ORIGINAL ARTICLE

A Family-Centered Neurodevelopmental Care Framework for Post-neonatal Intensive Care Unit of Preterm Infants: Delphi Study

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ABSTRACT

Objectives: This study aimed to develop a structured, culturally responsive neurodevelopmental care framework for preterm infants during the first three months following the neonatal intensive care unit (NICU) discharge, based on research evidence and multidisciplinary expert consensus in Iran.
Materials & Methods: A two-phase study was conducted. First, a scoping review (2000–2024) identified key domains and items for post-discharge care. Second, a panel of 24 multidisciplinary experts completed a two-round Delphi survey. Consensus was defined as 75% agreement or higher and a mean Likert score of 3.75 or above on a five-point scale. Quantitative and qualitative analyses were performed in accordance with Delphi study guidelines.
Results: The finalized framework comprises 57 items categorized across eight primary domains. Expert agreement ranged from 87% to 95%, with mean Likert scores ranging from 4.42 to 4.65. Positioning and postural care showed the highest agreement (95% t, mean = 4.57). Experts emphasized continuity of care, parent-mediated interventions, and integration of developmental, emotional, and environmental components.
Conclusion: This culturally adapted, family-centered framework provides structured post-discharge neurodevelopmental care for preterm infants. It promotes infants' motor, sensory, cognitive, and emotional development while supporting parental empowerment and psychological well-being, potentially optimizing early neurodevelopmental outcomes in home-based care settings.

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Introduction

Preterm birth, defined as delivery before 37 weeks of gestation, remains a foremost global public health challenge, affecting approximately 15 million infants annually, with a prevalence of 11–12% in Iran (1-4). Infants born preterm face a heightened risk of developmental delays, cognitive impairments, and sensory-emotional regulation complications, which can have lasting effects on learning, social functioning, and quality of life (5-9).

Hospitalization in the neonatal intensive care unit (NICU) often exposes families, especially mothers, to

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substantial psychological stress. Such stress can disrupt secure parent-infant attachment, compromise the quality of caregiving, and negatively influence infants' neurodevelopmental trajectories (10-12).

Consequently, the period immediately following NICU discharge represents a critical window for neurodevelopment, characterized by rapid brain growth and neural plasticity. During this period, infants consolidate neural circuits and acquire foundational self-regulatory skills, making them highly sensitive to caregiver support (13-15). Caregiver inability to respond appropriately during this period increases risk for developmental delays, whereas family-centered educational interventions empower caregivers to optimize neurodevelopment and prevent adverse outcomes (16-19).

Systematic evidence highlights gaps in post-discharge support, with families often receiving insufficient guidance at home (13, 14). While early developmental interventions like the Mother-Infant Transaction Program (MITP), the Supporting Play Exploration and Early Development Intervention (SPEEDI), Transmural Developmental Support (TOP Program), and the Newborn Individualized Developmental Care and Assessment Program (NIDCAP) show short-term benefits, heterogeneity in content, duration, and implementation limits generalizability. Moreover, many existing programs focus on single developmental domains or the hospital environment and require extensive professional input and financial resources, posing challenges in low-resource or culturally distinct settings (15-19).

Post-discharge care programs are inherently culture-dependent, as caregiving practices, family roles, and parental expectations vary across sociocultural contexts. In Iran, no nationwide structured program exists to support preterm infants and their families after NICU discharge, resulting in delayed interventions, missed opportunities for early neurodevelopmental support, and increased parental stress and economic burden (20-22). This gap underscores the urgent need for a comprehensive, family-centered, and culturally tailored program that guides caregivers, addresses infant developmental needs, and is feasible within the local context.

Accordingly, this study aims to develop a comprehensive, family-centered, and culturally tailored post-discharge care program for preterm infants during the first three months after NICU discharge. Utilizing a Delphi method, multidisciplinary experts, including neonatologists, developmental pediatricians, NICU nurses, therapists, and psychologists, were engaged to achieve consensus on evidence-based, clinically relevant, and contextually appropriate intervention components. This approach actively integrates global evidence with the sociocultural realities of Iranian families, strengthening caregiver capacity, reducing post-discharge vulnerability, and maximizing the neurodevelopmental potential of preterm infants during this critical early period.

Materials & Methods

Methodological framework: This study was designed and reported in accordance with the Conducting and Reporting Delphi Studies (CREDES) framework, providing structured guidance to ensure methodological rigor and transparency in Delphi research. The CREDES checklist was used to justify methodological decisions, define consensus criteria a priori, minimize potential sources of bias through careful questionnaire development and piloting, and ensure transparent reporting of the consensus evolution across rounds (23).

