

“SMART” Early Intervention programs for high-risk infants: what are the necessary ingredients?

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Abstract:

There is a gap in current knowledge about which early interventions facilitate the best outcomes for high risk infants. Reviews of early intervention do not offer clear guidance to those searching for a model for best practice. Identifying interventions which can reliably improve global development across domains is crucial, as the cost of minimal efficacy of early intervention is high in terms of quality of life for families. Interventions need to evolve to reflect and keep pace with what current evidence suggests are the key components of best practice.

The purpose of this article is to present a new framework (EI SMART) identifying key components which could contribute to more effective interventions. We present a clinical consensus of current challenges and themes in early intervention, based on multidisciplinary group discussions, including parents of high-risk infants, and supported by literature review. Components to include in early intervention programmes are: promotion of self-initiated developmentally appropriate motor activity; supporting infant self-regulation and the development of positive parent-infant relationships; promotion of early communication skills, parent coaching, responsive parenting and supporting parental mental wellbeing. Such multimodal programs may need to be evaluated as a package.

What this paper adds:

- *We propose EI SMART as a clinical reasoning framework based on an overview of the literature on early intervention (EI) programs beyond the NICU.*
- *EI programs should address SensoriMotor development, Attention and self-regulation, development of positive parent-infant Relationships and early communication skills, and Therapist input including parent coaching, responsive parenting and support for parental mental wellbeing.*
- *There is evidence of the importance of each of these domains in isolation: the challenge lies in delivering holistic and manageable multi-domain interventions within a multidisciplinary team.*

Background:

Improvements in neonatal intensive care have been associated with increased survival of very low birth weight and preterm infants; however, morbidity remains high. There is an increased risk of cognitive and/or behavioural impairments, speech and language delay, and sensorimotor deficits, including cerebral palsy (CP). This greatly increases the emotional and financial burdens on families, society and health care systems.

Multiple factors impact on cognitive, behavioural, language and sensorimotor outcomes in preterm infants. Periventricular leukomalacia, grades III-IV intraventricular haemorrhage and bronchopulmonary dysplasia are associated with a high risk of CP¹. There are also justifiable concerns about the impact of environmental factors in the neonatal intensive care unit (NICU) on preterm infants, including noise, bright lights, medical equipment and altered social interactions². Loud noises and bright lights have short-term negative effects on weight gain and cardiorespiratory parameters: these factors influence neurobehavioural outcomes². Isolation in an incubator, versus skin-to-skin caregiver contact, are very different sensory experiences with effects on cardiorespiratory parameters and sleep organisation. Non-medical factors including social demographics, parental education, parenting style, parental mental health, family structure, family functioning and the home environment are also associated with developmental outcomes³. In a longitudinal study³, the effects of biological and psychosocial risk factors on cognitive and socio-emotional functioning outcomes aged 2 years were additive.

The birth of an infant requiring NICU admission represents a life-changing crisis for parents, which could impact on parenting ability and sense of self-worth⁴. A high-risk pregnancy and/or preterm delivery may cause stress due to feelings of grief and guilt⁵. Around one quarter of parents of very preterm infants (especially mothers) report mental health problems over two years after the birth⁶. This may jeopardise parent-infant relationships, with effects on subsequent child development. Treyvaud et al.⁷ demonstrated a strong, positive association between parent-child synchrony and child cognitive development and social-emotional competence at two years corrected age.

Existing developmentally supportive care interventions *in the NICU* include the Newborn Individualised Developmental Care and Assessment Program (NIDCAP), Family Nurture Intervention, Family Integrated Care, and the Mother Infant Transaction Programme (Table 1). These are underpinned by an ethos of individually tailored collaborative care, developmentally supportive environments, and supporting the parent-infant relationship. All of these interventions are supported by evidence from large-scale randomised controlled trials.

Early intervention (EI) strategies *extending beyond discharge from NICU* are also critical to ameliorate the negative effects of prematurity on parenting, parent-infant interactions and developmental outcomes. Details of parent-focussed EI programmes extending beyond the NICU are provided in the narrative review by van Wassenaeer-Leemhuis et al.⁸, which considers the multimodal nature required of EI strategies, and issues around practicalities of implementation and evaluation.

