcombe & Fry-Bowers., 2017)[31]
Cognitive, motor, and sensory subsystem	
Early physical therapy	(Haseba et al, 2018);[26] (Fourdain et al, 2021)[28]
Tummy time	(Uzark et al, 2022)[27]
Oral feeding	(Medoff-Cooper et al, 2016)[32]
Physiotherapy	(Vikhe et al, 2024)[16]
Parent-infant interaction subsystem	
Skin-to-Skin Contact (SSC)	(Harrison et al, 2019)[8]
Nutritional risk management	(Huang et al, 2024)[33]
Individualized nutrition training, nutritional supplementation, and enteral nutrition support	(Yuruk & Cetinkaya., 2024)[5]
Environmental management subsystem	
Infant accompaniment	(Janz-Robinson et al, 2015)[35]

In the physiological subsystem, article 4 (Harrison et al, 2020) conducted a study related to post-cardiac surgery care interventions and massage therapy,[29] while article 5 (Gazzolo et al, 2000) conducted a study related to KC interventions.[30] Both have the same impact on improving the physiological stability of infants,[29,30] but article 4 showed an additional impact in the form of reduced pain levels.[29] In addition, article 7 (Newcombe & Fry-Bowers, 2017) and article 11 (Steltzer et al, 2016) conducted similar studies, namely nutritional care in the form of enteral feeding plus increased protein and the use of intravenous intralipid,[31] and exclusive breastfeeding via a nasogastric tube.[34] Both had the same impact on improving anthropometric measurements.[31,34]

In the cognitive, motor, and sensory subsystems, research related to early physical therapy interventions in article 1 (Haseba et al, 2018) and article 3 (Fourdain et al, 2021),[26,28] tummy time in article 2 (Uzark et al, 2022),[27] and physiotherapy in article 13 (Vikhe et al, 2024),[16] had similar impacts in improving gross motor and neurological development and reducing the duration of care. Meanwhile, article 8 (Medoff-Cooper et al, 2016) conducted a study related to the intervention of oral combination feeding and using tools that had an impact on improving mental and psychomotor development.[32] In the parent-infant interaction subsystem, research related to nutritional risk management interventions in article 9 (Huang et al, 2024) and individual nutritional supplementation training in article 10 (Yuruk & Cetinkaya, 2024) had the same impact on improving anthropometric measurements, motor and language development, and reducing readmission rates.[5,33] Meanwhile, article 6 (Harrison et al, 2019) conducted a study related to the SSC intervention having an impact on improving cognitive and autonomous development.[8] Finally, in the environmental management subsystem, article 12 (Jans-Robinson et al, 2015) conducted a study related to the intervention of accompanying infants who were treated that had an impact on minimizing developmental delays, duration of care, duration of mechanical ventilation, systemic infection rates, and levels of functional limitations.[35] Further analysis of each developmental care intervention in infants with CHD can be seen in (Table 3).[5,8,16,26–35]

Developmental Care Practice Implementation Strategies

Based on developmental care interventions in infants with CHD conducted in each research article, there are 3 categories of strategies covering aspects of health workers, aspects of intervention protocols, and aspects of intervention methods and models. In terms of health workers, strategies in the form of experienced health workers,[26] who have undergone training and formed a multidisciplinary team,[16,28,33–35] and are licensed,[29] can be applied to implement massage therapy interventions,[29] early physical therapy,[26,28] nutritional risk management,[33] exclusive breastfeeding,[34] physiotherapy,[16] and infant accompaniment.[35] In terms of intervention protocols, strategies in the form of procuring detailed intervention protocols,[26,29] can be applied to implement early physical therapy intervention,[26] and massage therapy.[29] Finally, in terms of intervention methods and models in the form of socialization,[5,27] strict supervision,[8,30,32] and the PDSA model,[31] can be applied to implement tummy time interventions,[27] individual nutritional supplementation training,[5] SSC,[8] KC,[30] nutritional care with enteral feeding and intravenous intralipid use,[31] and oral and device-based combination feeding.[32]

Discussion

Physiological Subsystem

In this review, several research articles related to developmental care interventions in infants with CHD in the physiological subsystem were obtained.[29–31,34] Physiological development in infants is one aspect that needs to be considered because it has an impact on other developments such as cognitive and sensory. Infants with CHD have physiological vulnerabilities that can be identified from several signs such as low motor tone, prolonged drug metabolism, and limited self-regulation.[14] In terms of limited self-regulation, infants with CHD have poor homeostasis systems so vital signs are unstable.