Delphi study design: The Delphi methodology, a widely used approach in healthcare, was adopted to establish consensus on clinical matters (24). The present Delphi study was conducted in two rounds and involved national professionals, following the CREDES guide (23). The Delphi technique, an iterative process, involves participants anonymously expressing their opinions to reach consensus through successive rounds (25)

Ethical considerations

This study received ethical approval from the Ethics Committee of the University of Social Welfare and Rehabilitation Sciences (Code: IR.USWR.REC. 1403.210). All procedures were conducted in strict accordance with national and international ethical standards for research involving human participants. All expert participants received complete study information electronically, and their voluntary completion and submission of the questionnaire in each Delphi round constituted informed consent. Furthermore, explicit informed consent was obtained from all parents of preterm infants who participated in the subsequent validation phase to evaluate the framework's clarity and feasibility.

Participants

Experts from multiple disciplines related to preterm infant care, including developmental pediatricians, neonatologists, NICU nurses, occupational therapists, physiotherapists, and speech-language pathologists, were selected using purposive sampling. Inclusion criteria consisted of a minimum of a master's degree and at least five years of direct and continuous clinical or research experience with preterm infants. Of the 30 invited experts, 24 (80%) participated in both Delphi rounds.

Formation of a multidisciplinary steering committee: Before the Delphi process, a multidisciplinary steering committee was established to provide scientific guidance and oversee the study. The committee comprised four experts with complementary expertise: A developmental pediatrician, an occupational therapist with NICU experience specializing in early intervention, and two senior occupational therapists focusing on motor-cognitive development and sensory integration. Its main responsibilities included final approval of the methodology, supervision of item extraction and initial validation, determination of criteria for selecting the expert panel, and preliminary data analysis and interpretation.

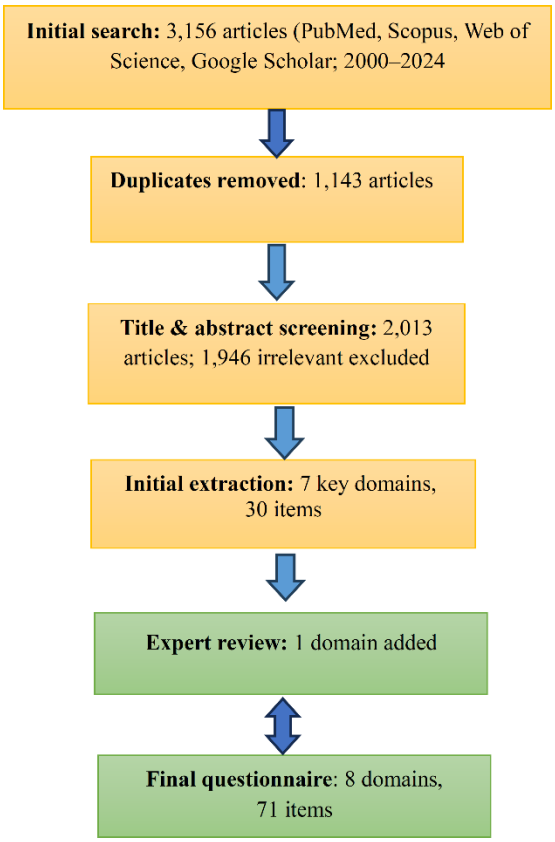

Figure 1. Process of Delphi questionnaire preparation

Delphi questionnaire preparation. The questionnaire is a crucial tool for obtaining professional opinions in the Delphi method .The Delphi questionnaire was developed in two phases to determine appropriate content for a family-centered neurodevelopmental care program for preterm infants.

The Delphi questionnaire, a key instrument for eliciting expert opinions, was developed to determine the content of a family-centered neurodevelopmental care program for preterm infants. A scoping review, guided by the Arksey and O'Malley framework, identified documented caregiving principles and interventions for developmental care of preterm infants. Studies addressing supportive developmental interventions initiated during NICU hospitalization and continued, or commenced immediately after discharge, were searched in PubMed, Scopus, Web of Science, and Google Scholar (2000–2024) in both English and Persian. Following the removal of duplicates and a rigorous screening of titles, abstracts, and full texts against predetermined inclusion criteria, 15 studies were deemed eligible for final inclusion. Based on this review, the steering committee identified seven preliminary domains: Physical environment regulation, positioning, motor stimulation, integrated sensory stimulation, emotional support and attachment, stress prevention and management, and psychological support and family empowerment, forming the initial structure of the open-ended questionnaire.

