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# Effects of Food Supplementation and Psychosocial Stimulation on Growth and Development of Severely Malnourished Children

*Intervention Studies in Bangladesh*

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### **Abstract**

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Early childhood malnutrition is a global public health problem with serious short- and long-term consequences. The aim of this thesis is to evaluate the effects of psychosocial stimulation (PS) with or without food supplementation (FS) on growth and development of severely malnourished children, quality of home environment, mother's child-rearing practices and depressive symptoms. The study setting was Dhaka, Bangladesh, and the participants were severely malnourished children, aged 6-24 months, admitted at Dhaka Hospital of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B). A hospital-based study was conducted in Nutrition Rehabilitation Unit of ICDDR,B hospital, where a control group (n=43) was studied initially, followed by an intervention group (n=54). All received standard nutrition rehabilitation care. The intervention group received daily group meetings and play sessions in the hospital, and was thereafter visited at home for 6 months. A community-based randomised trial was conducted including children (n=507) admitted at hospital for initial treatment of an acute infection, and thereafter assigned to PS, FS, PS+FS, clinic control or hospital control groups. PS was delivered at follow-up visits, fortnightly for 6 months at community clinics. FS included distribution of cereal-based food packets (150–300 kcal/day depending on age) for 3 months. All groups received standard medical care and micronutrient supplementation. In the hospital-based study, the intervention group had significantly higher scores in mental ( $p<0.001$ , effect size 0.52 SD) and motor development ( $p=0.047$ , effect size 0.37 SD), and weight ( $p=0.03$ , effect size 0.39 SD), after 6- months intervention. In the community-based trial, there was a significant effect of stimulation after six months of intervention on children's mental development (group\*session interaction  $p=0.037$ , effect size=0.37 SD) and weight (group\*session interaction  $p=0.02$ , effect size=0.26 SD) but no effect on motor development or linear growth. The PS+FS and PS groups differed in total HOME score, two HOME subscales (maternal involvement and play materials), and in mother's child-rearing practices scores but not in depressive symptoms. PS with or without FS had small improvement on children's growth and development, quality of home environment and mother's rearing-practices of severely malnourished children. More intensive interventions with longer duration are therefore recommended.

**Keywords:** Psychosocial stimulation, food supplementation, HOME, child-rearing practices, maternal depressive symptoms, severe malnutrition, Bangladesh

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## Dedication

*To my father who is not alive to see this day*



# List of Papers

This thesis is based on following papers, which are referred to in the text by their Roman numerals.

- I Nahar, B., Hamadani, JD., Ahmed, T., Tofail, F., Rahman, A., Huda, SN. and Grantham-McGregor, SM. (2009) Effects of psychosocial stimulation on growth and development of severely malnourished children in a nutrition unit in Bangladesh. *Eur J Clin Nutr*, 63(6): 725-731
- II Nahar, B., Hossain, MI., Hamadani, JD., Ahmed, T., Huda, SN., Grantham-McGregor, SM. and Persson, LA. (2012) Effects of a community-based approach of food and psychosocial stimulation on growth and development of severely malnourished children in Bangladesh: a randomised trial. *Eur J Clin Nutr* Feb 22. doi:10.1038/ejcn.2012.13[Epub ahead of print].
- III Nahar, B., Hossain, MI., Hamadani, JD., Ahmed, T., Grantham-McGregor, SM. and Persson, LA. (2012) Effects of psychosocial stimulation on improving home environment and child-rearing practices: results from a community-based trial among severely malnourished children in Bangladesh (manuscript submitted)
- IV Nahar, B., Hossain, MI., Hamadani, JD., Ahmed, T., Grantham-McGregor, SM. and Persson, LA. (2012) Effect of a community-based trial providing psychosocial stimulation and food supplements to severely malnourished children on the level of maternal depressive symptoms (manuscript)