Since 2016 a multidisciplinary UK-based group of early intervention therapists (occupational therapy, physiotherapy, speech and language therapy), a paediatric neurologist and a child psychotherapist with an interest in early intervention, and parents of high-risk infants, have convened to consider the largely fragmentary nature of the evidence around EI and propose how a more integrated approach could be implemented. The group was initiated by BH who,

from clinical experience and awareness of increasing interest in EI in other centres worldwide, became strongly motivated to ensure UK-based infants and their families receive optimal EI services and invited colleagues from relevant disciplines to form a group addressing this issue.

This paper presents an overview of the evidence and proposes a clinical reasoning framework for use in early intervention settings with high-risk infants for consideration.

What is an early intervention programme?

An EI programme for high-risk infants typically begins within the first year of life. The early years are critical: all early development (cognitive, motor, language and communication and growth) is influenced by social and emotional development through caregiving relationships. Interventions during this period have a high potential to impact positively on neurodevelopmental outcomes^{9,10}. EI aims “to promote child health and well-being, enhance emerging competencies, minimize developmental delays, remediate existing or emerging disabilities, prevent functional deterioration and promote adaptive parenting and overall family function”¹¹. A meta-analysis showed improvement in cognitive outcomes up to preschool age and in early motor outcomes with EI in preterm infants¹². However, the effect on motor outcomes was small; furthermore, fewer than half of the studies provided information on motor outcomes at preschool and school age.

Attributes of early intervention programmes

Environmental enrichment

Increasingly, EI programmes specify “environmental enrichment” (EE). The term has been derived from animal studies describing an environment that facilitates enhanced cognitive, motor and sensory stimulation in comparison to standard housing conditions¹¹. In their review of effectiveness of EI programmes for infants with CP, Morgan *et al*^{13,14} operationally defined EE as “interventions that aim to enrich at least one of the motor, cognitive, sensory, or social aspects of the infant’s environment for the purposes of promoting learning”. EE components of interventions are often implicit in their approaches but have rarely been overtly described.

Responsive parenting: Attention, Regulation and Relationships

It is key that health professionals create a central and ongoing role for parents in their infant’s care starting in the NICU, to foster parental feelings of inclusion, helpfulness, efficacy and control. Post-discharge EI programmes must also focus on nurturing the parent-infant relationship by promoting responsive parenting⁸. Increased parent-infant attunement and responsive parenting are associated with improved developmental outcomes⁷ and increased resilience in the child¹⁵. Given the high prevalence of poor parental mental health outcomes, impacting on the ability to provide responsive parenting, it is important for effective parental psychosocial support to be available where needed.

Within the setting of a strong parent-infant relationship, the infant learns self-regulatory skills (e.g. crying but being consolable; self-soothing; state changes between sleeping and waking; feeding). Various structured assessments appraise these neurobehavioural capabilities, such as the Neonatal Behavioural Assessment Scale (NBAS)¹⁶, Newborn Behavioural Observations (NBO)¹⁷ and NICU Network Neurobehavioral Scale (NNNS)¹⁸. The NNNS was developed from the NBAS: advantages are its strong psychometric properties and the

availability of standardised norms. Administration of the NBAS and NNNS sensitises the therapist to the complex dynamics of infant behaviour, physiological stability, and attempts at self-regulation. The NBO, which primarily addresses relationship building, is a shorter clinical tool, allowing the clinician to engage with the family in observing and interpreting the infant's behaviour and communication cues. These approaches provide a framework which inherently includes parents by providing information about infant behaviours and ways to modify interactions to match infant needs. They provide structured feedback about the infant's neurobehavioral development and regulation which can support sensitive, contingent and responsive parent caregiving, promote a parental sense of competence and help parents make informed choices about caring for their infant. A Cochrane review¹⁹ found a significant improvement in parent-infant interactions in the intervention group (NBAS/NBO) compared with controls, though individual studies were of poor quality.

Self-regulation in early development is embedded in the child's relationships with others. Beginning with attachment to primary caregivers, early relationships are the scaffold on which cognitive, linguistic, emotional and social development unfold. A critical element of good caregiving is to provide a supportive environment, with experiences and encouragement, enabling the child to take over and self-regulate in one area of functioning after another. The Infant Behavioral Assessment and Intervention Program (IBAIP) is an effective intervention focussing on supporting infant self-regulatory competence and responsive parenting and using similar approaches to NIDCAP but beyond the neonatal period²⁰. In a randomised controlled trial (RCT), IBAIP for very low birthweight infants until 6 months corrected age led to improved performance IQ, visuomotor skills and certain gross motor skills at age 5.5 years compared with standard care.

