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Preventive Interventions for Preterm Children: Effectiveness and Developmental Mechanisms

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Abstract

This article provides an integrative review of the effectiveness of and possible developmental mechanisms associated with preventive interventions for preterm children. An analysis of randomized clinical trials carried out within the last 15 years was framed within a contemporary developmental model emphasizing the role of parental adjustments to preterm children's characteristics. Evidence suggested positive outcomes could be understood in terms of improvements in developmental pathways associated with parental sensitive-responsiveness and child participation in intensive intervention-oriented child care. Implications for the critical role of the Medical Home model for preventive interventions for preterm children were discussed.

Keywords

preterm birth; intervention effectiveness; developmental mechanisms

The adverse neurodevelopmental consequences of preterm birth remain major concerns world-wide. Despite the identification of risk factors contributing to preterm birth, preventive efforts have not been effective.[1] Moreover, increased survival of very preterm infants in particular has added substantially to this burden as the severity of the impact of preterm birth on children's social and cognitive competence increases in an almost linear fashion with decreasing gestational age.[2–4] It is also the case that follow-up of children at low biomedical risk (30 – 34 weeks gestational age) without apparent disabilities has revealed an increased risk for many minor but nevertheless developmentally significant problems.[5,6] Even late preterm children (34–37 weeks gestational age) manifest poorer developmental outcomes than do full-term children.[7–9] Increased risks for sensory and motor problems create additional complexities for these children.[3]

The diversity of neurodevelopmental outcomes is quite remarkable but can be understood primarily in relation to variations in biomedical risk and the neurobiological mechanisms involved.[10,11] As manifested at the behavioral level, a wide range of risks to basic developmental processes are evident including visual motor skills, visual memory, spatial processing, language, as well as more complex and higher order organizational processes including metacognition, executive function, and motivation.[12–18] Difficulties regulating attention have been noted as well.[13,19] Correspondingly, numerous socioemotional and emotion regulation concerns have been observed. Early on, preterm children exhibit arousal, regulatory, organizational, and attentional difficulties that often manifest as increased irritability, reduced emotional expression, and lower levels of social initiations.[13, 20–22]

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Taken together, risks to these and related developmental resources and organizational processes combine to adversely influence children's emerging cognitive and social competence throughout early childhood. Indeed, from a cognitive perspective alone, on average preterm children's intelligence quotients are lower by one-half to three-quarters of a standard deviation compared to those born full term.[2, 23] Correspondingly, academic difficulties become apparent over time as do increased risks for a range of behavioral and social skills problems.[24–26]

Complementing ongoing biomedical efforts to counter the potential adverse consequences of preterm birth is the wide range of behavioral and developmentally oriented post-natal interventions that have been designed and implemented in an attempt to prevent entirely or at least minimize risks to children's social and cognitive competence. Developmental research has strongly suggested that experientially-based environmental influences are closely linked to a preterm child's developmental level.[27] When translated into preventive interventions, behavioral/developmental approaches have varied extensively in terms of rationale, timing, comprehensiveness, intensity, professional staff involved, and numerous other factors. Although some interventions have been highly focused, such as those that are oriented toward physiotherapy, the vast majority have had a broader but common goal, i.e., to assist parents and other caretakers to adjust effectively to a preterm child's developmental and behavioral characteristics in order to optimize their social and cognitive competence. As will be seen, this is clearly a co-regulatory process.

In this article, the possible developmental mechanisms through which preventive interventions emphasizing parental adjustments to preterm children may operate and their effectiveness are examined. This analysis is framed within a contemporary developmental model, the Developmental Systems Approach (DSA)[28,29] and is summarized following this introduction in the first section of this article. As will be seen, the DSA is organized in terms of the risk and protective factors associated with each of three hierarchically arranged but interrelated levels: (1) children's social and cognitive competence; (2) family patterns of interaction that influence children's competence; and (3) family resources that directly affect family patterns of interaction (see Figure 1). The second and major section of this article provides a summary of the outcomes of recent randomized clinical trials that have focused on assisting parents to adjust to their child's characteristics. More specifically, these outcomes and their effectiveness are evaluated in terms of the developmental mechanisms described within the framework of the DSA. The implications of this analysis for the design of intervention programs for preterm children from a systems perspective are discussed in the final section.

Developmental Systems Approach

The DSA framework is designed specifically to address issues related to children at risk for developmental delays and disabilities as well as young children with established disabilities in relation to the design and implementation of early intervention programs. This includes preventive interventions for preterm children. For ease of communication, preventive intervention will be referred to here as intervention in most instances. As illustrated in Figure 1, as children seek to accomplish goals and demonstrate their social and cognitive competence, they rely upon a series of developmental resources (fundamental developmental domains of cognitive, language, motor, socio-emotional, and sensory-perceptual) as well as organizational processes (executive function, metacognition, social cognition, motivation, and emotion regulation).[30] As noted earlier, preterm children are at increased risk with respect to many developmental resources (and components of these resources such as visual memory) as well as organizational processes. Accordingly, these child-specific risks interact with protective factors at the level of child development to

establish a child's level of social and cognitive competence at various points in time. For preterm children, these child-specific risk factors often exert an influence sufficient to reduce their overall levels of social and cognitive competence in relation to full-term children.[26]

Family Patterns of Interaction

As is the case for all children, however, their competence is substantially influenced by the environmental context as primarily established by their families.[31, 32] In most instances, through an array of family patterns of interaction, families are able to adjust to their child's unique and changing developmental patterns to support child development in as optimal a manner as possible. This adjustment process is represented by the dotted arrow from the level of child social and cognitive competence to the level of family patterns of interaction in Figure 1. Three types of family patterns of interaction (parent-child transactions, family orchestrated child experiences, and health and safety provided by the family) can be identified, and their major components are depicted in the figure. Within the DSA, these three components constitute the major developmental pathways directly influencing the level of child competence.

