Long-term Benefits of Home-based Preventive Care for Preterm Infants: A Randomized Trial

**WHAT’S KNOWN ON THIS SUBJECT:** Randomized controlled trials of early developmental interventions for very preterm infants demonstrate short-term benefits for infant neurobehavioral functioning. The longer-term benefits of these interventions for children and their families are not yet clear.

**WHAT THIS STUDY ADDS:** This randomized trial shows that home-based preventive care over the first year of life for very preterm infants has selective long-term benefits. Caregivers report less anxiety and fewer were at risk for an anxiety disorder. Preschoolers show fewer internalizing behaviors.

**abstract**

**BACKGROUND:** We have previously reported improved caregiver mental health and infant behavior at 2 years following a home-based preventive care program for very preterm infants and their caregivers. This study aimed to determine the longer-term effectiveness of the program by reviewing caregivers and children at preschool age.

**METHODS:** One hundred twenty very preterm infants (<30 weeks’ gestation) were randomly allocated to intervention (n = 61) or control (n = 59) groups. The intervention included 9 home visits over the first year of life targeting infant development, parent mental health, and the parent-infant relationship. The control group received standard care. At 4 years’ corrected age, child cognitive, behavioral, and motor functioning and caregiver mental health were assessed.

**RESULTS:** At age 4 years, 105 (89%) children were reviewed. There was little evidence of differences in cognitive or motor functioning between groups. The intervention group had lower scores for child internalizing behaviors than the control group (mean difference −5.3, 95% confidence interval [CI] −9.6 to −0.9, P = .02). Caregivers in the intervention group had fewer anxiety symptoms (mean difference −1.8, 95% CI −3.3 to −0.4, P = .01) and were less likely to exhibit "at-risk" anxiety (odds ratio 0.3, 95% CI 0.1 to 0.7, P = .01) than those in the control group.

**CONCLUSIONS:** This home-based preventive care program for very preterm infants has selective long-term benefits, including less caregiver anxiety and reduced preschooler internalizing behaviors.
Infants born very preterm (VPT, <32 weeks' gestational age) are at increased risk for developing a range of cognitive, academic, behavioral, and motor problems compared with their term-born peers. Many of these neurobehavioral impairments persist into adolescence and young adulthood. An additional concern is that caregivers of VPT survivors experience high rates of mental health problems. Studies examining the effectiveness of early developmental intervention programs designed to reduce the burden of developmental problems report short-term benefits for infants and their caregivers. However, the longer-term benefits of these programs remain unclear. Limited studies examining long-term outcomes have typically focused on child outcomes in general cognitive and/or motor domains and failed to examine child behavior or caregiver well-being. We previously demonstrated short-term benefits of the Victorian Infant Brain Studies (VIBeS) Plus home-based preventive care program for VPT infants and their caregivers over the first year of life, with improved child behavior at 2 years' corrected age and lower rates of depression and anxiety symptoms in caregivers in the intervention in comparison with the control groups. Given the important role of parenting on child development, it is possible that the full benefits of this preventive care program will not be observed until later in development.

This study aimed to determine the longer-term effectiveness of the VIBeS Plus home-based preventive care program for VPT infants and their caregivers and address many limitations of previous studies by conducting a follow-up of the caregivers and children in the randomized controlled trial (RCT) at preschool age (4 years' corrected age), a critical developmental age. We expected that benefits of the program for infant behavior and caregiver mental health observed at 2 years' corrected age would continue into preschool age. Furthermore, we predicted better cognitive functioning in children who received the program because of the positive influence of better caregiver mental health on child development. Finally, we expected motor functioning to be similar for preschoolers who received the program and standard care, consistent with previous studies.

METHODS

Study Design

This follow-up phase of our RCT was approved by the Human Research Ethics Committee of the Royal Children's Hospital in Melbourne, Australia, and the original RCT was registered with the Australian New Zealand Clinical Trials Registry (ACTRN12606000252516). We have previously described in detail the study design, recruitment, and randomization procedures, the preventive care program, and 2-year outcomes. A summary of the study is presented below.