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# Abbreviations

WAZ	Weight-for-age Z-score
WLZ	Weight-for-length Z-score
WHZ	Weight-for –height Z-score
LAZ	Length-for-age Z score
HAZ	Height-for-age Z-score
MDI	Mental Development Index
PDI	Psychomotor Development Index
NRU	Nutrition Rehabilitation Unit
HNFU	Hospital Nutrition Follow-up Unit
CNFU	Community Nutrition Follow-up Unit
ICDDR,B	International Centre for Diarrhoeal Disease Research, Bangladesh
WHO	World Health Organization
UNICEF	United Nation Children’s Education Fund
DALYs	Disability adjusted life years
PS	Psychosocial stimulation
FS	Food supplementation
CC	Clinic-control
CH	Hospital-control
PL	Play leader
SD	Standard deviation
NNP	National Nutrition Programme



# Introduction

Early childhood malnutrition is a major public health problem in low and middle-income countries. It is not only associated with high case fatality rate (1, 2) but also with low intelligence levels, behaviour problems and poor school achievements (3) that persists till adolescence if not treated early (4). It is estimated that every year over 200 million under-five children fail to reach their developmental potentials (5).

Dhaka Hospital of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) treats more than 400 severely malnourished children [weight-for-age Z-score (WAZ)  $<-4$  and/or weight-for-length Z-score (WLZ)  $<-3$  with or without oedema] in the Nutrition Rehabilitation Unit (NRU) each year, after recovery from acute illnesses. The hospital uses a nutritional supplementation protocol (6) based on WHO recommendations (7). Children with  $>-4$  WAZ  $<-3$  and severely malnourished children whose caregivers are unable to stay at NRU are advised to attend Hospital's Nutrition Follow-up Unit (HNFU).

We conducted two studies at Dhaka Hospital of ICDDR,B: 1) a nonrandomised hospital-based intervention study in NRU providing psychosocial stimulation (PS), to the malnourished children, who were followed-up after discharge either at HNFU or at home and 2) a randomised intervention trial with severely malnourished children who had been admitted to the hospital for initial treatment and were allocated to food supplementation (FS) and/or PS and followed-up at community nutrition follow-up unit (CNFU).

In this thesis I discuss the global and national problem of malnutrition and child development and present and discuss the findings of above mentioned two intervention studies.

## Malnutrition

Protein-energy malnutrition in children is defined by measurements that fall below 2 standard deviations (SD) under the normal WAZ (underweight), length/height-for-age Z-score (LAZ/HAZ) (stunting) and weight-for-height/length Z-score (WLZ/WHZ) (wasting). Wasting indicates recent weight loss, whereas stunting usually results from chronic malnutrition (8).

## Magnitude of malnutrition: Global picture

Malnutrition continues to be a major public health problem in low-income countries, particularly in southern Asia and sub-Saharan Africa (8). It is estimated that globally around 60% of 556 million children under the age of 5 years suffer from malnutrition (1) (Table 1). The prevalence of severe acute malnutrition (WLZ<-3 with presence of oedema) in low-income countries is approximately 2% (13 million) (9). Mild and moderate types of childhood malnutrition are more prevalent, with severe public health consequences for child morbidity and mortality (10, 11).

Although the prevalence of childhood malnutrition is decreasing in Asia, countries in South Asia still have both the highest prevalence of malnutrition and the largest numbers of malnourished children: stunting 41% (74 million), wasting 16% (29 million), severe wasting 5.7% (10 million) and underweight 33% (61 million). Three countries in this region — India, Bangladesh and Pakistan, account for almost half the world's total number of underweight children (1).