Especially during the first three years of the child's life, parent-child transactions are most influential and salient at this level and are emphasized in this article. These parent-child transactions are considered to be relationships necessary for promoting optimal child development that take the following three forms: (1) discourse framework; (2) instructional partnership; and (3) socioemotional connectedness. Each relationship creates a psychological state in which both partners (parent and child) have expectations about each others' roles in the transaction.[33] Although it is beyond the scope of this article to discuss details, these relationship processes encompass, for example, active and elaborate "conversations" (discourse framework),[34,35] scaffolding of tasks (instructional partnership),[36,37] and the formation of a shared or mutually responsive orientation including a secure attachment (socioemotional connectedness).[38,39] Parent-child transactions are core features of the DSA and have received widespread conceptual and empirical support.[30] It is these three relationship processes that are thought to be the mechanisms that mediate many of the effects of family influences on children's competence especially during the child's first three years of life.

Most often, however, as will be seen, interventions for preterm children focus not on the three relationship processes themselves but on their building blocks; i.e., sensitive and responsive interactions occurring between parents and children. Measures of parental "sensitive responsiveness" take many forms and include assessments of contingent responsiveness, affective warmth, and intrusiveness of exchanges when interacting with their child. Sensitive-responsiveness is best assessed in different contexts and family routines as well as evaluated in terms of frequency of interactions. That is, parents and children should be engaged with one another to a sufficient extent. High quality parental sensitive-responsiveness occurring during parent-child interactions represents an awareness of their child's interests, skills, and abilities as well as their emotional and motivational state. It is suggested that the three relationship processes emerge over time as a result of ongoing sensitive-responsive exchanges. Moreover, these processes are clearly interrelated but yet sufficiently differentiated to produce varying effects on children's competence.[40]

Stressors to Parent-Child Transactions

For many families, adjustments to create high quality parent-child transactions are not entirely successful as a result of child-specific characteristics. Within the DSA, these child characteristics are said to constitute stressors (see Figure 1). Available evidence suggests

that, in fact, preterm children's characteristics discussed above substantially increase the risk that they will serve as stressors and affect numerous components of a family's pattern of interactions, especially parent-child transactions. In general, mothers' difficulties in adapting to their preterm child to support development in as sensitive and responsive a manner as possible have been well described. Indeed, problems establishing an overall synchronous relationship with their infant are evident even in the Neonatal Intensive Care Unit (NICU).[20,41] Specific maternal behaviors of concern include increased intrusiveness, frequently re-directing their child, and failure to recognize and adjust to their child's signals, among others. These difficulties often continue through various periods of early childhood.[13,42]

A series of studies by Landry and her colleagues[27] as well as by other investigators have clearly demonstrated the close association between levels of sensitive-responsiveness and numerous child developmental resources and organizational processes for preterm children. Toy play, language development, and executive function have been especially well studied.[27, 43] Moreover, associations between sensitive-responsiveness and child outcomes closely co-vary over time, as changes in maternal behaviors at different time points in early childhood are associated with corresponding changes in children's social and cognitive competence.[44] Of significance, various studies of these interactions indicate that the direction of influence on preterm children's development is from parent to child.[13,42,45,46]

When stressors are extensive and sensitive-responsiveness is of correspondingly low quality, preterm children's competence appears to be more adversely affected than that of full-term children.[47] Fortunately, higher levels of sensitive-responsiveness may also provide a special benefit for preterm children.[44] This moderating effect is illustrated in Figure 1 by the dashed line from the level of child social and cognitive competence to the level of family patterns of interaction. Accordingly, interventions that enhance parent sensitive-responsiveness to the extent that improvements in the quality of parent-child transactions occur can be expected to promote children's competence.

Family Resources

Finally, characteristics of preterm children (in terms of both their health and development) can create stressors that can also affect a family's resources (see bottom section of Figure 1). Among the most common effects are unusually high levels of parental distress (a mix of anxiety and depression), especially during the first year of the child's life[20,48–50] as well as perceptions of child vulnerability that may persist for long periods of time.[51] In turn, these and other stressors affecting the level of family resources can adversely influence one or more components of a family's pattern of interactions, especially parent-child transactions (see Figure 1). For example, increased maternal distress in the child's first year is associated with lower levels of sensitive-responsiveness.[20,52] Moreover, given the co-occurrence of limited family resources (high environmental risk) and the likelihood of a preterm birth, these pre-existing family resource problems are certain to also adversely influence family patterns of interaction over time. Problems associated with families at high environmental risk are often exacerbated by the stressors created by the birth of a preterm child. As discussed later, these "doubly vulnerable" children create unusually complex problems for interventions seeking to improve the quality of parent-child transactions.[53]