Recruitment

Infants were recruited at term-equivalent age from January 2005 to January 2007 from the Royal Women's and Royal Children's Hospitals, Melbourne, Australia. Infants born at <30 weeks' gestational age and with no major congenital abnormalities were eligible for inclusion. Infants were excluded if their family did not live within a 100-km radius of the Royal Women's Hospital or spoke no English.

Randomization and Trial Entry

After written informed consent, perinatal information was collected from medical record review and caregiver questionnaires. Primary caregivers completed questionnaires to provide baseline information on their own mental health and social demographic information.

Preterm infants were randomly assigned to intervention or control groups, stratified by the severity of white matter abnormality on MRI (none to mild, moderate to severe, or no MRI) and singleton or multiple births to ensure the equal distribution of these factors between groups. For the small number of infants who did not undergo MRI (n = 2 too unwell, n = 13 no parent consent), ultrasound before term age showed no anomalies. We ensured equal numbers of infants with no MRI in the intervention and control groups by using stratified randomization. In analyses, these infants were considered to have no moderate/severe white matter abnormality. Children from multiple births were randomly assigned to the same group because the intervention was family-based. Although it was not possible to blind families, all assessors were blinded to treatment allocation.

Intervention

The intervention group received the VIBeS Plus home-based preventive care program. The program aims to educate the primary caregiver(s) about evidence-based interventions for improving infant self-regulation, postural stability, coordination and strength, parent mental health, and the parent-infant relationship. A therapy team comprising of a physiotherapist and psychologist delivered the 9 sessions of the program (each session was 1.5–2 hours long) in the family home over the infant’s first year of life.

The control group received standard follow-up care. Although standard care in Australia varies, families in both the intervention and control groups had access to a maternal child health nurse in the community who assessed developmental progress of the infant and performed surveillance such as height and weight checks. In both groups,
referral could be made to early intervention services by the infant’s health care team at any time. Variability in access to external health professionals was documented during the study.

Outcome Measures
At 4 years’ corrected age,14 children completed a cognitive assessment conducted by a psychologist and a motor assessment by a physiotherapist. Primary caregivers completed parent-rated questionnaires to evaluate preschooler behavior and self-rated questionnaires to assess their own mental health and social risk. We administered age-appropriate and psychometrically sound clinical measures that could be administered at follow-up assessments when the children are school age and older.

Preschooler Outcomes
Cognitive functioning was measured by using the Differential Ability Scale15 that requires children to perform a range of cognitive tasks. The primary cognitive outcome was the General Conceptual Ability score, a summary measure of general reasoning and conceptual abilities. Secondary cognitive outcomes were (1) Verbal composite score, a measure of acquired verbal concepts and knowledge; (2) Nonverbal Reasoning composite score, a measure of complex, nonverbal, inductive reasoning requiring mental processing; and (3) Spatial Reasoning composite score, a measure of complex visual processing. Age-standardized scores were calculated (mean 100, SD 15), with higher scores reflecting better performance. Consistent with the manual, a score $>1$ SD below the normative test mean was considered to be at risk for impairment.

Motor functioning was assessed by using the Movement Assessment Battery for Children216 that requires children to perform a series of fine and gross motor tasks. The primary motor outcome was the total score, a summary measure of general motor abilities. Secondary motor outcomes were (1) Manual Dexterity score, a measure of fine motor skills based on posting coins, threading beads, and drawing trails; (2) Aiming and Catching score, a measure of gross motor skills based on catching and throwing a beanbag onto a mat; and (3) Static and Dynamic Balance score, a measure of balance skills based on a single-leg balance, walking on a line with heels raised, and jumping on consecutive mats. Percentile scores were calculated, relative to the normative values, with higher percentiles representing better performance. A percentile $\leq 15$ was considered to be at risk for impairment.

