ENCYCLOPEDIA on Early Childhood Development

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Effective Early Intervention Programs for Low Birth Weight Premature Infants: Review of the Infant Health and Development Program (IHDP)

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March 2017, 3e éd.

Introduction

Over several decades, survival rates of low birth weight (LBW) infants have markedly increased. Following a downward trend from 2007 to 2014, the U.S. low birthweight rate (the percentage of infants born at less than 2,500 grams or 5 lbs., 8 oz.) rose in 2015 to 8.07%, up from 8.00% in 2014.[1] The percentage of very low birthweight (VLBW) infants (less than 1,500 grams) was stable at 1.39% in 2015. The percentage of infants delivered at moderately low birthweight (1,500-2,499 grams) rose to 6.67% in 2015, from 6.60% in 2014.[1] These trends are important, keeping in mind that low birth weight premature infants are at higher risk than full-term normal birth

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weight infants for medical and developmental complications that, in turn, can affect the families and infants well into childhood.[2]

A large body of research since the 1970s has documented the short- and long-term health and developmental consequences of low birth weight.[3,4,5,6,7,8] LBW infants exhibit increased rates of neurodevelopmental, health and academic problems. These include developmental delays and behavioural difficulties in the first three to five years of life, with continuing behavioural problems and academic difficulties at later school ages.[5,6] A recent meta-analysis clearly shows that very preterm and/or VLBW children have moderate-to-severe deficits in academic achievement, attention problems, internalizing behavioural problems and poor executive functioning (EF) skills, which are adverse outcomes that were strongly correlated to their immaturity at birth. Furthermore, even during transition to young adulthood these children continue to lag behind term-born peers.[9] All these problems are more pronounced for the lowest birth weight infants. LBW infants are more likely to die within the first 28 days of life and are at substantially higher risk for increased morbidity and rehospitalization than children born at normal birth weights.[8] Not surprisingly, the risk for neonatal mortality and morbidity increases substantially with decreasing birth weight.[10] Furthermore, a significant body of research indicates that negative outcomes experienced by many LBW children are worsened by environments characterized by poverty, low educational attainment of caregivers and poor parental stimulation and interactions with the children.[11]

Early intervention (EI) appears to be an important strategy to improve outcomes in this population.[12,13,14] A landmark intervention study with low birth weight infants that was conducted in the 1980s was the Infant Health and Development Program (IHDP). The IHDP was unique in that it was the first multi-site randomized clinical trial designed to evaluate the efficacy of combining early childhood development and family support services with pediatric follow-up in reducing developmental, behavioural and other health problems among low birth weight premature infants.[15]

Subject

The intervention approach for LBW infants in the IHDP was based on two longitudinal studies of successful early interventions with socially disadvantaged normal birth weight infants.[16] The IHDP intervention began at hospital discharge and continued until 36 months of corrected age (CA) (corrected age is based on the age the child would be if the pregnancy had actually gone to

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term). By providing pediatric, educational and family support services, the IHDP sought to enhance parenting resources for families and the developmental status of infants. The conceptual model of the IHDP was based on maximizing the likelihood of positive caregiver-child transactional experiences hypothesized to support early cognitive and behavioural development of LBW premature children.[16] It was hypothesized that more developmentally appropriate, positive social interactions, guided by knowledgeable professional educators and parents, would promote the cognitive and behavioural development of LBW children. It was also hypothesized that more frequent participation in the multiple intervention modalities would be associated with more positive child outcomes.

Problems

Intervention studies on LBW infants have had mixed outcomes. Some intervention studies have shown improved outcomes for infants born with low birth weight. However, many were conducted at single sites, had small numbers of subjects and assessed short-term benefits.[15] Other single-site, home-based early interventions had only modest effects on the cognitive performance of LBW children, but other similar programs did not detect any measurable benefits.[16] The strategy used by the IHDP of combining home visits, parent support and a developmental educational curriculum within child development centres was unique in that it built on earlier findings on disadvantaged children and was comprehensive in its approach.[18,19] It was also the first study to use a randomized design to test the applicability of interventions designed for normal birth weight children on LBW premature children.

Research Context

The earliest EI programs for preterm LBW infants were mostly hospital-based intensive care nursery interventions,[20] some of them including home-visiting components in the first year of life.[13] Other programs with home visiting in the first or second year of life have sought to teach parents appropriate developmental stimulation and interactional skills, as well as to provide general social support.[20] Nevertheless, before the IHDP, there had been no large-scale efforts to implement or evaluate the effects of an intensive long-term intervention with preterm infants. It was in this research context that the IHDP was initiated in 1984.