The initial domains and items were then refined and validated through expert feedback. Items were retained when at least 75% of experts rated them as necessary, consistent with standard Delphi consensus criteria. Qualitative feedback and suggested revisions were analyzed independently by two researchers using conventional content analysis. This process led to operationalization of broad items, subdivision and redefinition of some items, and the addition of a new domain, "nutrition optimization." The steering committee approved a revised draft that incorporated all consensus-based and newly identified items, yielding a final structured Delphi instrument consisting of 71 items across eight domains (Figure 1*).*

Delphi survey

Round procedures: During each round of the Delphi study, the progression of questionnaire items was guided by established Delphi principles. Items were either confirmed for retention, modified based on expert feedback, or removed according to predefined consensus thresholds. Decisions were based on both the percentage of agreement among participants and the mean rating of each item. Specifically, items achieving 75% agreement and a mean score of 3.75 or higher were retained, while items with moderate agreement (50–75% agreement and/or mean 2.5–3.75) were revised and re-evaluated in subsequent rounds. Items failing to meet these criteria were excluded. This approach ensured that only the most relevant and strongly supported items progressed, maintaining methodological rigor and systematically refining the questionnaire based on expert input (26-28) (*Figure 1)*

Round 1: The finalized questionnaire was distributed to experts via email and remained open for four weeks, with reminders sent after two weeks if necessary. Items meeting strong consensus criteria,

along with newly suggested items and those with moderate agreement, were carried forward for further evaluation in Round 2.

Round 2: A revised questionnaire included items that had not reached consensus in Round 1, along with any new items suggested by participants. Experts re-evaluated these items using a five-point Likert scale. Subsequently, experts retained only the items that satisfied the predefined consensus threshold, while those failing to meet the criteria were excluded from the final instrument.

Domain-level agreement calculation

For each core domain, only items that achieved consensus in the Delphi rounds were included. Domain-level agreement was defined as the mean percentage of experts who rated items as essential. Additionally, domain-level mean scores were calculated by averaging the mean Likert scores of all constituent items within each domain. Items failing to reach consensus were excluded, ensuring that domain-level values reflect only content supported by experts

Results

In the initial phase of the study, an initial pool of 71 items across eight core domains was generated through a systematic literature review and expert consultation, with the aim of developing a family-centered neurodevelopmental care program for preterm infants. These domains included the physical environment, positioning and postural care, motor stimulation, sensory stimulation, emotional support and attachment, stress and pain management, psychological support and family empowerment, and feeding optimization.

During the Delphi process, 24 out of 30 invited experts participated actively in both rounds, representing an 80% response rate. The demographic characteristics of the panel showed that 18 participants were female and six were male. Regarding educational level, eight experts held a doctoral degree, two had a professional doctorate, ten held a master's degree, and four had a bachelor's degree. The professional background of the expert panel included occupational therapy (33%), neonatology and pediatrics (21%), physiotherapy (17%), nursing (13%), psychology (8%), and speech-language pathology (8%). Regarding professional experience, 66% of the experts had more than ten years of clinical practice, indicating a high level of expertise within the Delphi panel.

Supportive physical environment: Findings from the first Delphi round indicated that items related to regulating the physical environment, including lighting, temperature, noise reduction, and provision of a safe sleep space, achieved the highest level of expert agreement, with approximately 90% agreement and mean scores above 4.5. Several items were removed due to insufficient consensus or limited feasibility for direct parental implementation, particularly those requiring complete reconstruction of NICU conditions or specialized environmental assessment. Based on expert feedback, the item referring to creating a NICU-like environment at home was revised to a more practical formulation described as a gradual transition from the controlled NICU environment to the home setting during the first 4 to 8 weeks after discharge. In the second round, after merging and clarifying items related to lighting, the final version emphasizing the use of natural, indirect, and controllable light reached high consensus, with more than 90% agreement and a mean score of approximately 4.4. Overall, all items in this domain exceeded the predefined consensus threshold of 75% agreement and a mean of 3.75 in the second round.