Behavioral functioning was assessed by the Behavior Assessment System for Children – Preschool version,17 completed by the primary caregiver. The primary behavioral outcome was the Behavioral Symptoms Index, a composite of overall adaptive skills and problem behaviors in the home and community. Secondary behavioral outcomes were (1) Externalizing Problems composite, based on aggression, hyperactivity, and conduct problems scales; (2) Internalizing Problems composite, based on anxiety, depression, and somatization scales; and (3) Adaptive Skills score, based on activities of daily living, adaptability, functional communication and social skills scales. Age- and gender-standardized T scores were calculated (mean 50, SD 10). Consistent with the manual, a behavioral score $>1$ SD above the normative test mean was considered to indicate the preschooler was at risk for behavioral problems, and an adaptive score $>1$ SD below the mean to indicate at risk for adaptive problems.

Primary Caregiver Outcomes
Primary caregiver mental health was assessed by the Hospital Anxiety and Depression Scale,18 a self-rated questionnaire that provides separate Anxiety and Depression symptom scales. Raw scores for each scale range from 0 to 21, and higher scores indicate more severe symptoms. A score $\geq 8$ was considered to indicate at risk for symptomatology on both scales.19

Power of the Study
This preschool age follow-up study of 105 children provides 80% power to detect a difference of 0.55 SD in mean outcomes between the 2 groups (based on a 2-sided test with $\alpha = .05$).

Statistical Analyses
Analysis was by intention-to-treat performed by using Stata 12.20 Linear regression was used to examine the differences in preschooler outcomes between the intervention and control groups adjusted for the stratification factors of multiple birth and moderate-severe white matter abnormality, with robust (sandwich) estimators of SEs to allow for clustering of twins. Results are presented as mean differences between the groups and 95% confidence intervals (CIs) for each child outcome measure. In addition, odds ratios and their 95% CIs are presented from logistic regression for the binary outcomes of being at risk for impairments in cognitive, motor, and behavior domains, again adjusted for stratification factors and by using sandwich estimates of SE. Preschoolers with a diagnosis of cerebral palsy who were not able to complete the motor assessment were assigned a score of 1 for the 3 subscales and the total score for the Movement Assessment Battery for Children 2, and were classified as $\leq 15$th percentile in the at-risk analysis. In sensitivity analyses, analyses were repeated adjusting for social risk measured by the Social Risk Index21 assessed at 4 years, known to influence child neurodevelopment.22 This index provides a score from 0 to 12, with higher scores reflecting greater risk,
and is a sum of the following factors: family structure, education of primary caregiver, employment status and occupation of the primary income earner, language spoken at home, and maternal age at birth of the child.

Caregiver outcomes were compared between the intervention and control groups with the use of linear regressions, with caregivers of multiple births included in the analyses only once, adjusted for the stratification factors of multiple birth and moderate-severe white matter abnormality. In sensitivity analyses, analyses were repeated with adjustment for social risk and baseline depression measured by the Edinburgh Postnatal Depression Scale to acknowledge any preexisting caregiver depression symptoms. Odds ratios and 95% CIs are also presented from logistic regression for the binary outcomes of being at risk of anxiety and depression symptoms, again adjusted for stratification factors.

RESULTS

Participants and Social Demographic Characteristics

During the study period, 343 infants were born <30 weeks’ gestational age, and 191 met the study inclusion criteria (Fig 1). Of these, 120 infants were recruited, including 14 sets of twins and 106 families, and were randomly assigned to intervention (n = 61) or control (n = 59) groups. By 2 years’ corrected age, 2 infants had died and 115 (97%) returned for evaluation. At 4 years’ corrected age, 105 (89%) of the surviving children, including 92 (87%) families, were reviewed. The intervention and control groups remained similar for social demographic and clinical characteristics at the 4-year assessment, with similar proportions of children having accessed external intervention services in the 2 groups (P > .40 for all group comparisons) (Table 1).

Preschooler Outcomes

At 4 years’ corrected age, 105 (100%) children completed the cognitive assessment (Table 2) and 100 (95%) completed the motor assessment. Four children could not complete the motor assessment because of cerebral palsy (Table 3). A small number of children (n = 5) did not complete all of the motor assessment because of time restrictions or refusal, and, hence, scores could not be calculated for these children on some subscales. There was little evidence of differences in cognitive or motor scores between the intervention and control groups. Similarly, there was little evidence of group differences in the odds of preschoolers having cognitive or motor impairments.