Key Research Questions

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Eight medical institutions serving diverse demographic populations in different geographic locations were selected for the IHDP. The primary analysis group on which the IHDP findings were based consisted of 985 low birth weight premature infants (birth weight 2,500 grams or less; gestational age 37 weeks or less) who survived neonatal hospitalization and lived close to the various sites. The program was initiated on discharge from the neonatal nursery and continued until 36 months of age. The research design included claissification by eight sites and two birth weight groups (those infants weighing 2,001 to 2,500 grams, designated as “heavier,” and those 2,000 grams or less, designated as “lighter”). Infants in the intervention and follow-up groups participated in the same pediatric follow-up, which included medical, developmental and social assessments, with referral for pediatric care and other services as needed. The intervention group also received home visits, child attendance at a child development centre and parent group meetings. The key research questions were:

1. Do the intervention and follow-up groups differ in terms of cognitive development?
2. Do the intervention and follow-up groups differ in terms of behavioural competence?
3. Do the intervention and follow-up groups differ in terms of health status?[16]

Research Results

The IHDP clearly demonstrated that the children who received the intervention experienced, at 36 months: (a) significantly higher IQ scores; (b) significantly lower behaviour problems as reported by the caregivers; and (c) a small but significant increase in maternally reported minor morbidity (defined as the presence or absence of health conditions), with no evidence of an increase in serious health problems. Subject retention was high in both treatment and follow-up groups (93%).[16]

The largest treatment effect was that the intervention group achieved significantly higher cognitive scores relative to the follow-up group at the corrected age (CA) of 36 months. Birth weight had a main effect on the level of IQ scores, with a greater effect on the heavier LBW infants. The heavier intervention infants scored 13.2 IQ points higher than their follow-up counterparts, and the treatment group difference was 6.6 IQ points for the lighter infants. The positive effects on IQ scores were seen at seven of the eight sites.

Compared with the follow-up group, the intervention group experienced a small, significant advantage in behavioural competence, as indicated by lower behaviour problem scores on the

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Child Behavior Checklist. Treatment group differences were seen largely in reports from the less educated mothers.

Across six health status measures, only the Mother's Report: Morbidity Index had a significant treatment effect. Higher morbidity scores were reported for lighter-born children in the intervention group relative to the follow-up group. Maternal age interacted with this outcome, with younger mothers in the intervention group reporting higher morbidity scores than younger mothers in the follow-up group.

The primary purpose of the IHDP was to study the efficacy of early intervention in reducing developmental, behavioural and other health problems among LBW premature infants. However, the study also provided an opportunity to gather important data about this population for other purposes. These included additional studies about the growth of these infants, neurologic outcomes, children's prosocial behaviour, mother-child interactions and the quality of the home environment. The IHDP growth studies found that even the largest premature LBW infants had not achieved growth patterns of full- term infants by age three. Neuromotor outcomes, examined at 36 months, showed an increasing incidence of neurologic disability associated with decreasing birth weight. In a study of social competence using the Adaptive Social Behavior Inventory (ASBI),[21] the intervention group scored higher than the follow-up group on prosocial behaviours and had significantly lower scores on the items tapping noncompliant behaviours. Mother-child interactions were examined at 30 months. Small, significant positive effects were found. Intervention dyads were rated as more synchronous and reciprocal in their interactions.[22] Mothers in the intervention group had higher ratings on quality of assistance when helping children with a problem-solving task, and intervention children had higher ratings on persistence and enthusiasm and on an overall child rating of social competence and involvement. Finally, the quality of the home environment to stimulate the child's development was assessed with the Home Observation for Measurement of the Environment (HOME) inventory when the children were one year and three years old. There were no differences at one year, but differences favouring the intervention group were noted on five of the eight HOME subscales at three years. Further analyses revealed that the positive effects of the intervention on the children's development appeared to be mediated to a certain extent by the home environment.[23]

To evaluate the persistence of intervention effects on the child outcomes after the intervention ended at 36 months of age, annual evaluations were made at age five and again at age eight on behavioural, health and cognitive outcome measures. In the cognitive domain, at age five overall, there were no significant differences between the intervention group and the follow-up group.

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However, further analyses revealed that children in the heavier LBW intervention group (2,001-2,500,g) had higher full-scale IQ scores and higher verbal IQ scores. No such differences were noted in the lighter LBW group. The intervention and follow-up groups were similar in behaviour and health measures irrespective of LBW stratification.[24] At age eight, there were modest intervention-related differences in the cognitive and academic skills of heavier LBW, premature children. However, attenuation of the largely favourable effects seen at three years was observed in both the heavier and lighter LBW groups.[25] It is also interesting to note that children in the IHDP sample with behaviour problems at age 3 continue to show problematic behaviours at age 5 and 8, based on a cohort study that did not compare treatment and control.[26,27]

A prospective follow-up of the Infant Health and Development Program at 8 sites to assess whether improvements in cognitive and behavioural development seen in preschool educational programs persist was conducted when the subjects were 18 years of age.[28] Cognitive and behavioural development of those children (that were 18 years old at the time of this study) who received the intervention over the first 3 years of life (INT) versus those with follow-up only (FU) at 18 months of age was studied. The two birth weight strata were studied: heavier low birth weight (HLBW; 2001-2499 g) and lighter low birth weight (LLBW; < or = 2000 g). Results showed that after adjusting for cohort attrition, differences favouring the intervention group were seen on the Woodcock-Johnson Tests of Achievement in math (5.1 points), Youth Risk Behavior Surveillance System (YRBSS) (-0.7 points), and the Peabody Picture Vocabulary Test - 3 rd edition (PPVT-III) (3.8 points) in the HLBW youth. In the LLBW youth, the Woodcock-Johnson Tests of Achievement in reading was higher in the FU that INT group (4.2). The findings in the HLBW intervention group provide support for preschool education to make long-term changes in a diverse group of children who are at developmental risk.

