Psychosocial Stimulation Improves the Development of Undernourished Children in Rural Bangladesh

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Abstract

Undernutrition in early childhood is associated with poor mental development and affects 45% of children in Bangladesh. Although limited evidence shows that psychosocial stimulation can reduce the deficits, no such interventions have been reported from Bangladesh. The Bangladesh Integrated Nutrition Program (BINP) has provided nutrition supplementation to undernourished children through community nutrition centers (CNCs). We added psychosocial stimulation to the treatment of undernourished children in a randomized controlled trial to assess the effects on children’s development and growth and mothers’ knowledge. Twenty CNCs were randomly assigned to intervention or control groups with 107 children in each group. We also studied 107 nonintervened better-nourished children from the same villages. Pre- and postintervention measurements included children’s height, weight, development assessed on Bayley Scales, behavior ratings during the test, and a questionnaire on mothers’ knowledge of childrearing. The intervention comprised home visits and group meetings with mothers and children for 12 mo. Intervention benefited children’s mental development (4.6 ± 2.0, P = 0.02), vocalization (0.48 ± 0.23, P = 0.04), cooperation (0.45 ± 0.16, P = 0.005), response-to-examiner (0.50 ± 0.15, P = 0.001), emotional tone (0.33 ± 0.15, P = 0.03), and mothers’ knowledge (3.5 ± 0.49, P < 0.001). At the end, undernourished controls had poorer mental (−4.6 ± 2.0, P = 0.02) and motor (−6.6 ± 2.2, P = 0.003) development, were more inhibited (−0.35 ± 0.16, P = 0.03), fussier (−0.57 ± 0.16, P < 0.001), less cooperative (−0.48 ± 0.17, P = 0.005), and less vocal (−0.76 ± 0.23, P = 0.001) than better-nourished children. Intervened children scored lower only in motor development (−4.4 ± 2.3, P = 0.049). Neither group of undernourished children improved in nutritional status, indicating that treatment had no effect. In conclusion, adding child development activities to the BINP improved children’s development and behavior and their mothers’ knowledge; however, the lack of improvement in growth needs to be examined further. J. Nutr. 136: 2645–2652, 2006.

Introduction

An estimated 149 million children <5 y of age in developing countries are undernourished [weight-for-age Z-scores (WAZ)3 <−2 of the National Center for Health Statistics’ (NCHS) median (1)] and two-thirds of them live in Asia (2). Early childhood undernutrition is associated with poor current and later cognitive development and school achievement (3), and supplementation studies suggest a causal relation (e.g., 4–7). However, marked improvements in development can occur if severely undernourished children are adopted and exposed to more nurturing environments (8). In Cali, Colombia, mild to moderately undernourished children showed benefits from a center-based program in which they received both psychosocial stimulation and nutritional supplementation (9). However, neither adoption studies nor the Cali study could distinguish the effects of stimulation from those of improved nutrition.

There is some evidence that stimulation alone benefits undernourished children’s development. Early studies of stimulation, with severely undernourished children in hospital, showed only transient benefits (3). In contrast, in 2 small Jamaican studies, longer-term intervention with psychosocial stimulation benefited undernourished children’s development and some of these benefits remained in late adolescence (10,11); however, only 1 of the 2 studies was randomized (11). There are, therefore, few studies of stimulation with undernourished children. One preventive study in Bogota, Colombia provided stimulation from birth to 3 y of age and showed concurrent benefits to development (4). At follow-up, at ~7 y of age, the effects of stimulation on cognitive function were not fully reported but benefits to growth were found (12).
In Bangladesh, undernutrition (WAZ < -2 of the NCHS median) affects 48% of young children (2) but we are unaware of any interventions aimed at improving their mental development. The government of Bangladesh initiated a nutritional surveillance and supplementation program, the Bangladesh Integrated Nutrition Program (BINP), in 1995. In 2000, a total of 13,395 community nutrition centers (CNCs) were established in 59 Upazilas (subdistricts). Children with WAZ < -3, and those with growth faltering during 2 consecutive mo, were referred to CNCs for nutritional rehabilitation. Upon receiving a food packet, mothers and children were expected to attend the centers 6 d/wk for a minimum of 90 d. If the child remained severely undernourished after this period, their mothers were advised to attend the center for 30 more days. The packets contained roasted rice and lentil powders, molasses, and soy oil and provided 0.63 kJ energy. Children with moderate or severe malnutrition were given 1 or 2 packets, respectively. This program provided an opportunity to add psychosocial stimulation to the existing treatment of malnutrition. We therefore conducted a cluster-randomized trial in 2000–2002 to determine the effects of adding psychosocial stimulation to the BINP interventions in the CNCs. We measured the effects on children’s growth and development and mothers’ knowledge of child rearing. We also compared the growth and development of the undernourished groups with a matched group of better-nourished children.