The behavioral questionnaire (Table 4) was completed for 89 preschoolers (85%), although, for 1 child, the Externalizing Problems composite score could not be calculated because the caregiver had not rated a sufficient number of items. On average, the scores for internalizing problems in the intervention group were lower than those in the control group, although the proportion of preschoolers at risk for internalizing problems were similar across groups (13% in the intervention compared with 17% in the control group). There was little evidence of differences in the other behavioral scores, the adaptive score between the groups, or in the odds of preschoolers at risk for other behavioral or adaptive problems.

Caregiver Outcomes

The mental health questionnaire (Table 5) was returned by 77 primary caregivers (84%). On average, scores for caregivers in the intervention group were lower for anxiety symptoms than in the control group, and there was a substantially lower odds of caregivers with at-risk anxiety (26% compared with 55% in the control group). There was little evidence of a difference in scores for depression symptoms, and whereas fewer caregivers in the intervention group were considered to be at risk for depression (8% compared with 16% in the control group), this difference failed to reach significance. The lack of statistical significance in depression outcomes may partly reflect the small number of
TABLE 1  Social Demographic and Clinical Characteristics of the Sample at the Preschool Follow-up

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Intervention Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of preschoolers assessed</td>
<td>52</td>
<td>53</td>
</tr>
<tr>
<td>Gestational age in weeks, mean ± SD</td>
<td>27.2 ± 1.7</td>
<td>27.5 ± 1.4</td>
</tr>
<tr>
<td>Gestational age &lt;28 wk, n (%)</td>
<td>28 (54)</td>
<td>29 (55)</td>
</tr>
<tr>
<td>Birth weight, g, mean ± SD</td>
<td>1034 ± 300</td>
<td>1010 ± 234</td>
</tr>
<tr>
<td>Birth weight &lt;1000 g, n (%)</td>
<td>27 (52)</td>
<td>28 (53)</td>
</tr>
<tr>
<td>Males, n (%)</td>
<td>30 (58)</td>
<td>26 (49)</td>
</tr>
<tr>
<td>Multiple births, n (%)</td>
<td>17 (33)</td>
<td>18 (34)</td>
</tr>
<tr>
<td>Cerebral palsy at 4 y, n (%)</td>
<td>2 (4)</td>
<td>4 (8)</td>
</tr>
<tr>
<td>Maternal antenatal corticosteroids, n (%)</td>
<td>46 (88)</td>
<td>42 (79)</td>
</tr>
<tr>
<td>Postnatal corticosteroids, n (%)</td>
<td>2 (4)</td>
<td>3 (6)</td>
</tr>
<tr>
<td>Physiotherapy</td>
<td>20/51 (39)</td>
<td>24/47 (51)</td>
</tr>
<tr>
<td>Speech therapy</td>
<td>24/46 (52)</td>
<td>21/47 (45)</td>
</tr>
<tr>
<td>Psychological</td>
<td>8/46 (17)</td>
<td>8/47 (17)</td>
</tr>
<tr>
<td>Kindergarten aide</td>
<td>5/45 (11)</td>
<td>7/47 (15)</td>
</tr>
<tr>
<td>Other specialist</td>
<td>15/33 (45)</td>
<td>17/37 (46)</td>
</tr>
</tbody>
</table>

PMA, postmenstrual age; NEC, necrotizing enterocolitis; IVH, intraventricular hemorrhage; PVL, periventricular leukomalacia.