One of the study findings shows that KC is a developmental care intervention that can be performed on infants with CHD because it can improve cardiorespiratory parameters.[30] KC intervention has been shown to provide stabilization activity on heart rate and blood flow rate.[14] This has a positive impact on the thermoregulatory and cardiovascular systems so that blood circulation to the brain remains optimal and has an impact on cognitive development.[30] However, there is other study that state the positive effects of KC intervention on cardiorespiratory parameters cannot be

Table 3 Results of Article Analysis

No	Author, Year, and Country	Research Purposes	Research Sample	Research Methods	Intervention			Results
					Setting	Developmental Care Practices	Strategies	
1	(Haseba et al, 2018)[26] Country: Japan	To identify the effect of early physical therapy on motor development in infants with cyanotic and acyanotic CHD.	51 infants with CHD (5–12 months) who underwent cardiac surgery between April 2013 and March 2015 (cyanotic CHD: 25 and acyanotic CHD: 26)	Retrospective and randomized controlled trial	Intensive care unit and inpatient care	Infants are given developmental care in the form of early physical therapy (respiratory physical therapy exercises and limb and trunk therapy exercises) by health workers (1–3 times per day for 20–60 minutes in 5/6 days a week). Respiratory physical therapy exercises include postural drainage therapy, thoracic expansion, and chest mobilization. Extremity and trunk therapy exercises include passive exercises and active assisted movements (exercises in supine, prone, side-lying, and sitting positions with support).	Early physical therapy interventions in infants are performed by experienced pediatric physiotherapists using detailed exercise protocols.	Early physical therapy in infants with cyanotic (88.0%) and acyanotic (96.2%) CHD has a significant effect on gross motor recovery because it is able to increase the level of preoperative mobility at the time of discharge from the hospital (p=0.01) thereby reducing the duration of treatment in the ICU.
2	(Uzark et al, 2022)[27] Country: America	To evaluate the effectiveness of tummy time intervention on motor skill development in infants with CHD after cardiac surgery.	64 parents who had infants (less than 4 months) with postoperative acyanotic CHD	Randomized controlled trial	Intensive care unit and inpatient care	Parents of infants with CHD undergoing cardiac surgery were instructed to perform tummy time (n = 20), tummy time + ambulatory strengthening (n = 21), and standard care (n = 23). The tummy time program was performed for more than 15 minutes each day.	Parents are first given socialization by the health worker team regarding the implementation of tummy time for babies.	Infants who received tummy time from their parents, either tummy time alone or tummy time plus outpatient reinforcement for more than 15 minutes each day, showed a greater increase in motor development scores compared to infants who received only standard care and no tummy time (p = 0.01).