Emotional regulation is strongly associated with the development of attentional control²¹. Attention is defined as achieving and maintaining an alert state. Parenting that is sensitive to the infant's signals of interest and distress, participating in collaborative play and helping the infant to engage with challenging situations and persist in achieving their goals, will improve attention and emotional regulation. Attention promotes learning by allowing the infant to engage in activities for longer periods of time and to shift attention flexibly. Self-regulatory behaviours are critical early mediators of successful development of emotional reactivity, attention and activity level, school readiness and cognition. A large cohort study compared sustained attention, temperament and maternal sensitivity at 10 months with self-regulation outcomes at 18 months²¹. Early ability to engage in sustained attention was positively correlated with regulation outcomes. Moreover, responsive maternal behaviour predicted better infant regulatory behaviour and a longer latency to infant distress. The findings highlight the importance of the caregiving environment in infant development.

Sustained attention develops from the earlier emergence of alertness, spatial attention and feature identification. Deficits in sustained attention likely emerge from a complex interaction between biological factors and the individual's pre- and postnatal environment, including cascading effects resulting from atypical sensory and motor interactions¹⁴. Effective early intervention could help limit such escalation of difficulties.

Communication

Programmes such as PremieStart (an adaptation of the Mother Infant Transaction Programme), which focus on increasing maternal sensitivity to infant behavioural cues, show a promising positive impact on maternal-infant synchrony at term age and on developing communication skills up to 6 months corrected age (Table 1).

Communication development begins *in utero* and continues throughout infancy, childhood and into early adulthood. Fetuses are surrounded by the maternal voice; in comparison, preterm infants in the NICU are relatively deprived of maternal voice and opportunities for early language learning. Language exposure at 32 and 36 weeks gestation impacts infant vocalisations and conversational turns²², with effects on communication outcomes at 7 and 18 months²³. This highlights the importance of parental presence and input during the neonatal period to facilitate early language acquisition. However, communicating through incubator walls, over the sounds of monitors, can feel embarrassing and pointless and lack intimacy and spontaneity. Parents may require education, encouragement and permission to engage in behaviours such as talking and singing to their infants, which would feel acceptable and natural in a private setting.

Between 6 months and 2 years there is development of gesture, early vocalisations and linguistic communication, and symbolic and functional play, all of which require a responsive communication environment. Despite this, most early language intervention programmes begin at age 2 years, which may not be optimal.

Sensory development

Sensory information has an important role in all areas of development throughout the first year of life. Infants use sensory information to modify movement and postural control from the first months of life. However the NICU environment presents sensory challenges, with prolonged and excessive exposure to auditory, visual and tactile stimulation during a period of critical brain development, potentially leading to difficulties with sensory modulation²⁴. Longitudinal studies have identified a relationship between the sensory profiles of children born very preterm and neurodevelopmental outcomes at two years of age²⁵. Abnormalities of basic sensory processing and adaptive responses likely lead to later problems with more complex developmental and cognitive processes. It is important to adapt the NICU environment where possible to avoid exposing the infant to potentially harmful sensory stimuli, and to offer more helpful stimuli: for example, infant massage was shown to promote EEG-based surrogate markers of brain maturation²⁶.

Evidence for the efficacy of interventions aiming to improve sensory processing remains weak, partly due to study methodological issues²⁷. Robust research findings in this field would be welcome. In the absence of such evidence, parents and practitioners should be aware of how the individual infant may respond to sensory input and of any limitations in sensory processing (including visual and hearing impairments), how these may impact on behaviour, and how to ameliorate the situation including modification of the environment and interactions as necessary.

Motor learning: active “scaffolding”

Motor skill development is dictated by a mixture of genetic and environmental influences, and can be profoundly altered by insults to the developing brain. The challenge is to find effective approaches to optimise motor outcomes following such insults. Interventions are being shaped by the increased ability to identify infants at high risk of developmental delay and those with emerging CP²⁸.