**Subjects and Methods**

**Location**
The study was conducted in the Monohardi subdistrict, which was accessible to Dhaka, and the BINP had recently begun operating there. This is a poor rural area and the householders are mostly peasant farmers.

**Subjects**
Five unions accessible to Dhaka were first selected. Then we identified all villages in these unions with >5 undernourished children attending the village's respective CNC. From each of the 5 unions, 4 CNCs were randomly selected, of which 2 were randomly assigned to intervention and 2 to control, making a total of 10 intervened centers and 10 control centers.

Children with moderate and severe undernutrition were identified from the BINP records. All children aged 6–24 mo of age, with WAZ < -2 (reassessed by the researchers), were enrolled if their mothers provided informed consent to participate in the study. Children with developmental problems (reported by their mothers) were included in the stimulation program but not in the study. The number of children in each CNC varied from 7 to 15. Alternate undernourished children in each of the CNCs were matched for age ± 6 mo, sex, and village of residence with a better-nourished child (WAZ ≥ -2). We had planned on selecting children with WAZ > -1.5, but, unfortunately, we did not find a sufficient number of children to participate and therefore decided to enroll the better-nourished controls at WAZ ≥ -2. We initially selected 107 children in each of the 3 groups, but 7 families withdrew their children before the baseline measurements were made, leaving 104 intervened undernourished, 102 control undernourished, and 107 better-nourished children (Fig. 1).

**Measurements**
The following measurements were made at the beginning and end of the study.

**Developmental assessment.** The mental and psychomotor development of children was assessed on the revised version of Bayley Scales of Infant Development (BSID-II) (13) by 1 of 3 trained female testers who were blind to the child's group. Children were tested in a quiet room in the presence of their mothers. Those who were sick on the day of the scheduled test were treated and tested when they recovered. The BSID-II consists of mental (MDI) and psychomotor (PDI) development indices.

MDI measures cognitive, language, and personal-social development of the children, and PDI is a measure of their fine and gross motor development. This test has been used previously in Bangladesh when the mean scores of urban (14) and rural (15) children were within the normal range.

**Behavior ratings.** The children’s behavior during the tests was rated by the testers on five 9-point scales: 1) responsiveness to examiner in the first 10 min (avoiding or inhibited = 1, friendly and inviting = 9); 2) infant’s activity (very still = 1, overactive = 9); 3) emotional tone (unhappy or fussy = 1, radiates happiness = 9); 4) cooperation with test procedures (resists all suggestions = 1, always complies = 9); and 5) vocalization (very quiet = 1, constant vocalization = 9). These scales were modified from those of Wolke (16) and have also been used in Bangladesh (14). Test-retest reliabilities of the Bayley scores were assessed in a previous study over a span of 7 d by the same research group and intraclass correlation coefficients of r = 0.94 for MDI and 0.98 for PDI (both P < 0.001) were achieved with 21 children (14). During the study, interobserver reliabilities were assessed for 7% of the tests and the mean measures of intraclass correlation coefficients among the 3 testers were r = 0.99 for MDI and PDI, with a range of r = 0.92–0.98 (P < 0.001) for all behavior ratings except for activity, with r = 0.79 (P < 0.01).

**Anthropometry.** Two trained research assistants measured weights, lengths, mid-upper arm and head circumferences of all study children using standard techniques (17), and the coefficient of reliability for technical error was >0.9 for all measurements (18).

**Mothers’ knowledge.** A questionnaire was developed to assess mothers’ knowledge of nutrition, health and hygiene, child development and child-rearing practices likely to promote good child development. Two trained female interviewers, blind to the groups, administered the questionnaire to the mothers, and interobserver reliabilities were checked for 10% of the interviews during the study, with agreement between the interviewers (intraclass correlation coefficient r = 0.98).

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**Figure 1** Flow chart.
**Socio-economic status.** All homes were visited at the beginning of the study and information was sought on the families’ household possessions, standard of housing, family structure, and parental education and occupation.

**Intervention**
The intervention consisted of weekly group meetings at the CNCs for 10 mo followed by meetings every 2 wk for 2 mo, and twice weekly individual visits at home for 8 mo followed by weekly home visits for 4 mo. Literate women from each village were trained for 2 wk to serve as play leaders. They conducted the intervention and 1 of 2 supervisors attended the visits regularly. The curriculum was based on one that was previously used in Jamaica (19) and modified for use in Bangladesh. We initially conducted focus group discussions with mothers of undernourished and well-nourished children to determine their practices, knowledge, and attitudes toward child care and development. We identified the positive and negative caring practices and obtained details of traditional games and songs. The curriculum was based on improving the mother-child interaction, and providing developmentally appropriate activities for the child. The importance of praising children, giving positive feedback, chatting with them, and labeling things in the environment was emphasized to the mothers and punishment was discouraged. We included traditional games and songs and produced low-cost picture books suitable for Bangladeshi children and mothers with little reading ability. The group sessions included topics on child development and the importance of play. For the individual sessions at respective homes, the play leaders demonstrated play activities to the mothers using toys made from recycled materials; the toys were left in the homes and exchanged with new toys on the following visit.