In partial summary, at each of the three levels of the DSA (child social and cognitive competence, family patterns of interaction, family resources) a series of components have been identified each capable of serving as a risk or protective factor for all children, including preterm children. These risk and protective factors interact with one another within each level and also exert influences between levels as illustrated in Figure 1 and described above. Optimal child development occurs when children consistently experience

high quality family patterns of interaction. Most families are able to make necessary adjustments to their child's characteristics to achieve sufficient levels of high quality family patterns of interaction. However, others experience considerable problems. The consequence is to create stressors that elevate risk factors at the level of family patterns of interaction or at the level of family resources.

Especially for the first three years of life, a major stressor to family patterns of interaction created by preterm children's characteristics is the ability of parents to engage in sensitive-responsive interactions as effectively as parents of full-term children. It is suggested that this circumstance impairs the formation of relationship processes - - discourse framework, instructional partnership, and socioemotional connectedness - - processes essential for supporting all children's social and cognitive competence across the early childhood period. Accordingly, successful intervention programs for preterm children will have effectively maximized parent-child transactions and other family patterns of interaction.

Preventive Interventions

In this section, the effectiveness of recent preventive intervention programs for preterm children is reviewed from the perspective of the DSA. As suggested, interventions for preterm children should be most effective if the quality of family patterns of interaction improves, with a primary developmental mechanism being enhanced parent-child transactions. High quality parent-child transactions that are established early in the child's life may well provide the continuity of relationships necessary to permit adjustments to children's characteristics and to minimize stressors that may emerge over time. As a consequence, a child's development will be maximized in the context of biological constraints. As noted, most intervention studies address the building blocks of those transactions, referred to as parental sensitive-responsiveness. However, these measures serve as useful indices for the three key relationship processes and their associations with child outcomes.

In addition to targeting parent-child transactions, another potentially important intervention approach at the level of family patterns of interaction is enrollment of their child in quality child care or preschool programs. Intervention-oriented child development programs may be especially valuable for children at risk as school readiness may be improved and enhanced child competence may contribute to better quality interactions between parents and children. It is in this context that teacher-child relationships can be formed in a manner that parallels parent-child relationships. As discussed later, this suggests the operation of similar developmental mechanisms identified by the DSA functioning with different caregivers in different contexts. This circumstance may also provide a line of continuity needed to establish longer-term benefits of early childhood interventions.

Finally, these developmental mechanisms directly addressing the level of family patterns of interaction can be supplemented by interventions utilizing more indirect approaches, i.e., those focused at the level of family resources, including reducing parent distress, providing professional support, or improving parent coping skills (see Figure 1). The expectation is that components at this level in which intervention successfully reduces risk factors will support higher quality family patterns of interaction and, as a consequence, improved child competence will result. Accordingly, a more complete understanding of the developmental mechanisms that have been influenced or failed to have been influenced by intervention programs can contribute to a better understanding of the current status of the effectiveness of preventive intervention programs for preterm children and provide a framework for future research and practice.

Organization of This Review

With this background, randomized clinical trials carried out in the last 15 years will be evaluated. Interventions initiated at earlier points are included if warranted by follow-up studies of earlier cohorts. Studies were identified based on a comprehensive search of the literature using standard databases. Only studies that addressed outcomes related to children's social and cognitive competence and provided sufficient detail about the interventions to permit an assessment of possible developmental mechanisms were included.

The review is organized into sections defined by the timing of intervention initiation. Accordingly, the first section describes interventions carried out entirely while the child was in the Neonatal Intensive Care Unit (NICU). The prospect of capitalizing on sensitive periods was central to the rationale for intervening while infants were in the NICU.[41,54] The second section addresses studies that were initiated in the NICU but were continued into the home setting for various periods of time. The intent here was to facilitate the transition from the NICU to home, often by providing ongoing professional support as well as by assisting parents to maximize family patterns of interaction. The third section focuses exclusively on interventions that were initiated following discharge from the NICU. By having interventions begin after a period of time has elapsed since discharge from the hospital, parents may be more aware of issues and perhaps more receptive and comfortable with the intervention program. As will be seen, post-discharge interventions, in particular, varied extensively in terms of the intervention length and other characteristics. Please note that children's ages in the studies described in the three sections represent a correction for preterm birth.

Neonatal Intensive Care Unit Interventions (NICU)

Despite the challenging circumstances for all involved in the NICU environment, a concerted effort was made beginning in the late 1980's to assist infants to organize their behavior and to reduce stress.[55] The term "developmental care" has been used to characterize this shift in NICU practices that included structural and staffing modifications.[56] However, central to developmental care were efforts to assist parents to recognize and then adjust to their child's behavioral capacities. The primary approach was to foster sensitive and responsive exchanges to establish a foundation for the development of synchronous parent-child relationships. From the perspective of the DSA, over time these more global relationships would become more differentiated, ultimately supporting all three critical forms of parent-child transactions (discourse framework, instructional partnership, socioemotional connectedness). Accordingly, relationship processes constituted the primary developmental mechanisms intended to produce the hoped for long-term gains in children's social and cognitive competence for this form of intervention.