3	(Fourdain et al, 2021)[28] Country: Canada	To evaluate the effectiveness of physical therapy on gross motor development in infants with CHD conducted at the age of 4 to 8 months.	29 infants (4 months) with CHD (acyanotic CHD: 27 and cyanotic CHD: 2) who had undergone heart surgery	Retrospective controlled cohort study	Intensive care unit and inpatient care	**Routine intervention group (n=10)** Infants with CHD receive regular one-hour physical therapy (3–6 sessions) that includes strengthening the muscles of the neck, chest, and extremities as well as maintaining sitting positions and rolling movements. **Occasional intervention group (n=13)** Infants with CHD received physical therapy in the same manner as the routine intervention group, but only occasionally (1–2 sessions). **Control group (n=6)** The baby was only given regular care and did not receive physical therapy.	Physical therapy for infants with CHD is performed by professionals who have undergone training for the Alberta Infant Motor Scale (AIMS) and Bayley-III to provide standardized physical therapy.	Infants with CHD who received regular physical therapy showed higher motor development scores at 12 to 24 months of age compared to the occasional intervention group or the control group ($p = 0.002$). The occasional intervention group ($p = 0.758$) and the control group ($p = 0.103$) did not show significant changes in motor development scores.
4	(Harrison et al, 2020)[29] Country: America	To determine the effect of massage on postoperative pain scores and physiological responses in infants with CCHD compared to a rest period.	60 infants with CCHD aged less than 12 months	Two-group randomized controlled trial design	Intensive care unit	**Intervention group (n=30)** The group received standard postoperative care and a 30-minute massage (either at 12 noon or 5 p.m. for 7 days). The massage was performed using a lotion that included gentle rubbing, stroking, kneading, and passive touch on the head and face, back, upper and lower extremities. **Kelompok kontrol (n=30)** The group received only standard post-operative care and rested for 30 minutes.	Massage for infants with CCHD is performed by licensed practitioners using standard massage therapy protocols that adhere to Swedish massage principles.	In the group of infants who underwent postoperative massage, there was a decrease in pain levels of 52% (pre: 1.29 and post: 1.04), while in the control group there was an increase in the average pain score. In addition, developmental care in the form of massage can maintain physiological stability in infants with CCHD (lower HR, normal RR, and increased SpO2).
5	(Gazzolo et al, 2000)[30] Country: Italy	To evaluate the effects of Kangaroo Care (KC) on cardiorespiratory status in term infants with CHD.	5 infants with acyanotic CHD aged 4–6 months who underwent heart surgery	Quasi experimental study	Intensive care unit	All babies received developmental care in the form of KC intervention with a 2-hour interval within 12 hours after heart surgery. The babies were carried by their mothers on their chests while only wearing diapers and covered with cotton blankets.	The nurse ensures that the KC intervention does not interfere with the medical equipment attached to the baby's body.	KC intervention in infants with CHD can significantly improve cardiorespiratory parameters including increased arterial oxygen saturation and TcpO2 ($p<0.05$), decreased TcpCO2 ($p<0.05$), and decreased heart rate and central venous pressure ($p<0.05$).

(*Continued*)

https://doi.org/10.2147/JMDH.S516216

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Table 3 (Continued).

No	Author, Year, and Country	Research Purposes	Research Sample	Research Methods	Intervention			Results
					Setting	Developmental Care Practices	Strategies	
6	(Harrison et al, 2019)[8] Country: America	To determine the effect of neonatal Skin-to-Skin Contact (SSC) intervention on cognitive and autonomic development in infants with Complex Congenital Heart Disease (CCHD).	36 infants (less than 12 months) with CCHD post cardiac surgery (intervention group: 26 and control group 10)	Randomized controlled trial	Intensive care unit	Mothers and infants in the intervention group (n=26) were given developmental care in the form of SSC every day before the baby underwent heart surgery and for 14 days after the baby underwent heart surgery. During SSC (60–90 minutes), the baby only wore a diaper and was laid face down and then placed in a kangaroo cloth support device used by the mother in a naked condition.	Nurses accompany the bedside to provide support in repositioning the baby when the mother and baby undergo SSC and try to reduce distractions and provide privacy.	Infants with CHD who underwent SSC showed increased cognitive and autonomous development compared to infants who only received usual care and did not undergo SSC. Infants with CHD who did not receive SSC intervention showed reduced capacity to collect physiological resources to carry out cognitive tasks.
7	(Newcombe & Fry-Bowers, 2017)[31] Country: America	To evaluate the effects of a nutritional care protocol during the postoperative period on nutritional and developmental outcomes in neonates with CCHD.	53 infants (less than 12 months) with CCHD undergoing cardiac surgery (intervention group: 26 and control group: 27)	Randomized controlled trial	Intensive care unit	Fulfillment of nutritional needs in the group of neonates with CCHD who were given intervention began after 12 hours after extubation by providing enteral food with a determined duration (continuously or bolus). In the nutritional care program, neonates were also given increased protein to 4g/kg/day and the use of intravenous intralipid (100 kcal/kg/day) with enteral administration.	In implementing nutritional care interventions using the Plan-Do-Study-Act (PDSA) model which has been tested, is reliable, and valid in health service settings.	Neonates with CCHD who were given nutritional care showed significant results in improving neurodevelopment and anthropometric measurements including body weight, body length, and head circumference ($p<0.05$). In addition, the application of nutritional care in the intervention group can also reduce the Length of Stay (LOS) in the intensive care unit ($p=0.002$) compared to the control group.
8	(Medoff-Cooper et al, 2016)[32] Country: America	To determine the impact of feeding methods using tools on nerve development in infants with CHD.	72 infants (0–12 months) with CHD (acyanotic CHD: 43 and cyanotic CHD: 29) who had undergone cardiac surgery (intervention group: 34 and control group: 38)	Prospective cohort study	Intensive care unit	**Intervention group** Babies are fed with the help of devices such as nasogastric tubes or gastric tubes combined with oral feeding. **Control group** Babies are only fed orally.	Oral feeding of infants with CHD is done gradually every day.	In infants with CHD aged 3 months who were fed orally had a higher mental development index ($p=0.045$) and psychomotor development index ($p=0.016$) at 6 months and 12 months than infants who were fed with the help of a device.