**Ethics**
The Ethical Review Committee of the International Center for Diarrheal Disease Research, Bangladesh (ICDDR,B) approved the study, and written informed consent for participating in the study was obtained from the mothers or guardians before enrolling each child in the study. The field workers in the control villages were taught the curriculum at the end of the study and were encouraged to teach the mothers in those villages.

**Statistical analysis**
The data were analyzed using the SPSS-Win, version 10 (SPSS). Housing, sanitation, crowding, and asset indices were calculated as follows: 1) a housing index was calculated based on the condition of the roof and walls of the house and the presence or absence of electricity; 2) a sanitation index was calculated by rating the type of latrine and the availability of water inside or outside of the home; 3) an asset index was calculated based on the presence of 12 commonly found household possessions (e.g., chair, bed, radio, etc.). Each item was given a score of 1 and these were then summed to make a possible total of 12; and 4) a crowding index, which comprised the number of people per room. Transformations were used to normalize the variables when necessary; the crowding index was skewed and a log-10 of the variable was used to normalize the data. Parents’ education was dichotomized based on completing 5 yr of formal schooling or not. The mothers’ responses to the questionnaire were assessed for knowledge of child rearing, health, and hygiene by giving a score of 1 to each correct response and then summing the scores. The children’s WAZ, height-for-age (HAZ) and weight-for-height (WHZ) Z-scores were calculated according to the NCHS references (1). Results are expressed as means ± SD in the text. Group comparisons (control vs. intervention, combined undernourished vs. better-nourished, and lost vs. tested) were performed using independent sample t test for continuous variables or χ² test for categorical variables. The relation between the developmental variables and socio-economic and child variables were examined by Pearson’s correlation. Age was controlled when the developmental variable was significantly related to age.

Using intention to treat analyses with the undernourished groups only, we first conducted a series of multiple-regression analyses for each outcome, controlling for age and initial scores only. We repeated the analyses controlling for variables that differed between the tested children and those lost to follow-up and were significantly correlated with the outcome variables. We also controlled for any variable that differed between the 2 tested groups at enrollment. Because the children were randomized at the village level, we also conducted multilevel analyses (20) to take into account differences at the village level. The findings did not differ when we used multilevel analyses, and we thus report multiple regressions for simplicity. We then compared the better-nourished group with each of the 2 undernourished groups separately by using 2 dummy variables. Furthermore, we divided the better-nourished group on the basis of their final WAZ into ≥−1 and < −1 groups and compared their developmental outcomes using analyses of covariance controlling for age. Differences were considered significant at *P* < 0.05.

**Results**

**Frequency of home visits, group meetings, and supplementation.** The maximum possible number of home visits for the year of the study was 86, and the completed visits ranged from 43 to 83 (68.3 ± 8.7), or equivalent to 1 every 5 d. The main reasons for missing a visit were the absence of the mother-child pair at home during the visit and sickness of the child.

Between 28 and 39 group meetings (33.6 ± 3.6) were held by the play leaders in the 10 villages. Sixty-eight percent attended ≥20 meetings. The number of group sessions attended by mothers was 23.3 ± 9.3.

The number of days that children received supplementation did not differ between the groups (70.4 ± 44.2 and 76.4 ± 42.5 for intervened and control groups, respectively).

**Loss from sample.** Fourteen children (4.5%) were lost from the study after the baseline measurements were made: 12 from the intervention group, and 1 each from the 2 remaining groups (Fig. 1). We therefore examined the differences between the tested children and those lost to follow-up in the intervention group only. At enrollment, the lost children had lower MDI scores, WAZ, and HAZ, and lived in more crowded homes than the children who completed the study. Other socio-economic variables, PDI, and behavior ratings did not differ.

**Characteristics on enrollment of sample tested post intervention.** At enrollment, the 2 undernourished groups were similar in all measured socio-economic and parental characteristics (Table 1) except that higher proportion of fathers of the intervened group had attained grade 5 level of education (*P* = 0.03). The children were also similar in nutritional status, Bayley scores, and behavior ratings (Tables 2 and 3). In contrast, the better-nourished children had better socio-economic backgrounds than the combined undernourished groups (Table 1), and their fathers (*P* = 0.009) and mothers (*P* = 0.003) had higher levels of education; mothers had better nutritional status [BMI, *P* = 0.02; and mid-upper-arm circumference (MUAC), *P* = 0.002] and higher scores for health and child-rearing knowledge (*P* < 0.001); and the fathers had higher-status occupations (*P* = 0.001). As expected, all the better-nourished children’s nutritional indices were better (Table 2) and they had higher MDIs (*P* = 0.06) and PDIs (*P* < 0.001) than the undernourished groups combined. None of the 3 groups differed in the 5 behavior ratings (Table 3).