The most well known intervention carried out within the developmental care framework is the Neonatal Individualized Developmental Care Program (NIDCAP).[55] Briefly, although there are a number of variations of this approach, well-trained developmental specialists carry out observations, including those related to the infant's autonomic, motor, and state organization as well as attentional and self-regulating patterns. This information then forms the basis for designing individualized strategies to enhance parent-child transactions.

Als and her colleagues implemented this approach in a number of randomized clinical trials yielding positive short-term outcomes (two weeks post-term) for both low and high biological risk preterm children.[54, 57–59] At the level of child competence, available evidence suggests that certain developmental resources (e.g., motor responses) and even the rudiments of organizational processes (e.g., emotion regulation and attentional mechanisms) can be enhanced by the intervention.[57] These more organized behavioral patterns may well

permit infants to attend to the environment and process information more effectively. The result is improved competence, at least in the short-term, and perhaps even placing some children on a trajectory that can support longer-term effects. Indeed, NIDCAP continued to have a positive effect on children's cognitive development at 9 months.[54,58] In this context it should be noted that, although not a randomized trial, rigorously carried out work emphasizing one of the components of the multi-component NIDCAP intervention, skin-to-skin contact with the mother generally referred to as the Kangaroo Care approach,[60] has also produced positive sustained effects in comparison to a group for whom this approach was not part of the NICU's standard protocol. Specifically, at six months of age, preterm children receiving Kangaroo Care achieved higher scores on cognitive measures and on measures of attention and exploration.[61,21] Improved parental sensitive-responsiveness was associated with positive child outcomes.[61]

An alternative or complementary developmental pathway which may have produced these effects are influences that operate at the level of family resources. Indeed, all of the various forms of developmental care provided professional and other forms of social supports to parents while their child was in the NICU. To the extent that this supportive relationship occurred, it can be expected to influence a number of possible components at the level of family resources. [62–64] In fact, available evidence indicates that developmental care interventions do reduce many risk factors associated with family resources. Specifically, as a result of these interventions, parents perceive their child more positively, experience less overall distress, and consider themselves to be more competent parents.[57,61,65] As noted earlier, many of these family resource components are at elevated risk as a result of preterm birth. Reductions in these risk factors can be expected to have a positive influence on parent-child transactions thereby augmenting any effects of the intervention focusing more directly on these relationships.

Despite these promising results, other investigators have only partially replicated the NIDCAP findings, producing complex outcomes and often failing to find sustained effects.[66,67–70] Compounding these inconsistencies are the many methodological problems that have been identified.[56,71] At present, it can be concluded that interventions in the NICU may well have the potential to assist families to develop more synchronous relationships with their child in the NICU through enhanced sensitive-responsiveness and improved family resources related to reduced parent distress and more confident parenting. However, firm conclusions must await the results of well-designed studies focusing on these particular developmental mechanisms and their impact on children's competence.

Combined NICU and Home Interventions

The transition to home provides a more comfortable and familiar setting for families but also brings about an entirely new set of responsibilities. Moreover, the potential clearly exists for different child-specific risk factors to emerge or now exert a stronger influence on family patterns of interaction and family resources. To ease this transition and to try to maintain any positive benefits that may have occurred in the NICU, a number of interventions have been carried out with the idea of helping families adapt to these new circumstances.

Many contemporary studies followed the approach of an earlier intervention that produced unusually promising effects. Referred to as the Mother-Infant Transaction Program (MITP), this intervention was modeled closely after NICDAP and provided seven sessions in the NICU during the week prior to discharge.[72] Mothers were assisted in identifying child cues to distress and provided with techniques to support their child's self regulation. Improving parental sensitive-responsiveness was again at the center of this intervention. The four home visits that followed discharge from the hospital were designed to provide professional support (e.g., caretaking advice, information on child temperament) and to enhance parental

confidence while continuing to encourage effective parent-child exchanges. A major influence on child competence for those participating in the MITP resulted from this modest, eleven session intervention. Specifically, the cognitive development of control group children (and many aspects relevant to their social development) declined over time whereas the intervention group remained stable and eventually became comparable to a full-term group.[73,74]

A reasonable interpretation of these findings, and consistent with other measures obtained in this long-term longitudinal study, is that the MITP intervention provided families, most of whom were not at high environmental risk, with the skills and confidence to continue to adjust parent-child transactions and ultimately other aspects of family patterns of interaction to changing child characteristics over time. That is, stressors to optimal family patterns of interaction were minimized. Of note, other early studies similar to the MITP involving high environmental risk families produced far more modest effects despite an extended home-based component of one to two years.[75, 76] The ongoing cognitive declines for both intervention and control groups for these high environmental risk families, despite less of a decline for intervention children, emphasizes the powerful role of limited family resources including their influence on virtually all components of family patterns of interaction.[53,77] Again, however, better outcomes for preterm children were associated with higher scores on measures related to sensitive-responsiveness.