9	(Huang et al, 2024)[33] Country: China	To determine the impact of nutritional risk management programs on the growth and development of infants with CHD.	174 infants with acyanotic CHD aged 5–6 months (intervention group: 87 and control group: 87)	Quasi experimental study	Intensive care unit	In the intervention group (n=87), a nutritional risk management program was implemented, consisting of providing parents with an understanding of timely nutritional status, monitoring growth and development, identifying high risks, and establishing an intervention mechanism for clinical doctors in providing nutritional interventions.	In integrating these interventions, it is necessary to form a follow-up information management team and a nutrition support team that has undergone rigorous training related to nutrition and the team consists of cardiologists, specialist nurses, and special nutritionists.	In the intervention group, it was shown that the nutritional risk management program had an impact on a higher percentage of growth and development curves than the control group (3%–97%) ($P < 0.05$). In addition, the intervention also had an impact on a lower readmission rate in the intervention group than in the control group within 6 months ($P < 0.05$).
10	(Yuruk & Cetinkaya, 2024)[5] Country: Turkey	To determine the effectiveness of individual nutrition training and nutritional supplementation in mothers who have infants with CHD on child growth and development.	15 infants with acyanotic and their families (have undergone or are planned for heart surgery)	Randomized controlled trial	Intensive care unit and inpatient care	**Group 1 (n=5)** This group receives developmental care that involves interaction between parents and infants in the form of information related to providing breast milk and additional food. **Group 2 (n=5)** This group received developmental care like group 1 plus information related to enteral nutritional support. **Group 3 (n=5)** This group is a control group.	Information to improve parent-infant interaction is presented in an educational group consisting of all parents who have infants with CHD.	Infants from parents in the intervention group (group 1 and 2) showed a more significant increase in weight, height, chest circumference, and head circumference compared to the control group ($p = 0.001$). In addition, language development scores, fine and gross motor skills, social skills, and general development in the intervention group increased more significantly than the control group ($p < 0.05$).
11	(Steltzer et al, 2016)[34] Country: America	To evaluate the effect of exclusive breastfeeding on growth and development in infants with CHD.	10 infants (less than 5 months) with acyanotic CHD	Retrospective cohort study	Intensive care unit	The mother exclusively breastfed the baby with CHD 6 times in addition to being fed through a nasogastric tube before the heart surgery. The baby also received breast milk through a nasogastric tube of 12 mL/hour.	Breastfeeding nutritional support involves a multidisciplinary team including nurses, nutritionists, cardiologists and pediatricians.	Exclusive breastfeeding in infants with CHD has a positive impact on average weight gain (3.41 kg to 7.05 kg at 5 months of age).

(*Continued*)

https://doi.org/10.2147/JMDHS516216

https://doi.org/10.2147/JMDH.S516216

Table 3 (Continued).