**Treatment effect.** Children’s anthropometric measures and maternal knowledge of health and hygiene remained similar in both the undernourished groups at postintervention, whereas maternal knowledge of child rearing was improved in the intervention group at final test (Table 2). The undernourished intervened children showed improvements in their MDI, response to examiner, and cooperation when using independent sample *t* test (Table 3).

**Development.** Age of the children at the time of testing negatively correlated with MDI (*r* = −0.53, *P* < 0.001) and PDI (*r* = −0.12,
TABLE 1 Parental and socio-economic characteristics by groups on enrollment

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Undernourished intervention</th>
<th>Undernourished control</th>
<th>Undernourished combined</th>
<th>Better nourished</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>92</td>
<td>101</td>
<td>193</td>
<td>106</td>
<td></td>
</tr>
<tr>
<td>Mothers’ BMI, kg/m²</td>
<td>18.2 ± 1.9</td>
<td>18.0 ± 1.6</td>
<td>18.1 ± 1.8</td>
<td>18.6 ± 1.9</td>
<td>0.02</td>
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<td>Mothers’ MUAC, cm</td>
<td>21.7 ± 2.0</td>
<td>21.6 ± 1.7</td>
<td>21.6 ± 1.8</td>
<td>22.3 ± 1.8</td>
<td>0.002</td>
</tr>
<tr>
<td>Mothers’ education (&lt;5 y of schooling), %</td>
<td>52</td>
<td>57</td>
<td>54</td>
<td>37</td>
<td>0.003</td>
</tr>
<tr>
<td>Fathers’ education (&lt;5 y of schooling), %</td>
<td>49</td>
<td>63</td>
<td>56</td>
<td>41</td>
<td>0.009</td>
</tr>
<tr>
<td>Fathers’ occupation (peasant), %</td>
<td>64</td>
<td>73</td>
<td>68</td>
<td>49</td>
<td>0.001</td>
</tr>
<tr>
<td>Sanitation index</td>
<td>1.0 ± 0.7</td>
<td>0.9 ± 0.7</td>
<td>1.0 ± 0.7</td>
<td>1.3 ± 0.7</td>
<td>0.001</td>
</tr>
<tr>
<td>Housing index</td>
<td>1.4 ± 0.6</td>
<td>1.3 ± 0.7</td>
<td>1.4 ± 0.7</td>
<td>1.7 ± 0.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Assets</td>
<td>4.3 ± 1.9</td>
<td>4.2 ± 1.8</td>
<td>4.2 ± 1.9</td>
<td>5.2 ± 2.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Crowding index</td>
<td>0.6 ± 0.2</td>
<td>0.6 ± 0.2</td>
<td>0.6 ± 0.2</td>
<td>0.5 ± 0.2</td>
<td>0.1</td>
</tr>
</tbody>
</table>

1 Values are means ± SD or %.
2 t test comparing 2 undernourished groups.
3 t test comparing combined undernourished and better-nourished groups.
4 χ² test.

P = 0.04), and positively with emotional tone (r = 0.015, P = 0.007), activity (r = 0.25, P < 0.001), and vocalization ratings (r = 0.43, P < 0.001). We examined the treatment effect using multiple regression analyses for each final outcome variable with the 2 undernourished groups only. In all regression analyses, we entered initial scores, age, and treatment group. There were treatment effects on MDI (P = 0.007) (Table 4), response to examiner (P = 0.001), cooperation (P = 0.005), emotional tone (P = 0.03), vocalization (P = 0.04), and maternal knowledge of child rearing (P < 0.001) (Table 5). The effect on PDI approached significance (P = 0.06).

Crowding and initial HAZ and WAZ differed between the tested children and those lost to follow-up, and were related to the Bayley scales. We therefore repeated the regressions of the Bayley scales, controlling for these variables (HAZ was used, but not WAZ, because they were highly related to each other and HAZ had the highest correlations with the outcomes). Fathers’ education was also offered in the regression because this differed among the undernourished groups at enrollment. The treatment effect was only slightly reduced in MDI (P = 0.02) and PDI (P = 0.1) (Table 4). Crowding had a significant effect on MDI, and father’s education had a significant effect on PDI. Crowding, WAZ, or HAZ did not correlate with maternal knowledge or any behavior rating, therefore, we entered only fathers’ education in the adjusted regressions of the behavior ratings and maternal knowledge but it did not enter any regression.

To assess whether the treatment effect was modified by child or family characteristics, we examined several possible interactions. Interaction terms were computed for treatment with age, sex, children’s enrollment HAZ, crowding, and mothers’ and fathers’ education. In addition, growth in height and weight was calculated by regressing final measures on initial measures, and saving the residuals as a measure of growth. Interaction terms between growth and treatment were then computed. All the interaction terms were offered as extra variables in the multiple regressions, using the above model to detect treatment effects, but none of them entered the equation.