The results of contemporary studies using the MITP protocol or variations of this intervention have not been nearly as promising.[78–81] Either no effects or minor effects on children's cognitive development have been found, despite findings of improved parent sensitive-responsiveness. In fairness, however, children have not been followed for long periods of time. This makes it difficult to evaluate the ultimate effects of these modest interventions as any influences of sensitive-responsiveness that might exist are often not apparent until later periods during early childhood development. Moreover, for both high and low environmental risk samples, those families participating in the interventions were not only found to display higher levels of sensitive-responsiveness but also experienced less child-related stress and considered their children to be less challenging and temperamentally easier.[81–85] These findings were not consistent across studies but do allow the possibility that benefits to children may arise at later points in time. Although all these studies were based on the MITP, variations in the MITP protocols emphasized by different groups of investigators, sample differences, and the varied training levels and types of professionals implementing the interventions (e.g., nurses, occupational therapists, and physical therapists) make it difficult to find any meaningful patterns in the outcomes for combined NICU and home interventions.

Interventions Initiated in the Home

As discussed below, similar and perhaps even more disappointing outcomes were obtained from a series of studies that emphasized beginning intervention in the home after allowing time for more stable family routines to be established and giving parents an opportunity to identify any child-specific issues that were of concern, especially for interventions that began a few months post-discharge. These interventions initiated in the home were generally of modest intensity typically consisting of one to one-and-a-half hour home visits monthly or twice monthly for periods of 6 months to as long as two years. They also tended to have substantial didactic or educational skills features. Nevertheless, the intervention curricula were quite diverse but sought to build a relationship between home visitors and parents, provide professional support, and make referrals to other service providers as needed. Supportive efforts to promote high quality parent-child transactions through strategies to improve sensitive-responsiveness were also central to most of the home initiated interventions. Despite many variations of this general approach, the most consistent result

was an absence of effects on children's competence.[86- 88] Not only did these studies fail to find short-term effects, but longer term follow-ups were equally disappointing.[89] Unfortunately, limited information with respect to changes in sensitive-responsiveness was obtained but it is likely that minimal effects occurred.[88]

PALS Intervention—The sole exception to the disappointing outcomes of these modest home visiting approaches was the intervention referred to as Playing and Learning Strategies (PALS).[27] In contrast to the work noted above, this intervention incorporated more contemporary approaches supporting sensitive-responsiveness and related developmental mechanisms and provided extensive information with respect to the possible relationships existing among all three levels of the DSA. Accordingly, this intervention is considered in detail.

Initially designed to provide only ten one-and-a-half hour home visits when the child was between 6 and 10 months of age, the intervention was supplemented by an additional 11 week home visiting program when the child was approximately 30 months of age. The detailed curriculum was designed to promote four components representing sensitive-responsiveness: (1) contingent responding, (2) emotional affective support, (3) supporting the infant to focus attention (maintaining), and (4) language support consistent with the child's needs. Of importance, this intervention was based on years of careful developmental research identifying the components of sensitive-responsiveness associated with optimal child outcomes most likely to have an impact on the three DSA-based relationship processes.

Highly interactive sessions including strategic use of videotapes and alternate caregivers along with techniques to integrate interactive behaviors into everyday routines together contributed to create a highly sophisticated intervention approach. A special challenge for the intervention program was the fact that the children studied were doubly vulnerable, as most families were at high environmental risk. Despite these circumstances, measures obtained from observations of mother-child interactions, independent child play, and interactions with an examiner at different points in time following the end of intervention that began during the child's first year yielded highly encouraging results. Among the positive findings, measures related to child language and cognitive development were higher for children in the intervention group as compared to a control group assessed three months following completion of the initial ten sessions.[90] Changes in children's competence were accompanied by corresponding changes in parent sensitive-responsiveness. Of note, sensitive-responsiveness for control group mothers declined over time, likely reflecting the influence of child-specific stressors on parent-child transactions and possibly contributing to elevating risk factors related to other components of family patterns of interaction or components at the level of family resources. Moreover, the cumulative effect of pre-existing limited family resources for this high environmental risk sample also likely contributed to the observed decline in sensitive-responsiveness for control families. That the PALS intervention, acting directly at the level of parent-child transactions, was able to overcome these risk factors attests to the quality of this intervention.[91] Adding intervention components at the level of family resources to provide professional supports and assist in accessing community services would be expected to have further positive effects on child competence. Preliminary findings suggests that this is precisely what occurs.[92]

The second phase of the PALS intervention allowed both a follow-up of children receiving the initial ten intervention sessions as well as an evaluation of any additional benefits of the second intervention implemented during the preschool period. In this second phase, an eleven week intervention followed the same approach to increasing mother's sensitive-responsiveness but was adjusted to children's characteristics at their current developmental

level. Findings were complex, but nevertheless revealed that the second phase made an important additional contribution to key aspects of sensitive-responsiveness, particularly contingent responding and verbal engagement.[93] Moreover, child competencies with respect to language development and social engagement were more optimal when families participated in both PALS interventions. Contingent responding was especially important and reflected the ability of mothers to adapt appropriately to their child's changing characteristics. Although other factors such as professional support may have contributed to these outcomes, further analysis revealed that the contingent responding and warm sensitivity components of sensitive-responsiveness were important mediators of the intervention effects on preterm children's competence.