Stress and pain management domain: In the first round, items concerning stress and pain management—specifically those pertaining to the identification of stress signs, cessation of stimulation, and provision of rest—attained consensus levels ranging from 75% to 85%. In the second round, after merging items into a stepwise, parent-implementable framework, agreement increased to 88% to 95% with mean scores ranging from 4.3 to 4.7. Final items included parental education on stress recognition and infant self-regulation, timely cessation of stimulation, and non-invasive calming strategies.

Positioning and postural care domain: In the positioning domain, the first Delphi round revealed conceptual ambiguity and safety concerns in some items, particularly regarding infant sitting and broadly defined flexor positioning. In contrast, items based on evidence-based sleep safety, such as supine positioning during sleep and prone positioning during supervised wakefulness, were highly accepted from the first round, with approximately 90% agreement. In the second round, after revising the items emphasizing safety criteria, developmental timing, and feasibility at home, the final set of recommendations included maintaining flexor positioning until a corrected age of 42 weeks, avoiding unsupported sitting, supine positioning during sleep, avoiding prone positioning during sleep, and prone positioning during wakefulness only under supervision. These items achieved very high consensus, with agreement ranging from 91% to 97% and mean scores above 4.5, and were established as a practical, evidence-based guide for parents.

Motor stimulation domain: In the motor stimulation domain, several initial items were excluded due to their specialized nature or potential risk to the infant, including direct stimulation of primitive reflexes and use of unsafe equipment. Gentle activities

based on parent–infant interaction received higher acceptance. In the second round, items were redesigned using a play-based, infant-responsive approach tailored to the infant's level of alertness. The final items focused on promoting spontaneous movements, gentle movements within the natural range of joint motion, eye–head coordination, and antigravity activities with safe tools and parental interaction. All items achieved approximately 90% agreement with mean scores ranging from 4.5 to 4.8.

Table 1. Core domains, developmental goals, and sample items of the family-centered neurodevelopmental care program for preterm infants after NICU discharge

No.	Core domain	Developmental objective	Example items	Agreement (%)	Mean Likert score
1	Supportive physical environment	Promote infant self-regulation and reduce sensory load	Adjust lighting; control auditory stimuli; provide safe sleep space; gradual NICU-to-home transition	90.5%	4.42
2	Stress & pain management	Reduce stress responses and support physiological–behavioral regulation	Identify stress signs; stop stimulation timely; non-invasive calming strategies	92%	4.55
3	Positioning & postural care	Facilitate neuromotor development and postural safety	Supine sleep positioning; supervised prone during wakefulness; maintain midline/flexor posture	95%	4.57
4	Motor stimulation	Enhance spontaneous movements and motor coordination	Encourage antigravity movements; interactive play; gentle movements within joint range	90%	4.65
5	Sensory stimulation	Prevent sensory overload and support integration	Gentle tactile input; controlled visual/auditory stimuli; respond to infant behavioral cues	88%	4.63
6	Emotional support & attachment	Promote mutual emotional regulation and secure attachment	Skin-to-skin contact; eye contact; calm verbal interaction; sensitive response	87%	4.48
7	Parental empowerment	Increase caregiving self-efficacy and reduce anxiety	Hands-on training before discharge; active family participation; parental self-care	88%	4.47
8	Feeding optimization	Support safe and interactive feeding	Proper feeding positioning; suck-swallow-breath coordination; monitor satiety and fatigue cues	87%	4.45

Sensory stimulation domain: In the multisensory stimulation domain, first-round items achieved moderate consensus due to conceptual dispersion and the lack of a shared guiding principle. Items related to parental education for recognizing infant stress signs and sensory overload had lower agreement, ranging from 75% to 80%. A key principle emerged in the second round, advocating for sensory stimulation tailored to infant behavioral cues to preclude sensory overload or deprivation. This principle achieved 90% to 95% agreement with mean scores above 4.6. After conceptual reorganization, the remaining items reached agreement between 80% and 88%.

Psychological support and family empowerment domain: Comparison of the first and second Delphi rounds in this domain showed a gradual increase in expert consensus. In the first round, most items were close to the consensus threshold, with 75% to 80% agreement and mean scores of 3.7 to 4.0. In the second round, after integration and revision into broader principles such as hands-on education before discharge, active family participation, continuous communication with the healthcare team, phased parental emotion management, and attention to parental self-care, agreement increased to 85% to 90% with mean scores of 4.3 to 4.7.

Feeding optimization domain: A similar pattern was observed in the feeding domain. First-round items had agreement of 75% to 80%. In the second round, following integration, scientific refinement, and emphasis on cue-based feeding and parent-infant interaction, agreement increased to 85% to 90% with mean scores of 4.3 to 4.6.