TABLE 2 Characteristics of children and mothers’ knowledge of childrearing at enrollment

<table>
<thead>
<tr>
<th>Characteristic of childrearing</th>
<th>Undernourished intervention</th>
<th>Undernourished control</th>
<th>Undernourished combined</th>
<th>Better nourished</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>92</td>
<td>101</td>
<td>193</td>
<td>106</td>
<td></td>
</tr>
<tr>
<td>Age at enrollment, mo</td>
<td>14.6 ± 4.5</td>
<td>14.9 ± 4.3</td>
<td>14.8 ± 4.4</td>
<td>14.2 ± 5.3</td>
<td>0.04</td>
</tr>
<tr>
<td>Gender, boys %</td>
<td>39</td>
<td>52</td>
<td>46</td>
<td>45</td>
<td>0.5</td>
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<tr>
<td>HAZ</td>
<td></td>
<td></td>
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<td></td>
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<td>Baseline</td>
<td>−2.6 ± 1.1</td>
<td>−2.6 ± 1.0</td>
<td>−2.6 ± 1.0</td>
<td>−1.3 ± 0.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Final</td>
<td>−2.6 ± 0.9</td>
<td>−2.5 ± 1.0</td>
<td>0.6</td>
<td>−1.3 ± 0.8</td>
<td></td>
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<tr>
<td>WAZ</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>−2.7 ± 0.6</td>
<td>−2.8 ± 0.7</td>
<td>0.9</td>
<td>−2.8 ± 0.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Final</td>
<td>−2.7 ± 0.7</td>
<td>−2.8 ± 0.6</td>
<td>0.8</td>
<td>−1.4 ± 0.7</td>
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<tr>
<td>WHZ</td>
<td></td>
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</tr>
<tr>
<td>Baseline</td>
<td>−1.4 ± 0.7</td>
<td>−1.5 ± 0.7</td>
<td>0.3</td>
<td>−1.5 ± 0.7</td>
<td>&lt;0.001</td>
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<tr>
<td>Final</td>
<td>−1.6 ± 0.6</td>
<td>−1.7 ± 0.6</td>
<td>0.4</td>
<td>−0.8 ± 0.8</td>
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<tr>
<td>Mothers’ knowledge</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>of childrearing</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>15.5 ± 3.4</td>
<td>15.2 ± 3.4</td>
<td>15.3 ± 3.4</td>
<td>16.8 ± 3.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Final</td>
<td>19.1 ± 3.8</td>
<td>15.4 ± 3.5</td>
<td>&lt;0.001</td>
<td>16.7 ± 3.5</td>
<td></td>
</tr>
</tbody>
</table>

1 Values are means ± SD or %.
2 t test comparing 2 undernourished groups.
3 t test comparing combined undernourished with better-nourished.
4 χ² test.
Program characteristics. Finally, we examined whether the intensity of the intervention was associated with developmental improvement. We conducted multiple regression analyses predicting the final Bayley scores with the intervened children only. Variables that were significantly correlated to the scores within the group were controlled. In the regression of MDI, the initial score and age were entered in the first step; mothers’ education, fathers’ education and occupation, crowding, and sanitation were offered in the second step; and number of visits and number of group meetings attended by mothers were entered in the third step. Neither the number of visits nor the number of group meetings was significant. In a similar regression of PDI, the number of visits had an effect on PDI (regression coefficient (B) = 0.54 SE = 0.18, P = 0.003) whereas the number of group sessions did not.

**Anthropometry.** There was no initial difference between the undernourished groups in anthropometric measurements but, as expected, the better-nourished group was better in all anthropometric measures than the undernourished groups (Table 2). In the intervention and control groups 35 and 29% of children were severely undernourished (WAZ < -3) and 33.7 and 27.5% of children were severely stunted (HAZ < -3), respectively. Moderate wasting (WHZ > -3 and < -2) was 21.8 and 22.5% in the intervention and control groups, respectively. Multiple regressions controlling for age and using the initial scores for HAZ, WAZ, and WHZ on undernourished groups after treatment, showed no treatment effect in any of the 3 indicators. Furthermore, paired *t* tests showed that deterioration in WHZ occurred in all 3 groups (intervened undernourished, *P* = 0.04; control undernourished, *P* = 0.02; better-nourished, *P* < 0.001) over the study period. There was no change in the HAZ and the only change in WAZ occurred in the better-nourished group, which deteriorated (*P* < 0.001).

**Mothers’ knowledge.** We conducted multiple regression analyses of mothers’ knowledge of child rearing, controlling for the initial score and fathers’ education. The treatment improved mothers’ knowledge of child rearing (*P* < 0.001) (Table 4). There was no treatment effect on mothers’ knowledge of health and hygiene.