The persistence of long-term behavioural problems was also reported in a follow-up of the IHDP sample. Using the Youth Risk Behavior Surveillance System (YRBSS) with known patients that were 17-18-year-old that were originally part of the IHDP as young children, adolescent behaviour was explored in this follow up study (that did not include a treatment versus control group comparison). Of the participants studied, a safety plan was activated for almost a third of the participants (i.e., a safety plan is a prioritized written list of coping strategies and resources for use during a behavioural and/or suicidal crisis). Risk behaviours included binge drinking, alcohol/substance use and driving, depression, hopelessness, and suicidal ideation. Findings were consistent with the literature, for example, higher rates of conduct problems were found in

males, more suicidal ideation in females, greater sexual risk in African Americans, more substance use in males and whites, and more alcohol use in youth with mothers with higher levels of education.[29]

The IHDP also demonstrated the impact of poverty and socioeconomic status on cognitive functioning during early childhood. Using longitudinal data from the IHDP, family income and poverty status were found to be significant predictors of IQ scores in five-year-olds, even after accounting for maternal education, family structure, ethnicity and other differences between low- and high-income families. Family income and poverty status were more powerful predictors of IQ scores than was maternal education.[30] Furthermore, poverty status at age three predicted children's IQ at age five, even after controlling for IQ at age three.

Conclusions

The IHDP clearly demonstrated the efficacy of a comprehensive early intervention in reducing the developmental and health problems of LBW premature infants by age three. However, these effects appear to have attenuated by ages 5, 8 and 18. The modest sustained effects seen for the heavier LBW infants argue against the interpretation of no sustained effect of the intervention.[24] The results at age three showed that cognitive development could be enhanced, behaviour problems could be reduced and no adverse health effects resulted from high-quality group care beginning at 12 months of age. These effects were strongest for the heavier infants and those from socioeconomically disadvantaged families. Additionally, the intervention program led to modest positive effects on mother-child interaction patterns and the quality of the home environment. The IHDP's randomized design, use of multiple sites, a large socioeconomically diverse sample, and excellent retention of subjects in both treatment and follow-up groups make it a landmark early intervention study with trustworthy results. Noteworthy in the results is the fact that those children and families who participated most fully in the intervention were most likely to experience the best outcomes.

The IHDP results support transactional models of early development that recognize the interactions of biological and social-environmental factors to produce child outcomes. For example, research has clearly shown that income is associated with children's cognitive development, achievement and behaviour during the preschool years.[30] By age three, these effects are more pronounced for children who are experiencing deep poverty. In addition, family processes are also a potential pathway through which income affects children. They operate via home environments and parent-child interactions. The quality of caregiver-child interactions, the

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physical condition of the home and opportunities for learning all account for a significant portion of the effects of family income on cognitive outcomes in young children.[31]

Implications

"It is probably not possible to 'inoculate' a child against all future risk with a single early childhood education intervention;" indeed, at age 8, IHDP children who received more of the intervention had better outcomes.[32] There are multiple co-occurring factors, such as poverty, poor neighbourhoods or poor caregiver-child interactions, that influence children's developmental outcomes and must be considered when evaluating the efficacy of any early intervention program.[30] Many LBW premature babies, including many of those in the IHDP, face such co-occurring risks. It is also important to remember that the IHDP intervention ended when the children were three years old. Many of the participating children were living in poverty, had mothers with low educational attainment and lived in disadvantaged neighbourhoods. The attenuation of the highly positive intervention effects after the comprehensive intervention program ended does not mean that the intervention was not effective. At age three, the results showed that it was *highly* effective, particularly for the heavier infants and those with higher environmental risk. Rather, the attenuation of effects suggests that the enriched environmental supports and stimulation needed to sustain and nurture the children's continuing development throughout the preschool years and beyond may have been lacking for many of the participating children.

Designing interventions with higher intensity of program participation, as well as longer program duration, may be necessary for many high-risk children because the consistency and intensity of children's participation in early childhood intervention programs may be crucial for sustained effects.[32] Furthermore, those LBW premature infants born into poverty may have families and neighbourhoods that lack the resources necessary to enable them to support these children and enhance their developmental growth early in life and continuously through the early school years.[33] The IHDP has definitively demonstrated how a high-quality, comprehensive early intervention program for LBW premature infants can be implemented and can produce important outcomes in the early years of life, taking these factors into account.

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