Postural control strategies and movements of typically developing infants when learning new skills are highly variable. This variability allows for selection and adaptation of the most effective motor patterns through afferent feedback and active learning. This process has been described using Neuronal Group Selection Theory²⁹ and helps elucidate why active

exploration on the part of the infant facilitates motor learning. Infants with brain lesions have a more limited movement repertoire. These infants also need more task-specific practice than typically developing infants to learn a motor task. Intervention strategies providing ample opportunities for trial and error, active exploration, strategic use of postural support and considerable repetition of developmentally appropriate motor skills, are key to motor learning⁹. For some infants with severe CP, possibly with associated cognitive deficits, finding the most appropriate mix of sensory, motor and EE that results in active self-initiated movements is challenging but possible by breaking down the task and setting realistic intervention goals.

The GAME (Goals Activity Motor Enrichment)³⁰ programme is an example of a multifaceted approach for preterm and term-born infants at high risk of CP with early encouraging results. In an RCT with 30 participants receiving standard care or GAME for 16 weeks in the first year of life, motor skills, cognitive skills and parental satisfaction scores were higher in the intervention group. The approach encourages active infant participation, is goal-oriented, home-based and emphasises parent education. Scaffolding strategies are explored with parents; i.e. tasks and goals are tailored to the infant's developmental stage; as progress is made, physical help is gradually reduced or the environment adapted to ensure the infant remains challenged but able to participate with self-initiated movement.

The COPing and CARing approach (COPCA) for infants with special needs emphasises the importance of parent coaching in solution-focussed approaches to facilitate active infant participation. An RCT comparing COPCA with traditional infant physiotherapy for preterm and term-born high-risk infants found no difference in motor outcomes up to age 18 months; however, process evaluation revealed that for infants who developed CP, motor outcomes correlated with time spent by physiotherapists in coaching caregivers and with time spent challenging the infant to produce active motor behaviours³¹. In subsequent follow-up, COPCA-trained parents retained a trial-and-error approach when their school-age children were learning new skills. Providing rigid instructions to parents regarding intervention approaches was associated with worse motor outcomes at school age³². However, application of these findings to infants with CP may be limited due to the relatively low proportion of infants in the study who ultimately developed CP.

To date there has been no single early intervention approach designed specifically for use by physiotherapists, occupational therapists and speech and language therapists which encompasses all of the above evidence based 'ingredients'. Similarly, there is no single approach built around a central strategy of parental inclusion, education and empowerment beyond the NICU to maximise the effectiveness of EI for the infant. Typically, programmes are delivered by individual therapists who focus on their professional area of expertise (e.g. physiotherapists in COPCA). Parents may not know what to expect from service providers and may (potentially correctly) perceive different therapists as having competing intervention agendas. The focus needs to shift towards the holistic needs of the infant and family. A new approach is needed to produce collaborative evidence-based services with a common purpose, supporting professional development, placing parental empowerment and education at the centre of early intervention strategies and bringing about a change in practice.

The EI SMART Approach

“EI SMART” is a mnemonic to highlight key components of EI as being SensoriMotor development, Attention and regulation, Relationships and Therapist support. We propose EI SMART as a clinical reasoning framework, derived from consensus clinical expertise in

partnership with parents and supported by current evidence. The framework was developed to encourage practitioners working with preterm and other high-risk infants to work collaboratively with parents with the aim of optimising, and making manageable, early interventional support for infants and their families as well as identifying their own professional development requirements. Articulating the components enables therapists to support their consideration of the interplay of these elements and how they may be impacting on an infant's development and the parent-infant relationship, which will underpin the planning and delivery of their specific therapeutic intervention. As such, EI SMART can promote a multidisciplinary team-working ethos with the knowledge, skills and attitudes to undertake appropriate assessments and work with parents to identify and address the needs of the child and family in a tailored programme.

We consider the following as core components:

1. Actively involving, educating and empowering parents in biopsychosocial aspects of their infant's care.
2. Supporting a consistent and responsive parent-infant relationship.
3. Recognising, supporting and promoting the infant's self-regulatory behaviours.
4. Scaffolding the infant's next developmental cognitive, motor, sensory and communication steps to stimulate and elicit active participation.
5. Modifying the infant's environment to ensure the infant remains challenged and able to participate in a wide variety of self-initiated, self-produced motor activities in a variety of conditions.
6. Promoting parental well-being.