Finally, based on the integrated analysis of quantitative and qualitative data from both Delphi rounds, the final framework of the family-centered neurodevelopmental care program for preterm infants was developed, consisting of eight core domains and 57 finalized items (Table 1). To enhance clarity and caregiver applicability, the finalized framework was reviewed by 15 parents of preterm infants with post-discharge experience. Parents evaluated the program in terms of clarity, relevance, and feasibility for home implementation. Minor wording refinements were made based on parental feedback, supporting the face validity and acceptability of the program.

Discussion

Despite the documented benefits of specific developmental care interventions, the transition of preterm infants from the NICU to the home setting remains a high-stakes period for families (29, 30). Current evidence suggests that integrated, family-centered frameworks for post-discharge care are insufficiently developed, leaving a gap in comprehensive support systems (31-33). Using a structured two-round Delphi process, the present study developed an integrated neurodevelopmental care program comprising eight core domains and 60 items, all of which achieved high expert consensus (87–95%) and strong mean Likert scores (4.42–4.65), indicating both clinical relevance and feasibility for home implementation.

High consensus across all domains reflects the shared expert view that post-discharge care must extend beyond isolated interventions and address the infant–family system as a whole. Previous programs, such as the MITP, SPEEDI, TOP Program and similar frameworks, often focus on single developmental domains or the NICU setting and often rely on professionally intensive delivery models, which may limit feasibility, scalability, and continuity after discharge (33-42). In contrast, the present program emphasizes continuity of care following NICU discharge through caregiver-driven, family-integrated strategies that combine developmental, emotional, environmental, and feeding components within the home setting.

The first weeks at home are pivotal for neurodevelopment, as attentive caregiver interaction can positively influence neural organization, self-regulation, and socio-emotional development. Focusing on this period allows caregivers to support ongoing brain maturation in the natural home environment, where daily routines and parent-infant interactions play a central role in shaping developmental outcomes (14,15).

Cultural and family considerations were central. In Iran, parents are primary caregivers, yet many report inadequate emotional, informational, and practical support after discharge. Mothers of preterm infants often experience persistent concerns, reduced caregiving confidence, and unanswered post-discharge questions (43, 44), challenges that are further compounded by limited access to structured follow-up services and home-visit programs. Providing structured support reduces parental stress, increases confidence, and positively affects infant neurodevelopment (10, 11, 45, 46). These realities underscore the need for feasible, home-based interventions to empower caregivers and reduce reliance on resource-intensive professional services.

Environmental regulation and stress prevention emerged as key components, achieving a consensus of 90.5% with a mean score of 4.42. Items related to adjusting light and sound based on infant behavioral cues, reducing sudden or intense stimuli, avoiding strong odors, and providing a gradual transition from the NICU to the home environment align with evidence demonstrating that preterm infants have limited capacity to process multisensory input. These findings are consistent with developmental care models emphasizing individualized environmental modulation to support self-regulation and physiological stability (47). The notable agreement in this domain underscores the importance of empowering parents to actively manage the home environment within the infant's tolerance range.

The positioning and postural care domain achieved the highest expert consensus (95%, mean Likert score = 4.57), underscoring its clinical importance and clarity in practice. Recommendations such as supine sleep positioning, supervised prone positioning during wakefulness, maintenance of midline alignment, and gentle positional transitions are consistent with established safety and neurodevelopmental guidelines and have been shown to support neuromotor development while reducing the risk of adverse outcomes, including positional plagiocephaly (48, 49).

The motor stimulation domain demonstrated 90% consensus (Mean: 4.65), reflecting expert support for play-based, infant-responsive activities promoting spontaneous movement and exploration. Grounded in perception–action and dynamic systems theories, this area underscores the caregiver's role in creating an enriched and responsive context rather than directing infant movement. Evidence supports that parent-mediated, activity-based interventions positively influence motor and cognitive outcomes in preterm infants, particularly when tailored to the infant's alertness, abilities, and interests (36, 50).

Sensory stimulation achieved 88% consensus with a mean score of 4.63, emphasizing the value of a cue-based, individualized approach to multisensory input after NICU discharge. Rather than promoting overstimulation or excessive restriction, the program adopts a balanced sensory regulation strategy that integrates gentle tactile, vestibular, visual, and auditory input into routine caregiving. This approach aligns with developmental care and sensory integration frameworks, advocating meaningful, predictable, infant-guided sensory experiences to support neural organization and adaptive developmental outcomes (37, 51-53).