<table>
<thead>
<tr>
<th>Odds Ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.4 to 7.8</td>
<td>.85</td>
</tr>
<tr>
<td>2.2 to 10.4</td>
<td>.20</td>
</tr>
<tr>
<td>7.9 to 2.5</td>
<td>.31</td>
</tr>
<tr>
<td>4.8 to 9.7</td>
<td>.50</td>
</tr>
</tbody>
</table>

a Analysis allows for clustering of multiple births and is adjusted for stratification factors of multiple birth and white matter abnormality grade 3 or 4.

b Impairment defined as scores >1 SD below the test mean (mean 100, SD 15).

c The major finding of this RCT follow-up is that the VIBeS Plus home-based preventive care program for VPT infants had selective long-term benefits for children and their families. Caregivers who received the intervention reported fewer anxiety symptoms, and fewer were likely to be at risk for an anxiety disorder. This finding is particularly important given the high rates of parental distress after a preterm birth24 and the well-established relationship between parental psychopathology and the development of child symptomatology,26 which is increased for children born very low birth weight27 or VPT.24 In addition, children who received the intervention were reported by their caregivers to have fewer internalizing behavior problems.

It is somewhat surprising that cognitive gains were not observed for children in the intervention group given their caregivers reported fewer mental health problems at both 21 and 4 years. Our finding is in contrast to 3 previous preventive care RCT studies28–30 that showed evidence of long-term cognitive benefits of preventive care programs for VPT infants, but it is consistent with those of 2 other trials that found little difference in cognitive outcome.31,32 Preventive care programs differ greatly in terms of content, timing, and number of appointments, which is likely to explain some of the variability in child cognitive outcomes across these studies.10

The nature of the behavioral benefits observed at this 4-year follow-up differed from those observed at the 2-year follow-up. At age 2, infants who received the program showed less externalizing and dysregulation (but not internalizing) problems compared with those who received standard care.11 At age 4, the intervention benefits were restricted to caregivers with these problems, intensity of the intervention, and/or the sensitivity of the mental health measure to change. All comparisons remained similar when adjusted for social risk and parental depression at baseline.

DISCUSSION

The major finding of this RCT follow-up is that the VIBeS Plus home-based preventive care program for VPT infants had selective long-term benefits for children and their families. Caregivers who received the intervention reported fewer anxiety symptoms, and fewer were likely to be at risk for an anxiety disorder. This finding is particularly important given the high rates of parental distress after a preterm birth24 and the well-established relationship between parental psychopathology and the development of child symptomatology,26 which is increased for children born very low birth weight27 or VPT.24 In addition, children who received the intervention were reported by their caregivers to have fewer internalizing behavior problems.

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TABLE 2  Preschooler Outcomes on the Differential Abilities Scale

<table>
<thead>
<tr>
<th>Cognitive Domain</th>
<th>Intervention Group</th>
<th>Control Group</th>
<th>Group Comparisona</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean ± SD</td>
<td>n</td>
</tr>
<tr>
<td>Score</td>
<td>General Conceptual Ability</td>
<td>52</td>
<td>99.2 ± 15.3</td>
</tr>
<tr>
<td></td>
<td>Verbal composite</td>
<td>52</td>
<td>99.2 ± 11.1</td>
</tr>
<tr>
<td></td>
<td>Nonverbal Reasoning composite</td>
<td>52</td>
<td>96.8 ± 14.4</td>
</tr>
<tr>
<td></td>
<td>Spatial Reasoning composite</td>
<td>50</td>
<td>100.4 ± 18.3</td>
</tr>
<tr>
<td>At risk for impairmentb</td>
<td>General Conceptual Ability</td>
<td>52</td>
<td>n (%)</td>
</tr>
<tr>
<td></td>
<td>Verbal composite</td>
<td>52</td>
<td>4 (8)</td>
</tr>
<tr>
<td></td>
<td>Nonverbal Reasoning composite</td>
<td>52</td>
<td>9 (17)</td>
</tr>
<tr>
<td></td>
<td>Spatial Reasoning</td>
<td>50</td>
<td>8 (16)</td>
</tr>
</tbody>
</table>

Higher scores reflect better performance.

a Analysis allows for clustering of multiple births and is adjusted for stratification factors of multiple birth and white matter abnormality grade 3 or 4.