Spittle and Treyvaud also provide recommendations regarding key components of early intervention (e.g. when to commence, where to deliver, who should receive it, content, and duration)³³. In addition to their suggestions, it is important to consider who should deliver early intervention. We propose that EI should not be delivered in a time-limited way by one specialist therapist. Infants and parents will benefit from an integrated approach within the therapy team. Physiotherapists, occupational therapists and speech and language therapists, along with other healthcare professionals as appropriate, bring their unique skills, knowledge and expertise to the family (who bring their own vast situational knowledge, motivation and relationship with the infant) but in a co-ordinated approach with a lead contact, making intervention coherent and preventing overburdening. A "One size fits all" approach does not work for high-risk infants and their families: interventions must be tailored to individual needs and circumstances. This is achievable with a strong multidisciplinary team, good communication, appropriate assessments and sensitivity to individual situations.

Tailoring of interventions creates challenges for formal evaluation of therapy – however in clinical practice a pragmatic approach may be required, based on a combination of ingredients effective in isolation. Evaluation of the contribution of individual ingredients to the overall outcome may not be possible, but this does not preclude evaluation of the intervention package (e.g. the effect of having an early intervention team on child and family outcomes). Plans for development, evaluation and implementation must be made in partnership with parents³⁴. We are currently exploring parent views of their involvement in EI, barriers and facilitators to parent involvement and the influence of the parent-therapist partnership³⁵ prior to formal evaluation of the EI SMART approach.

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List of Tables

Table 1:

Examples of developmentally supportive care interventions in the NICU

Programme name and originator	Description	Effect
<p>Newborn Individualized Developmental Care and Assessment Program</p> <p>(NICDCAP: Als, 1984)</p>	<p>Assessment and individualised recommendations for caregiving including measures to reduce infant stress and promote physiological stability as well as parental involvement in care. Target population: low birthweight or preterm infants.</p>	<p>Ohlsson et al. 2013³⁶: Systematic review and Meta-analysis. No difference in death or major sensorineural disability or survival free of disability at 18 months compared with standard care. Improved scores on Bayley scales of infant development (mental development and psychomotor development indices) at 9 months, not reaching significance at 12 months. No outcomes related to parents, or healthcare providers, were studied.</p>
<p>Family Nurture Intervention</p> <p>(FNI: Welch, 2012)</p>	<p>Aims to facilitate emotional connection between mother and infant through eye contact, touch and voice, and thus to reduce maternal depression and anxiety following preterm birth, as well as positively influencing infant neuro-behavioural function. At least 4 hours per week of intervention until NICU discharge.</p>	<p>Welch et al. 2012: RCT comparing FNI with standard care in 150 preterm infants (26-34 weeks PMA)³⁷. Term equivalent age: Mothers demonstrated increased sensitivity during caregiving³⁸. Infant EEGs suggested greater maturation³⁹. 4 months corrected age: Mothers had reduced anxiety and depression⁴⁰. 18 months corrected age: Infants had improved language and cognitive scores (Bayley-III scales), fewer attentional problems (Child Behavioural Checklist) and decreased risk for autism spectrum disorders (Modified Checklist for Autism in Toddlers)⁴¹.</p>
<p>Family Integrated Care</p> <p>(FICare: O'Brien, 2013)⁴²</p>	<p>Ethos is that families of NICU infants should be educated and supported in providing as much of their infants' care as they can.</p> <p>Components of program are parent education, nursing education, peer-to-peer support and adaptation of</p>	<p>O'Brien et al. 2018⁴³: Multicentre, cluster-randomised controlled trial comparing FICare (n=895) with standard care (n=891) for infants with gestational age 33 weeks or less. Day 21: weight gain was greater in the FICare group and parents were less stressed and anxious. At discharge: more infants in FICare group were exclusively breastfed. No</p>

	the NICU environment to facilitate parent participation.	differences in morbidity, mortality, duration of stay. No longer-term outcomes available as yet.
Mother Infant Transaction Programme (MITP: Rauh 1990 ⁴⁴)	Parents are trained to recognise cues and minimise stress responses from preterm infants, through 10 sessions with a psychologist. Initial research showed improved cognitive outcomes at age 9 years.	Milgrom et al. 2013 ⁴⁵ : RCT with 123 infants born at <30 weeks gestation comparing “PremieStart” (an enhanced version of MITP) with standard care. Term equivalent age: Mothers in the intervention group were more sensitive and induced less infant stress during interactions. 6 months corrected age: Infants in the intervention group had higher scores on the Communication and Symbolic Behaviour Scales Developmental Profile Infant-Toddler Checklist.

Table 1: Examples of developmentally supportive care interventions in the NICU

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