Long-term effects of the PALS intervention have not been examined but findings for children from both phases of an intervention in the early childhood period that primarily focused on and benefited various components of sensitive-responsiveness are encouraging. It is unclear, however, the extent to which this modest intervention was able to substantially alter any of the three relationship processes central to the DSA. Unless this were to occur, only short-term effects would be expected. The added benefits of the second phase during the preschool years did increase prospects for establishing higher quality relationships in the form of parent-child transactions. Accordingly, this suggests the need for some form of periodic assessment process and corresponding interventions as needed over time to maximize long-term outcomes. As discussed earlier, child-specific stressors may emerge over time as preterm children encounter more complex and demanding developmental tasks that now tax developmental resources and organizational processes that are at higher risk.

Infant Health and Development Program—The Infant Health and Development Program (IHDP) is a landmark preventive intervention effort for preterm children that can be characterized by its comprehensiveness, high intensity, and multi-site features. The high intensity of the intervention with its many components distinguished it from other intervention programs, and is therefore also considered in more detail. Initial results of this well-designed study were reported in 1990[94] but many of the nearly 1000 children and their families have been followed for close to two decades. Three major intervention components were implemented for a three year period beginning soon after discharge from the hospital nursery. Although details have been well described elsewhere,[95] a central feature of the intervention was a home visiting component in which a home visitor assisted mothers to develop better problem-solving skills related to everyday problems as well as with respect to the care of their preterm child. Parent group meetings were also organized to provide an additional form of social support. In addition, and a major focus of the home visiting program, was the implementation of two formal educational/developmental curricula. The first was implemented soon after the infant was discharged from the hospital and was similar to most other curricula designed to assist mothers to recognize children's cues and to help them self-regulate. The second was adopted from a curriculum for full-term children whose families were at high environmental risk focused on promoting advances in the major developmental domains guided by each child's developmental pattern. Activities were carried out to maximize sensitive-responsiveness and affective warmth and there was a strong "educational skills" emphasis to the curriculum. This same curriculum was implemented by well-trained educational staff for children enrolled in an intervention-oriented child care center operated by the researchers. Families were encouraged to enroll their child in the center during years two and three of the intervention. Both intervention and control groups received regular pediatric follow-up care, related assessments, and referrals as needed to community specialists. Numerous measures were obtained at various points during and following completion of the intervention.

At the end of the three year period, highly positive effects of the intervention were found. Focusing on overall cognitive development, both intervention and control groups showed declines over time, but much less so for children participating in the intervention. In general, these effects were more pronounced for children at lower biological risk based on birth weight and for mothers at higher environmental risk.[96] Follow-up of children at later ages revealed some residual positive effects varying with birth weight, but the major differences between the groups were no longer apparent.[97–99]

Additional analyses were carried out in an effort to identify likely developmental mechanisms and perhaps provide an understanding as to the pattern of short-and long-term results. With respect to short-term benefits, the IHDP intervention appeared to have only minor effects on components assessed at the level of family resources. Specifically, less emotional distress was reported by mothers in the intervention group but maternal distress did not appear to mediate child outcomes nor were any effects found for maternal coping strategies.[96,100] Focusing on the level of family patterns of interaction, in view of the home visiting component positive short-term effects may well have been due to direct changes in sensitive-responsiveness, as appeared to be the case for the PALS intervention. Some differences between IHDP intervention and control groups were, in fact, found for relevant measures but appeared to revolve entirely around instructional issues designed to promote their child's development. Specifically, intervention group mothers were observed to provide higher quality assistance in a problem-solving task with their child, although the effects were quite small.[101] They also provided more appropriate and stimulating learning materials at home.[53] However, other measures relevant to parent-child transactions including a general assessment of sensitive-responsiveness as well as language stimulation did not differ between the groups.[53] In addition, no long-term effects of parental style or the provision of developmentally supportive activities in the home were found but opportunities for earlier employment due to the availability of the child care center may have had a positive effect.[102]

Although the cumulative impact of this comprehensive intervention must be considered, the pattern of findings suggested that the experiences of the child in the child development center were most likely responsible for the between-group improvements in children's competence. Both short-term and the longer-term outcomes were closely associated with participation in the center and engagement with the curriculum.[103,104] Of note, mothers at higher environmental risk for whom the program was most effective appeared to have less of an interest in the educational materials provided by the home visitor component.[105] Accordingly, particularly in instances in which engagement with teachers was high in the child care center, the quality of teacher-child relationships formed in the child development center appear to have created conditions for improving children's social and cognitive competence. Intensive, high quality child care or preschool programs which foster teacher-child relationships especially for children in high environmental risk families are much more likely to develop a discourse framework, an instructional partnership, and socioemotional connectedness. [106,107]