**Comparison with better-nourished group.** To determine whether the intervened and control undernourished groups differed from the better-nourished children at the end of the study,
TABLE 5  Regression coefficients (B) and standard errors (SE) from multiple regression analyses predicting final behavioral ratings and mothers’ knowledge of child rearing in undernourished groups.1,2

<table>
<thead>
<tr>
<th>Variables</th>
<th>MDI Response to examiner</th>
<th>MDI Emotional tone</th>
<th>MDI Cooperation</th>
<th>MDI Vocalization</th>
<th>PDI Response to examiner</th>
<th>PDI Emotional tone</th>
<th>PDI Cooperation</th>
<th>PDI Vocalization</th>
<th>Mothers’ knowledge of child rearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline scores</td>
<td>0.15 ± 0.06*</td>
<td>0.10 ± 0.05*</td>
<td>0.10 ± 0.05*</td>
<td>0.33 ± 0.07***</td>
<td>0.42 ± 0.07***</td>
<td></td>
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</tr>
<tr>
<td>Age, mo</td>
<td>0.02 ± 0.017</td>
<td>0.08 ± 0.02***</td>
<td>0.06 ± 0.02**</td>
<td>0.08 ± 0.03*</td>
<td>−0.007 ± 0.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>0.50 ± 0.15**</td>
<td>0.33 ± 0.15*</td>
<td>0.45 ± 0.16**</td>
<td>0.48 ± 0.23*</td>
<td>3.51 ± 0.49***</td>
<td></td>
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<td></td>
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<tr>
<td>R²</td>
<td>0.15 ± 0.06*</td>
<td>0.10 ± 0.05*</td>
<td>0.10 ± 0.05*</td>
<td>0.33 ± 0.07***</td>
<td>0.42 ± 0.07***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Values are B ± SE, n = 92 undernourished intervened and 101 undernourished controls. *P < 0.05, **P < 0.01, ***P < 0.001.
2 Predictions are assessed from baseline scores, age, fathers’ education, and treatment (Intervention = 1, Control = 0).

we conducted a further series of multiple regression analyses. Because there were treatment effects, the 2 undernourished groups were compared separately with the better-nourished group. We entered the initial age in the first step, then considered all socio-economic variables, which differed between the undernourished and the better-nourished groups (fathers’ occupation, parents’ education, mothers’ knowledge of child rearing, and that of health and hygiene, assets, sanitation, and housing indices) or related to the outcomes (crowding index). In the third step, we entered 2 dummy variables: one comparing the better-nourished children with intervened undernourished (coded as intervened undernourished = 1; else = 0) and the other comparing the better-nourished children with control undernourished children (coded as control undernourished = 1; else = 0).

In MDI, the intervened undernourished children did not differ from the better-nourished children, whereas the control undernourished children were behind the better-nourished children with a deficit of 4.6 points (P = 0.02) (Table 6). In PDI, both of the undernourished groups were still behind the better-nourished children with deficits of 6.6 (P = 0.003) and 4.4 (P = 0.049) points in control and intervened undernourished groups, respectively (Table 6).

As children in the better-nourished group deteriorated in nutritional status over the study, we examined whether the final nutritional status was related to development in this group. We divided the group into ≥ −1 in WAZ (n = 27) and < −1 (n = 77) and compared their Bayley scores using ANOVA, controlling for age. For MDI, the means of the adequately nourished children (93.2 ± 11.9) were higher than those of the poorer nourished children (87.6 ± 15.2) (P = 0.05). There was also a difference in PDI between the adequately nourished (105.3 ± 16.5) and the poorer nourished (97.2 ± 14.7) children (P = 0.02).

The undernourished control group differed from the better-nourished group in cooperation (P = 0.005), emotional tone (P < 0.001), response to examiner (P = 0.03), and vocalization (P = 0.001) (Table 6), whereas the intervention group did not differ in any rating, although there was a tendency to differ in emotional tone (P = 0.09) (Table 6). None of the groups differed in activity rating. Maternal knowledge of child rearing was higher in the intervention group (P < 0.001) compared with the better-nourished group, but there was no difference between the control and better-nourished groups.

Discussion

**Intervention effect.** To our knowledge, this is the first report of an intervention that substantially benefited mental development in undernourished children in Bangladesh. The intervened children were also more responsive to the examiner, more cooperative, happier, and vocalized more than the control children during the test. However, benefits to motor development were small and not statistically significant, and there was no treatment effect on growth. There was an improvement in maternal knowledge of child rearing but not in knowledge of health and hygiene.

TABLE 6  Regression coefficients (B) and standard errors (SE) from multiple regression analyses of final Bayley scores and behavior ratings and mothers’ parenting knowledge comparing better-nourished group with each of the undernourished groups.1,2