No	Author, Year, and Country	Research Purposes	Research Sample	Research Methods	Intervention			Results
					Setting	Developmental Care Practices	Strategies	
12	(Janz-Robinson et al, 2015)[35] Country: Australia	To compare neuro-developmental outcomes in premature infants with Patent Ductus Arteriosus (PDA) who underwent surgery with those who only received supportive developmental care.	All premature infants (5–7 months) with PDA (acyanotic CHD) born at 23 to 28 weeks of gestation between January 1, 1998 and December 31, 2004 (1473 respondents)	Retrospective population-based cohort study	10 neonatal intensive care units from New South Wales and the Australian Capital Territory	**PDA group with supportive developmental care only (n=826)** This group did not undergo surgery, but was given supportive developmental care in the form of indomethacin use and accompanying the babies being treated. **PDA group with surgery (n=647)** This group only underwent surgical ligation for closure without being given supportive developmental care.	Developmental care is performed on babies with a higher average birth weight, head circumference, and birth age (more than 27 weeks).	Compared with infants in the PDA group with surgery, infants in the PDA group with supportive developmental care alone had less developmental delay (P=0.001), had shorter duration of NICU stay (77 vs 109 days), shorter duration of mechanical ventilation (3 days vs 28 days), lower rates of systemic infection and steroid treatment, and lower rates of functional limitations (12.6% vs 28.2%).
13	(Vikhe et al, 2024)[16] Country: India	To determine the effectiveness of physiotherapy on development in infants with CHD who experience developmental delays.	1 infant (11 months) with acyanotic CHD (Patent Ductus Arteriosus) aged 14 months post heart surgery	Case report	Neonatal Intensive Care Unit (NICU)	Infants with CHD underwent physiotherapy interventions that included manual techniques (10 minutes), neurodevelopmental treatment (30 minutes), and multimodal stimulation (10 minutes). Manual techniques included percussion and vibration on the apical (between the collarbone and the top of the shoulder blades on each side), middle (above the middle lung fields), and basal (above the lower lung fields). Neurodevelopmental treatment involved holding the neck, rolling, and bearing weights while providing auditory and visual stimulation. Multimodal stimulation involved tactile stimulation of the face, legs, back, and body, as well as gentle shaking to the front, side, and back.	Developmental care is provided in collaboration between cardiologists, nurses, pediatricians, and physiotherapists to ensure care is tailored to each baby's needs.	Developmental care in the form of physiotherapy performed on infants with CHD has a positive impact on improving neurological development outcomes (pre: 25 and post: 44) which include motor function, muscle tone, reflexes, and other neurological signs.

generalized to the population of infants with unstable conditions who are less than three weeks old.[36] Nevertheless, based on the KC quality improvement committee, it shows that KC is proven to be safe to be integrated into developmental care for infants with CHD.[37]

In addition to the poor homeostasis system, the digestive system function in infants with CHD is also not fully developed so that energy reserves are less and compensation capabilities are not optimal. Therefore, infants with CHD need a strategy in implementing developmental care that focuses on managing the fulfillment of nutritional needs.[38] Optimal development in infants with CHD is related to the growth they experience. Optimizing the provision of nutrition to infants with CHD both before and after heart surgery is an effort that can be done to increase body weight.[39] The study findings show that interventions of exclusive breastfeeding and nutritional care by providing enteral feeding that focuses on protein fulfillment have been proven to improve anthropometric measurements including body weight, body length, and head circumference.[31,34]

Breast milk is a nutritional intake that has immunological properties and is beneficial for infants with CHD because it can prevent and reduce the level of nosocomial infections that can increase developmental disorders.[39] However, there are several obstacles in providing exclusive breastfeeding to infants with CHD, such as the mother's worry that the baby will become tired from sucking breast milk.[39] Other studies have shown that providing exclusive breastfeeding to infants with CHD does not affect the decline in their physiological condition, but can significantly increase oxygen saturation compared to infants who are not breastfed.[40]

Other physiological problems such as pain due to CHD conditions can be related to cognitive and sensory development in infants as they grow older. This is caused by disrupted homeostasis regulation due to the activated stress response system.[29] Infants with CHD often experience pain, either intermittent or continuous, making them vulnerable to hemodynamic changes related to sensory stimulation and the risk of impaired cognitive development.[41] Sensory stimulation in the form of pain felt by infants with CHD during the developmental period can permanently change the nociceptive pathways in the central nervous system and cause abnormal reactions to tactile stimulation.[29,42] Therefore, pain management is one of the things that must be considered in the implementation of developmental care.

Based on the findings of the study, massage therapy interventions applied in the provision of developmental care have been proven to be able to reduce pain levels by up to 52% in infants with CHD after heart surgery.[29] This finding is in line with the other study showing that massage is one of the sensory stimulations on the skin and non-nociceptive muscle fibers that can block impulse transmission, increase dopamine hormones and reduce cortisol levels, and modulate the sympathetic nervous system process so that pain is reduced.[43] There are also other studies that show no difference in pain levels in the massage therapy group with the control group because the implementation of massage therapy with a short duration.[44] 43 Therefore, the duration of massage therapy needs to be considered to provide more optimal results in infants with CHD where this intervention has also been shown to reduce anxiety scores.[43,45]