It is clear that many parents of preterm children, particularly those at low environmental risk, were able to adapt to any emerging child-specific risk factors. Family resources such as the ability to cope and utilize their social support networks, including professional supports, were likely among the characteristics of these families which ensured that high quality family patterns of interaction were provided. The IHDP was apparently not able to enhance this pattern. Moreover, perhaps as a result of the educational skills focus of the intervention, the IHDP did not have major effects on parent-child transactions nor family resources, irrespective of environmental risk level. As a consequence, following termination of the intervention, when the child was three years of age, many high environmental risk parents

likely experienced additional difficulties adapting to their child's changing developmental patterns especially when children encountered more demanding but less supportive situations such as those occurring during preschool or kindergarten programs. The advances that were achieved through participation in the child development center, perhaps including expectations for forming quality relationships with teachers, may have had some long-term benefits.[103] However, for the most part, in the absence of substantial changes in parent-child transactions as reflected by minimal changes in sensitive-responsiveness, any emerging child-specific risk factors (e.g., negative emotionality)[108] were likely to constitute stressors that persisted. These stressors would be compounded further by the many (pre-existing) family resource problems that inevitably occurred over time for high-risk families thereby elevating risk levels for the many components of family patterns of interaction and limiting long-term effects.

Conclusions and Implications for Practice

Despite important medical advances, preterm birth remains a major concern with significant consequences for children's development. Preventive intervention programs have addressed the challenges facing families to assist them to adapt to their child's characteristics and to establish as optimal a developmental environment as possible. These interventions have been initiated at various points throughout the early childhood period and have differed substantially not only in terms of timing, but in duration, approach, intensity, comprehensiveness, and other dimensions. In all instances, however, the expectation was that interventions occurring during the early childhood period will not only produce immediate, short-term benefits but also establish conditions that will create sustained effects over time.

The diverse characteristics of the available studies as well as the complexity and often inconsistent results that have been found do not allow straightforward conclusions as to effectiveness.[109] Nevertheless, sufficient information is available to suggest that interventions implemented at any point in time during the early childhood period can produce modest short-term effects on children's competence. Positive findings may be related to indirect effects of reduced parental distress, an enhanced support system, or other factors at the level of family resources that can influence parent-child transactions in particular. However, only limited support exists for this developmental pathway. With respect to a different pathway, especially for high environmental risk families, extensive participation in an intervention-oriented child development center can make an important contribution to children's competence at least during the time it is in effect. However, it has been difficult to demonstrate widespread sustained effects even for the high quality and highly intensive intervention provided by IHDP.

Alternatively, important positive findings have been accompanied by improvements to many components of parental sensitive-responsiveness. When positive effects do occur they are likely the result of direct intervention efforts to improve parents' ability to adapt to their child's characteristics. It is important to emphasize that sensitive-responsiveness is hypothesized to be of significance because it serves as the basis for establishing high quality relationships (i.e., discourse framework, instructional partnership, socioemotional connectedness). As suggested by the DSA, it is these parent-child transaction processes that provide the continuity necessary to maintain an optimal developmental environment for the child. Unfortunately, only limited evidence indicates that interventions were sufficient to substantially alter these relationship processes. Despite shorter-term effects produced by increases in sensitive-responsiveness, the consequence of this is an absence of continuity of parent-child transactions needed to sustain longer-term child social and cognitive

competence. Strengthening these relationships constitutes a critical task for future research and practice.

Clearly, so many diverse influences that can affect preterm children's development are beyond our control or current understanding. As discussed, many effects diminish substantially soon after the intervention is complete, often failing to be sustained even during later points in the early childhood period itself. Of note, the evidence for sustained long-term effects may be minimal, but most studies have not carried out the necessary follow-up work. In addition, high levels of variability are common, and many children not receiving intervention can manifest accelerated developmental patterns under favorable circumstances.[99,110,111] This further diminishes any intervention effects over time. Nevertheless, quality relationships formed during the early childhood period may well provide the level of continuity sufficient to offer at least some protection from the challenges that lie ahead.

Preventive Interventions and the Medical Home

Taken together, this analysis suggests that, to be successful, preventive intervention programs may well require a systems perspective that extends intervention activities across the entire early childhood period. This integrative review has emphasized the centrality of parent-child transactions but other components noted in Figure 1 must be part of the overall system. Such a system must ensure consistency and continuity over time as well as the ability to integrate and coordinate all the various factors that might be involved. Within the DSA framework this means organizing a system that is capable of addressing risk and protective factors at all three levels: (1) level of child development, (2) level of family patterns of interaction, and (3) level of family resources.

How to accomplish this from a practical perspective is, of course, extraordinarily challenging as systems approaches require levels of coordination, integration, and continuity seldom found in communities. However, the Medical Home is one model that should be considered as a framework for constructing such a comprehensive system. Characteristics of a successful Medical Home model are that care be accessible, family-oriented, continuous, comprehensive, coordinated, compassionate, and culturally effective.[112] This model is clearly compatible with preventive intervention programs for preterm children that are also likely to be most successful. Specifically, at the level of child development, the follow-up care practices for preterm children for developmental testing[113] and the American Academy of Pediatrics' algorithm for developmental surveillance and screening of young children in the Medical Home[114] provide essential guidance. At the next level of the DSA, by developing a family's trust and gaining their confidence, considerable information regarding many components of a family's pattern of interaction can be obtained. Eliciting parent concerns about interactions with their child focusing on relationships or their child's participation in community activities can be incorporated into the components of developmental surveillance.[114] Close working relationships with educational programs for children who qualify for special services, with child care or preschool program personnel, or with other community service agencies, can generate additional information with respect to risk and protective factors at the level of family patterns of interaction. These community resources would also be engaged as part of the intervention process. Despite some existing tools, [29] feasible measures of the various relationship processes and other components of family patterns of interaction (see Figure 1) remain to be developed. This constitutes an important future research effort. Nevertheless, the DSA can serve as a common framework for all resources that are involved thereby generating more continuity and intensive efforts to promote quality family patterns of interaction. To help address issues resulting from the limited resources available in many pediatric practices, other community programs can share or assume greater responsibility for coordinating interventions within this framework at