<table>
<thead>
<tr>
<th>Variables</th>
<th>MDI</th>
<th>PDI</th>
<th>Response to examiner</th>
<th>Cooperation</th>
<th>Emotional tone</th>
<th>Vocalization</th>
<th>Mothers’ parenting knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mo</td>
<td>0.5 ± 0.2**</td>
<td>−0.8 ± 0.2***</td>
<td>−0.04 ± 0.01**</td>
<td>0.06 ± 0.01***</td>
<td>0.10 ± 0.02***</td>
<td>−0.10</td>
<td>1.0 ± 0.4**</td>
</tr>
<tr>
<td>Fathers’ education</td>
<td>4.1 ± 1.8*</td>
<td>−0.08</td>
<td>−0.08 ± 0.04*</td>
<td>−0.08 ± 0.04*</td>
<td>−0.08 ± 0.04*</td>
<td>−0.08 ± 0.04*</td>
<td>0.39 ± 0.06***</td>
</tr>
<tr>
<td>Mothers’ education</td>
<td>−0.66 ± 0.3*</td>
<td>0.97 ± 0.3**</td>
<td>−0.04 ± 0.02*</td>
<td></td>
<td>−0.04 ± 0.02*</td>
<td></td>
<td>0.39 ± 0.06***</td>
</tr>
<tr>
<td>Mothers’ initial parenting knowledge</td>
<td>−0.08 ± 0.04*</td>
<td>−0.08 ± 0.04*</td>
<td>−0.08 ± 0.04*</td>
<td>−0.08 ± 0.04*</td>
<td>−0.08 ± 0.04*</td>
<td>−0.08 ± 0.04*</td>
<td>0.39 ± 0.06***</td>
</tr>
<tr>
<td>Sanitation index</td>
<td>−13.1 ± 5.0**</td>
<td>−12.5 ± 5.4*</td>
<td>−12.5 ± 5.4*</td>
<td>−12.5 ± 5.4*</td>
<td>−12.5 ± 5.4*</td>
<td>−12.5 ± 5.4*</td>
<td>0.39 ± 0.06***</td>
</tr>
<tr>
<td>Crowding index, log</td>
<td>−0.55 ± 2.0</td>
<td>−0.44 ± 2.3*</td>
<td>−0.35 ± 0.16*</td>
<td>−0.48 ± 0.17**</td>
<td>−0.57 ± 0.16**</td>
<td>−0.76 ± 0.2**</td>
<td>−0.41 ± 0.47**</td>
</tr>
<tr>
<td>Mother’s MUAC, cm</td>
<td>−0.66 ± 2.0</td>
<td>−0.66 ± 2.2**</td>
<td>−0.35 ± 0.16*</td>
<td>−0.48 ± 0.17**</td>
<td>−0.57 ± 0.16**</td>
<td>−0.76 ± 0.2**</td>
<td>−0.41 ± 0.47**</td>
</tr>
<tr>
<td>R²</td>
<td>0.13</td>
<td>0.14</td>
<td>0.07</td>
<td>0.10</td>
<td>0.12</td>
<td>0.13</td>
<td>0.31</td>
</tr>
</tbody>
</table>

1 Values are B ± SE, n = 92 undernourished intervened and 101 undernourished controls, and 106 better nourished. *P < 0.05, **P < 0.01, ***P < 0.001.
2 Model: step 1, age at enrollment entered; step 2, mothers’ and fathers’ education, crowding, assets, and sanitation indices, fathers’ occupation, and mothers’ initial knowledge of health, hygiene and parenting, and mothers’ BMI and mid-upper arm circumference (MUAC); step 3, groups entered treatment.
This was a randomized trial, there was little initial difference between the intervened and control children, and the testers were unaware of the children’s group assignments. The overall loss to follow up was small (4.5%), but the loss was higher among the intervened group (12%). The children lost to follow up lived in more crowded homes, and had slightly worse initial nutritional status and mental development than other children in the group. However, controlling for these factors did not make any difference to the treatment effect. It is therefore likely that the observed benefit was due to the intervention.

The size of the MDI benefit was one-third of a standard score. Assessing the functional importance of this effect size with confidence is difficult. When considered alone, it is probably of limited functional importance, but the improvement in the children’s behaviors and mothers’ child-rearing knowledge and practices suggests that the effect is likely to lead to sustained benefits. The MDI benefit was slightly smaller than the benefits in developmental quotients (DQs) found in similar interventions elsewhere with undernourished children. In those studies effect sizes were usually ~0.6 of a DQ standard score (6,21,22) and led to comprehensive sustained benefits (11).

We examined possible explanations for the smaller benefits in the Bangladeshi children. The Bangladeshi children were similar in age and initial nutritional status to those in other studies; however, they were the only ones whose nutritional status did not improve over the year. This may have made developmental improvement difficult. The interaction between growth and intervention was not significant; however, the groups were too small to detect significant interactions. Similarly, there was a nonsignificant tendency for the ratio of boys to girls between the groups to differ, but the interaction between gender and treatment was also not significant.

The children’s motor development did not benefit from intervention, but previous stimulation studies have also observed that stimulation mainly affects cognition and language development (4,21–23) and that motor development is less affected by stimulation.