b Impairment defined as scores >1 SD below the test mean (mean 100, SD 15).
At risk for impairment

ups may partly re-

ture of neurodevelopmental problems

changes, the in-

aiming the long-term bene-

Our study is important because it

lems across follow-ups, or a combina-

assess behavioral and emotional prob-

factors, different measures used to

abnormality grade 3 or 4. Impaired de

At risk de-

Score

1099

PEDIATRICS Volume 130, Number 6, December 2012

b At risk de-

TABLE 4

Preschooler Outcomes on the Behavioral Assessment Screener for Children

TABLE 3

Preschooler Outcomes on the Movement Assessment Battery for Children

Reduced scores for internalizing behav-

ior problems. Although there is some
evidence that early behavioral problems
remain stable across childhood,35 other
research has documented that the na-
ture of impairments can evolve with age
such that early problems diminish while
new issues surface.34 The changing na-
ture of neurodevelopmental problems
reported from the 2- to 4-year follow-
ups may partly reflect developmental
changes, the influence of environmental
factors, different measures used to
assess behavioral and emotional prob-
lems across follow-ups, or a combina-
tion of these.

Our study is important because it con-
tributes to the limited studies ex-
amiing the long-term benefits of pre-
ventive care programs for preterm
infants. In particular, our study adds to
only a handful of RCTs assessing care-
giver mental health in infancy,35,36 which
together highlight the substantial long-
term benefits of early intervention for
caregivers.

The major strength of this study is the
assessment of both primary caregiver
mental health and a broad range of child
functions, including cognitive, motor,
and behavior domains, which was not
possible in infancy. We used established,
reliable, and age-appropriate clinical
measures that are routinely used in
clinical settings, providing confidence in
the study findings. The majority of infants
in this trial received MRI (a small number
received ultrasonography only) to ensure
that similar proportions of infants with
white matter abnormalities were allo-
cated to intervention and control groups.
We chose to include children in the study
who did not have an MRI (reasons in-
cluded parental choice or too unwell for
MRI at term) to improve the generaliz-
ability of the results. In addition, we in-
cluded families with multiple births,
increasing the generalizability of our
study findings compared with other stu-
dies that have excluded multiple
births. Our study recruited a high pro-
portion of eligible infants whose char-
acteristics are typical of infants born
before 30 weeks’ gestation. We therefore
believe our results are generalizable to
children born 30 weeks’ gestation with
similar social strata as the population
served by our hospital.

One limitation of this study is that
caregiver mental health and child be-
behavior were assessed by caregiver
reports. Additional ratings from pre-
school teachers would provide greater
confidence in the study findings and
insight into child behavior in a social
setting. However, this was not possible
in our study because not all 4 year olds
in Australia attend formal preschool.
Larger samples are required to exam-
ine the possible influence of sex on child
outcomes after interventions, as well as
the examination of successful com-
ponents of such interventions.

TABLE 4

Preschooler Outcomes on the Behavioral Assessment Screener for Children

Higher scores indicate more problematic behaviors and less adaptive behaviors.

b Analysis allows for clustering of multiple births and is adjusted for stratification factors of multiple birth and white matter abnormality grade 3 or 4.

at risk defined as scores >1 SD above the test mean for behavioral scores and below the test mean for the adaptive score (mean S0, SD 10).
Contrary to expectations, the home-based preventive care program did not result in improved cognitive trajectories. Given the benefits observed in parental and child emotional status, we have not discounted that delayed improvements in cognitive functioning will occur as has been reported previously. However, the primary aim of the intervention was to improve cognitive and motor development, and, as such, it needs to be acknowledged that a more intensive, targeted approach may be required to enhance development in these domains. It is also possible that interventions that commence earlier (ie, before discharge) may be more effective.

REFERENCES


CONCLUSIONS

The VIBeS Plus home-based preventive care program for VPT infants and their caregivers has selective long-term benefits, with caregivers experiencing fewer anxiety symptoms and lower odds of an anxiety disorder and preschoolers showing fewer internalizing behavior problems. Further follow-up at school age is essential for establishing even longer-term benefits of preventive care for infants born VPT.

ACKNOWLEDGMENTS

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