various points in the child's development. Proper coordination may enable a cost-effective and developmentally effective system to emerge. Finally, surveillance and screening within the Medical Home has also been recently recommended for many components at the level of family resources.[115] This is certainly not common practice today but psychosocial screening tools for families are available in many domains including mental health, physical health, substance abuse, and social support. As is the case when child-specific problems are identified, referral to community resources will be necessary. Without question, there are clearly many barriers including time and resources to implementing a system of preventive interventions for preterm children but for many of these children optimal child development is not likely to occur in its absence.

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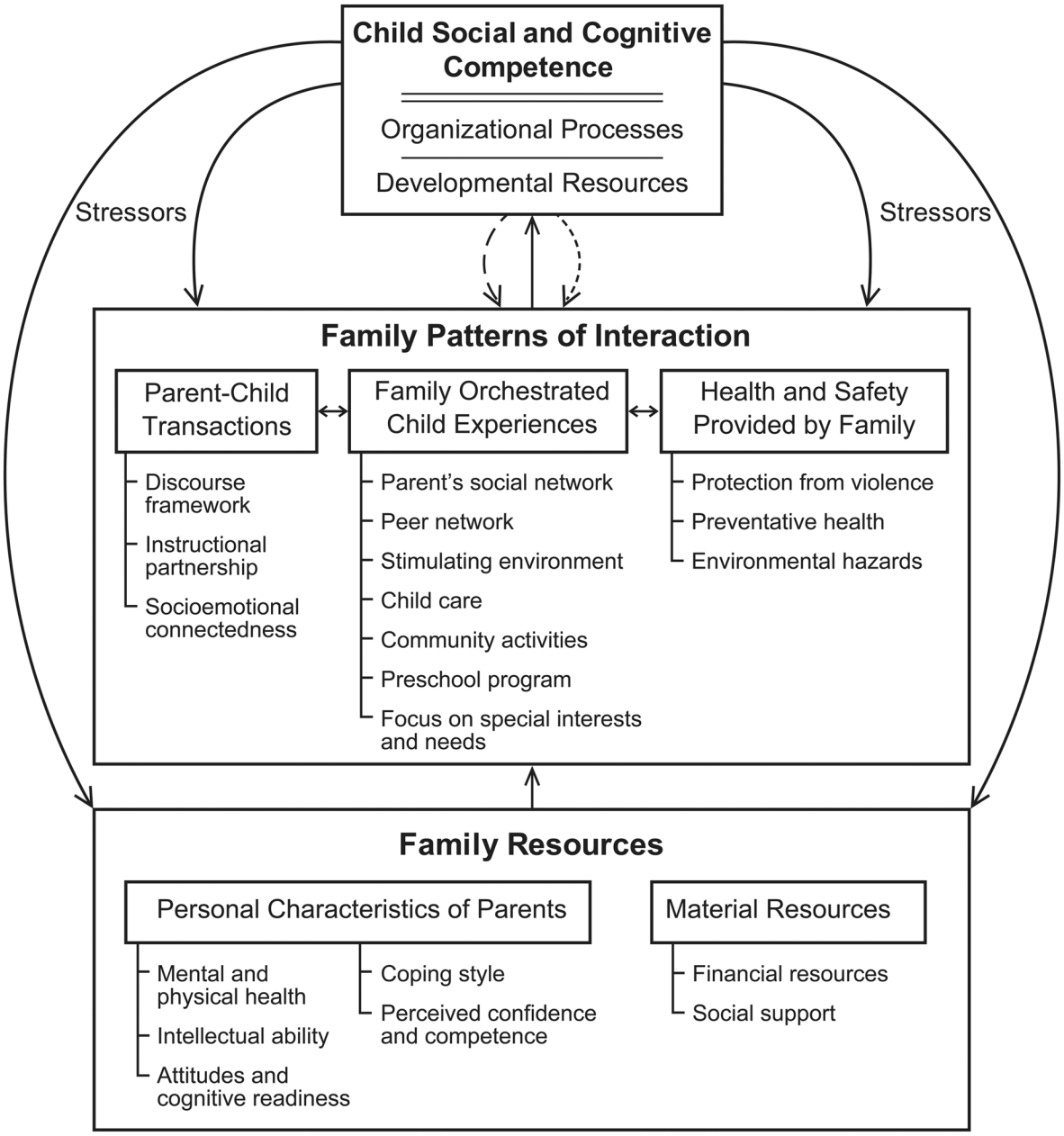

Figure 1.
The three levels of the Developmental Systems Approach with key components illustrating interrelationships and reciprocal influences including the effects of child-based stressors (Adapted from Guralnick, 2011).