Cognitive, Motor, and Sensory Subsystem

Infants with CHD who do or do not undergo heart surgery experience a combination of motor, cognitive, and sensory disorders.[46] Neurological injuries are very susceptible to occur in infants with CHD in the pre-, peri-, or postoperative period and this is closely related to developmental disorders.[21] Cognitive development in infants with CHD is influenced by several factors, one of which is brain maturity.[8] Brain maturity in infants with CHD who are born at term has been shown to be similar to that of premature infants born at 35–36 weeks' gestation.[11] Immature brain maturity carries a higher risk of brain injury that can cause changes in brain hemodynamics, resulting in neurodevelopment disorders, including cognitive function.[8,11]

Infants with CHD who undergo cardiac surgery are at greater risk for neurodevelopmental abnormalities.[2,27] The primary manifestation of neurodevelopmental changes is gross motor delay.[28] Infants with CHD often undergo prolonged intensive care, leading to muscle weakness that also contributes to decreased motor skills.[26] This has an impact on the adaptive skills and cognitive performance of infants as they grow older. Study findings suggest several developmental care interventions that can affect cognitive and motor development in infants with CHD include early physical therapy, tummy time, and physiotherapy.[16,26–28,32]

Developmental care in the form of physical therapy and tummy time has been proven to improve gross motor development and mobility levels.[26–28] Other studies have shown that physical therapy can improve development through sensory and motor integration processes.[47] The majority of studies related to physical therapy in infants with CHD have not shown negative outcomes on infant development and the intervention may reduce parental anxiety about developmental delays in infants.[48] Physical therapy and tummy time share a common focus on structured exercises that improve muscle strength, coordination, and motor control.[28] Similar developmental care includes physiotherapy which can improve the development of motor and other neurological functions.[16] These interventions focus on individualized developmental care according to the baby's heart condition, developmental stage, and response to treatment.[26] Physiotherapy aims to improve heart function and respiratory function by facilitating the clearance of secretions and optimizing growth and development.[16,49]

In addition to cognitive and motor development, sensory development also needs to be considered in infants with CHD. Direct interaction between mother and infant can create a very complex interaction because there is sensory stimulation from the mother and the infant's neurobiological response which is known to affect brain development.[8] The study findings show that the implementation of oral feeding interventions in infants with CHD as a developmental care involving the role of parents has a positive impact on sensory and psychomotor development.[39]

Infants with CHD who are treated in intensive care often do not get the opportunity to receive neuroprotective stimulation from their mothers.[8] Restrictions on physical contact when the baby is treated in intensive care can cause various negative impacts, including sleep and wake disorders, disorders of gross and fine motor skills, and infant behavior that shows higher stress.[50] Therefore, oral feeding as one of the applications of developmental care needs to be applied to infants with CHD. These findings is in line with the other study that positive sensory experiences from these interventions in infants with CHD are the basis for their brain development and sensory stimulation from mother-infant interactions is the basic framework in regulating the development of autonomic, endocrine, and behavioral functions.[51]

Parent - Infant Interaction Subsystem

Infants with CHD often experience separation from their parents while receiving intensive care, so that the attachment process between parents and infants is disrupted.[14] This causes stress, anxiety and depression in parents because they cannot accompany their children during treatment.[52] Medical treatment that is often carried out on infants with CHD also greatly affects the emotional status of parents.[53] Previous studies have shown that parents experiencing stress can affect the overall development of children because the physiology of infants with CHD is significantly related to the mental health conditions of the mother.[14] Nurses have a role to increase parental participation in developmental care for infants with CHD by providing individual information regarding their child's condition in the intensive care unit.[54]

Parental involvement in developmental care can help determine the most optimal interventions for infants with CHD, so it needs to be a priority.[9] There are several developmental care interventions related to the interaction between mothers and infants with CHD in the study findings, including SSC, nutritional risk management, and nutritional training and support.[5,8,33] Previous studies have shown that the recovery process of infants with CHD increases along with increased maternal involvement in the developmental care process ($p < 0.001$).[54]

SSC intervention as one of the developmental care that involves interaction between mothers and infants with CHD has been proven to improve cognitive and autonomous development.[8] This is in line with other studies that SSC provides neuroprotective effects, improves autonomic function, improves neural development, and improves cognitive skills in infants with CHD.[8] However, the other study has shown an increase in cortisol levels as a sign of stress after infants receive SSC intervention.[55] The increase in cortisol is caused by the possibility of high exposure or environmental stimuli in the intensive care unit during SSC such as medical activity from health workers, noise, or lighting. Nevertheless, SSC intervention has been shown to be safe and feasible to be applied to infants with CHD as an effort to support physiological stability, comfort, autonomic nervous system function, and cognitive development.[37] In addition to being beneficial for the development of infants with CHD, SSC also supports attachment between mother and infant which has been proven to reduce physiological and psychological stress responses in parents, especially mothers.[20]