Emotional support, attachment, and parental empowerment domains achieved consensus levels ranging from 87% to 88%, underscoring their central

role in post-discharge care. Interventions, such as kangaroo care, sensitive responsiveness, eye contact, calm verbal interaction, and parental education, are strongly supported by attachment theory and transactional models of development. These interventions not only enhance infant co-regulation and socio-emotional outcomes but also significantly reduce parental stress, increase caregiving confidence, and strengthen the parent-infant relationship, highlighting the bidirectional impact of caregiver well-being on infant development. By positioning parents as active partners rather than passive recipients of instruction, the program reinforces parental self-efficacy and strengthens the parent-infant relationship (38, 45, 54, 55).

The feeding optimization domain, with 87% agreement and a mean score of 4.45, reflects the importance of safe, developmentally appropriate feeding practices after discharge. Emphasis on proper positioning, coordination of sucking–swallowing–breathing, cue-based feeding, and pre-feeding oral stimulation aligns with neurodevelopmental models of feeding and supports both nutritional adequacy and positive feeding experiences in the home environment (56).

To our knowledge, this is the first study to integrate multiple neurodevelopmental frameworks into a unified, post-discharge family-centered program tailored to the Iranian context. By combining evidence-based developmental principles with multidisciplinary expert consensus, the program offers a structured yet flexible model addressing both infant developmental needs and caregiver capabilities within real-world settings.

Strengths of this study include the systematic integration of evidence-based literature with multidisciplinary expert input, high consensus across Delphi rounds, and the development of a comprehensive framework designed for caregiver implementation.

This study has several limitations. First, experts were drawn from a limited geographic region, which may affect the generalizability of the findings to other settings. Second, the framework has not yet been assessed through long-term implementation or outcome assessment, limiting conclusions about its actual effectiveness on infant development and caregiver well-being. Future studies should address these limitations by including a broader range of experts' perspectives and conducting longitudinal evaluations to validate and refine the program.

In Conclusion

Through the synthesis of a scoping review and Delphi methodology, this study establishes a comprehensive framework for post-discharge developmental support. This framework is characterized by its family-centered approach and its sensitivity to cultural context, addressing a critical gap in preterm infant care. The approach allows identification, prioritization, and integration of effective care components based on scientific evidence and multidisciplinary experts' consensus. The designed program simultaneously addresses infant developmental needs, including motor, cognitive, sensory, and emotional growth, and parental needs, such as stress reduction, caregiving skill enhancement, and empowerment.

Implementing this program can bridge post-NICU care gaps, enhance infant development and self-regulation, and empower parents as active care partners. The simultaneous focus on multidimensional infant development and parental psychological and skill support, along with cultural and resource adaptation for Iran, increases the feasibility and successful implementation in real-world settings.

Practical implications include:

1. Improved post-discharge care: The program can close care gaps and prevent developmental delays.

2. Parental empowerment: Education enhances awareness, confidence, caregiving skills, and reduces anxiety and guilt.

3. Facilitation of culturally adapted programs: Program adaptation to local context and resource limitations promotes acceptance and successful implementation.

4. National strategy for developmental care: The program can serve as a strategic framework to improve developmental outcomes and reduce psychosocial burdens on families.

Ultimately, integrating this program into primary healthcare systems and establishing a defined "care pathway" from hospital to home for preterm infants could be transformative in improving the health of this vulnerable population.

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Authors' Contribution

All authors have contributed to this research and approved the final manuscript. Hajar Sabour eghabli mostafa khan, Farin Soleimani, and Nazila Akbar Fahimi conceived and designed the study. The Delphi protocol and questionnaire were developed by Nazila Akbar Fahimi, Hajar Sabour eghabli mostafa khan, Seyed Ali Hosseini. Data acquisition through expert panel recruitment and survey administration was managed by Seyed Ali Hosseini, Aida Ravarian. Farin Soleimani and Enayatollah Bakhshi performed the analysis and interpretation of the consensus data. The manuscript was drafted by Hajar Sabour eghabli mostafa khan, and Nazila Akbar Fahimi, and underwent critical revision by Seyed Ali Hosseini, Nazila Akbar Fahimi, and Enayatollah Bakhshi. Administrative, technical, and material support was provided by Aida Ravarian, Nazila Akbar Fahimi, Farin Soleimani, and, with overall study supervision led by Farin Soleimani.

Conflict of Interest

The authors declare no competing interests.

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