We were encouraged to find that the intervened children were significantly less inhibited, happier, more cooperative, and vocalized more often than the control undernourished children. Undernourished children are generally less exploring, more apathetic, and fussier than better-nourished children (3), and as a result, their caretakers are often less responsive. This behavior is known as “functional isolation” (24) and may reduce the children’s ability to acquire skills. It is, therefore, possible that improving children’s behavior could facilitate further improvement in their development. Similar changes in behavior were found following intervention with severely undernourished children in Jamaica (25).

**Anthropometry.** Benefit from stimulation to growth could be postulated, because the more active and interactive children would be expected to demand more food. However, we failed to find a benefit, possibly because the families were extremely poor and food availability was limited. Although the Colombian study mentioned earlier (12) showed growth benefits at follow-up, 3 previous studies failed to find concurrent growth benefits (6,10,21).

A weakness of the study design is that there was no control group receiving neither food nor stimulation, nor was there a group receiving stimulation alone. This would have been ethically impossible as the supplementation program was already in place. Therefore we were unable to evaluate the effect of supplementation alone or stimulation alone. However, the limited existing evidence suggests that combined supplementation and stimulation give the greatest benefits at least in the short term (6).

The lack of overall improvement in the nutritional status in both undernourished groups is worrying and indicates that the program was not sufficiently effective in the sample examined. It is possible that the supplement benefited the children by preventing further deterioration in their nutritional status. There are many possible reasons for failure to improve the nutritional status of the supplemented children. The supplement was probably insufficient to make an impact and much smaller than that given in other studies [e.g., 0.63–1.26 kJ/d in Bangladesh vs. 3.14 kJ/d in Jamaica (6)]. The nutritional packet also contained few micronutrients and these deficiencies could have been growth limiting. Furthermore, mothers were expected to walk to the center every day for a small amount of supplements, which would explain the relatively poor uptake of supplementation packets. Substitution of food to other members of the family (26) could also explain, at least in part, the children’s poor growth. Frequent infections may also have played a role. There are differences in the observed nutritional impact of the BINP intervention. One cross-sectional study found no significant difference in the nutritional status of younger children (27), and another prospective randomized trial observed improvement in only 23% of the children (28). It appears that the food supplementation program needs to be modified not only in terms of the amount and quality of the supplement but also as to how it is distributed. On the positive side, the program provides an infrastructure for access to many disadvantaged children and could be readily modified.

**Mothers’ knowledge.** Treatment improved mothers’ knowledge of child rearing compared with the control group but not their knowledge of health and hygiene. The BINP ran an educational program for mothers on health and hygiene, and both undernourished groups had received it, which could explain the lack of treatment effect.

**Comparison with better-nourished children.** At the end of the study, the intervened undernourished children remained similar to the better-nourished children in their MDI and behavior ratings but failed to catch up in PDI. In contrast, the ratings for undernourished control children fell well behind the better-nourished children in MDI and behavior during the study, and also remained behind in PDI. The deficit among the undernourished control children was ~0.3 of a standard score compared with the better-nourished children. However, the better-nourished children’s final mean WAZ and HAZ were <−1. The children with WAZ ≥−1 had significantly higher Bayley scores than those with poorer weights and heights for-age. The findings suggest that the undernourished control group’s deficit in developmental levels compared with better-nourished children would have been considerably greater (~100%) if the latter group had been well nourished. Although the size of the benefits from intervention would have been the same, the children would have failed to catch up with a well-nourished group in both MDI and PDI. This suggests that undernutrition was responsible for continuing deficits despite stimulation benefits. Furthermore, if the better-nourished group had received stimulation they also are likely to have benefited as found with poorly but adequately nourished children elsewhere (29).

**Program implications.** The findings show that it is possible to “piggy back” child development activities onto the Bangladesh nutrition services and improve undernourished children’s development. However, the benefits were modest, probably because

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**Program implications.** The findings show that it is possible to “piggy back” child development activities onto the Bangladesh nutrition services and improve undernourished children’s development. However, the benefits were modest, probably because
the children’s nutritional status failed to improve. The nutrition centers provide an excellent opportunity to integrate child-development activities into the nutritional interventions of undernourished children. Because this was a new approach, we hired extra village women to run the stimulation program, but it should also be possible to train staff members who already run the feeding centers. Using the existing infrastructure would reduce costs and make it more feasible to conduct stimulation intervention programs than to use a vertical approach. The government of Bangladesh has already started early childhood development activities using the infrastructure of nutrition centers. There is an urgent need to improve the supplementation program insofar as the children in our study failed to improve in their nutritional status.

Acknowledgments
We thank the testers (Afroza Parveen, Farhana Yasmin, and Fardina Mehrin), interviewers (Afroza Hilaly and Jesmin Akhter), supervisors (Parveen Sultana and Aklma Sardar) and play leaders (Ms. Umme Kulsum, Ms. Bilkis Begum, Ms. Jesmin Sultana, Ms. Rina Begum, Ms. Rima Akhtar, Ms. Lipi, Ms. Zakia Sultana, Ms. Begum Rokeya, Ms. Mafuza and Ms. Sufia Begum).

Literature Cited