In addition to SSC interventions, there are other interventions related to fulfilling nutritional needs in infants with CHD. Previous studies have shown that infants undergoing heart surgery often experience malnutrition which affects

growth and development, heart recovery, morbidity, and postoperative complications.[56] Acute and chronic malnutrition that occurs in infants with CHD can be up to 50% higher than in infants without CHD and malnutrition continues in 50–75% of infants with CHD after undergoing heart surgery.[57]

Health workers, especially pediatric nurses, need to consider the infant and the family simultaneously in providing family-centered care services to determine effective nutritional interventions.[5] Previous studies have shown that the majority of infants with CHD require developmental care in the aspect of parent-infant interaction that focuses on providing nutrition to improve developmental delays.[58] Study findings show that developmental care in the form of nutritional risk management interventions can improve growth and development curves and nutritional training and support interventions can improve anthropometric measurements and development in various aspects in infants with CHD.[5,33]

The results of this study are in line with other studies showing that weight loss in infants with CHD can stop when infants are given breast milk and complementary foods on time.[56] Growth and development in infants are known to occur more quickly than in older children, so infants require more nutrients and this can have an impact on increasing growth and development.[33] Therefore, infants with CHD really need developmental care that focuses on fulfilling nutritional needs because this has a significant influence on cognitive and motor development outcomes.[32]

Environmental Management Subsystem

The majority of infants with critical illnesses such as CHD experience physiological stress due to their illness, therapeutic procedures, or environmental exposures.[59] Infants who experience stress will try to maintain their body's homeostasis by activating important components to adapt to stress in the form of the hypothalamic-pituitary-adrenal axis which is followed by the release of cortisol from the adrenal cortex.[60] Environmental factors, especially the intensive care environment, can cause physiological changes in infants with CHD, such as high levels of sound and light which can cause sleep disturbances, hypoxemia, decreased cardiovascular function, and stress.[61] These physiological changes are characterized by a decrease in oxygen saturation and an increase in heart rate, respiratory rate, and blood pressure, all of which have a negative impact on growth and development.[59] Therefore, developmental care is needed that focuses on environmental management to facilitate growth and development in infants with CHD.

There is research in study findings that show that developmental care in environmental management in the form of accompanying infants with CHD who are being treated experiences minimal developmental delays compared to infants who are only given medical care.[35] This finding is in line with previous research that environmental factors are one of the most contributing factors in the development of infants with CHD.[62] However, other research shows that implementing interventions to accompany infants with CHD has major challenges and obstacles in the form of time constraints from health workers who have more patients so that this intervention requires consideration of various contextual factors that influence the success of the intervention.[2] Accompanying infants with CHD that is applied includes environmental management in terms of light, noise, and activity levels.[35] Infants with CHD are at higher risk of exposure to sensory stimuli during critical periods such as light and noise stimuli. Noise can negatively impact sleep quality and duration which changes brain development, so regulating noise levels can help optimize brain development in infants with CHD.[63] This is done by providing care calmly and peacefully, speaking in a low and soft voice volume, and minimizing the sound of alarms, telephones, or staff.[59]

The lighting arrangement in the intensive care room needs to be attempted to keep the light from hitting the eyes of infants with CHD directly.[35] This is done by darkening the room when the baby is sleeping and setting the lights to remain dim during the day. Dim light can improve healing and recovery process, while bright light can keep babies awake to expend energy when exposed to strong light.[59] In addition, activity level settings also need to be considered by considering the sleep-wake cycle in infants with CHD before providing treatment.[61] A calm and quiet atmosphere can increase the baby's comfort and minimize the pain experienced.[35]

Strategies in Developmental Care Practice for Infants with CHD

In implementing developmental care practices for infants with CHD in intensive care, effective and efficient strategies and approaches are needed to ensure the success of developmental care practices so that they are carried out

sustainably.[21] The implementation of developmental care is closely related to proactive and relational partnerships to support parents to be actively involved in the care process.[14] Based on the results of the study findings, it shows that the strategies used in implementing developmental care practices in infants with CHD can be categorized into three major strategies which include aspects of health workers, intervention protocols, and intervention methods and models.

Strategies in the aspect of health workers and intervention protocols need to get more attention from the agency in its improvement. The implementation of developmental care practices using strategies in the aspect of health workers, including practices that need to be carried out by experienced health workers,[26] health workers who have undergone training and formed a multidisciplinary team,[16,28,33–35] and licensed health workers.[29] Health workers who provide developmental care need to receive previous education or training such as individual developmental care interventions in the aspect of cardiac ICU care by assessing brain development, infant signals, infant development, and stress levels in their parents.[21] Previous studies have also shown that developmental care can take place optimally if there is coordination between health workers in a multidisciplinary team.[33] In addition, protocols related to providing interventions are needed as a strategy for implementing developmental care practices to optimize interventions given to infants with CHD.[26,29]

There are strategies in the aspect of methods and intervention models to improve the results of the implementation of developmental care practices in infants with CHD. Strategies in intervention methods include providing socialization to a group of parents who have children with CHD,[5,27] developmental care practices are carried out in stages, especially in fulfillment of nutritional needs,[39] and health workers need to carry out strict supervision during developmental care practices in infants with CHD.[8,30] The diagnosis of CHD in infants is a very stressful for parents, so optimal support is needed in providing socialization regarding their involvement in developmental care.[64] Infants with CHD also often experience challenges in fulfillment of nutritional needs which can cause stress for parents, so strategies in developmental care for fulfillment of nutritional needs need to be carried out in stages to minimize complications.[65] The implementation of the developmental care provision strategy in the aspect of intervention method also needs to be supported by the intervention model aspect strategy using the PDSA model.[31] The PDSA model is known to be tested, reliable, and valid in the healthcare service regulatory process.[66]

Strengths and Limitations

This scoping review has several advantages and limitations. To the author's knowledge in conducting a comprehensive literature search process, this review is the first review related to the implementation and strategy of developmental care practices specifically for infants with CHD in intensive care units. The results of the assessment using JBI on all findings of the studies analyzed showed a score of more than 75%. However, this review has several limitations, including this review only used five major databases for its article search, did not include a minimum number of patients for each study found, did not include a study year limit, and the average study sample was relatively small because specific research articles related to developmental care interventions in infants with CHD were very limited. In addition, this review also did not find any research articles related to developmental care interventions in the care subsystem according to developmental stage.

With these limitations, the author suggests that further research can involve more participants of infants with CHD and focus on developmental care interventions in the care subsystem according to developmental stages. The protocol for implementing a family-tailored Early Motor Intervention (EMI-Heart) as one of the developmental care that can be used by further research to determine the effects of its intervention on the development of infants with CHD.[67]

Conclusion

Developmental care is very important for all health workers as a multidisciplinary team for infants with CHD. This can help overcome developmental problems that often occur due to CHD. There are several developmental care interventions that can improve development in infants with CHD, including interventions on the physiological subsystem (massage therapy, KC, exclusive breastfeeding, and nutritional care); cognitive, motor, and sensory subsystems (early physical therapy, tummy time, oral feeding, and physiotherapy); parent-infant interaction subsystem (SSC, nutritional risk management, and nutritional training and support); and environmental management subsystem (infant accompaniment).

The implementation of developmental care needs to be accompanied by an adequate strategy to ensure its sustainability. The strategy for implementing developmental care interventions in infants with CHD includes several aspects, including aspects of health workers (experience, training, and license); aspects of intervention protocols; and aspects of intervention methods and models (socialization, close supervision, and PDSA models). The development of infants with CHD can be optimal if during intensive care, health workers, especially nurses, provide developmental care interventions by implementing several effective strategies. Although specific articles relevant to the purpose of this review are limited, there are several articles that conduct research on developmental care interventions in infants with CHD. However, there are still several gaps, including the relatively small average study sample and this review did not find any research articles on developmental care interventions in the developmental care subsystem. The author suggests that further research can involve more participants in infants with CHD in other developmental care interventions, especially in the developmental care subsystem.

Acknowledgments

All authors would like to thank Universitas Padjadjaran, Sumedang, West Java, Indonesia, for facilitating the database for this study.

Disclosure

The authors report no conflicts of interest in this work.

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