Table 1. Global estimates of malnutrition in 2005 (1)

Under-five children	Prevalence	
Stunting	32%	178 million
Wasting	10%	55 million
Underweight	20%	112 million

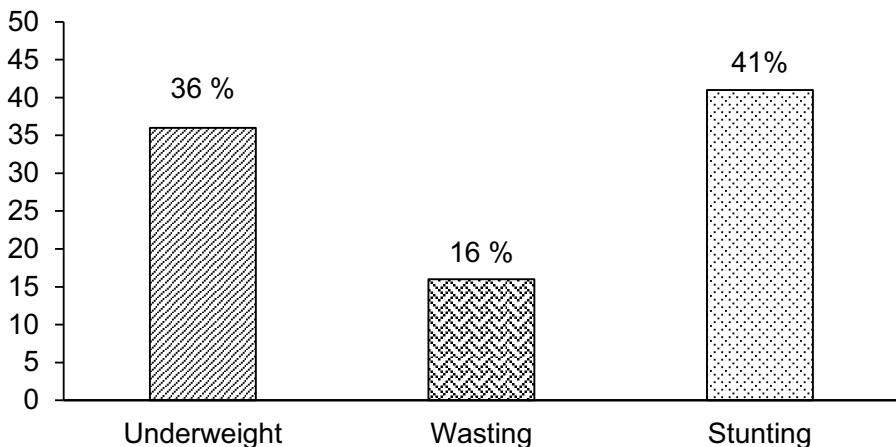
More than 2.2 million children under five years of age die in infectious diseases every year because of an underlying malnutrition (1, 12). Those who survive are locked into a vicious cycle of recurrent infection, faltering growth and intellectual impairment. Malnutrition passes from one generation to the next because malnourished mothers give birth to low birth weight infants, who struggle to thrive or grow well. Stunting, wasting and intrauterine growth restriction are together responsible for 21% of disability-adjusted life-years lost (DALYs) in children younger than 5 years (1, 2).

## Malnutrition: Bangladesh scenario

The prevalence of malnutrition in Bangladesh (Figure 1) is among the highest in the world and almost double that of sub-Saharan Africa (13). Although it has been reduced substantially over last three decades, the low annual rate of reduction in child undernutrition (1.27 percentage points per year) is not sufficient to reach the target of United Nation's Millennium Development Goal (MDG) 1(14, 15). Millions of children and women in Bangladesh are suffering from one or more forms of malnutrition, including low birth weight (LBW), stunting, underweight, vitamin A deficiency, iodine

deficiency disorders and iron deficiency anaemia (16). Nearly one-third of women are undernourished with body mass index less than  $18.5 \text{ kg/m}^2$ , indicating chronic energy deficiency (15).

Malnutrition continues to be a serious public health problem in Bangladesh. It is a major cause of morbidity and mortality of children aged less than five years (17) and severe impairment of growth and development (15).



*Figure 1.* Nutritional status of children younger than five years in Bangladesh in 2011 (18, 19)

### Ecology and causes of malnutrition

Malnutrition in children is rooted in interplay between infant feeding, diet and load of infectious diseases, and the ability of home and society to protect the child and promote growth. However, both poor intake and infections frequently coincide. Common infectious diseases like diarrhoeal diseases and helminthic infestation, respiratory infections, measles and tuberculosis contribute to malnutrition (12).

In the conventional and widely accepted UNICEF conceptual framework (20, 21), the basic causes of malnutrition are the social, economic, and political contexts that lead to a lack of financial, human, social, and natural capital (1) (Figure 2). The underlying causes include income poverty, which results in household food insecurity, inadequate care, and an unhealthy household environment. The immediate causes include suboptimal nutrient intake and disease, which ultimately lead to malnutrition. The interventions presented in this thesis focus some of the immediate causes and outcomes (malnutrition and developmental delay).

## Causes of malnutrition in Bangladesh

The causes of malnutrition of children under five years in Bangladesh are multi-factorial involving many immediate, underlying and structural factors. The immediate causes are diseases and inadequate intake of food. The underlying causes of malnutrition include the inability of households to grow and/or purchase sufficient food for their needs; poor maternal and child-care practices, including inadequate breastfeeding and complementary feeding for infants and young children, and inadequate provision of food for adolescent girls and pregnant and lactating women. These are compounded by delays in recognizing the signs of malnutrition or disease and in seeking care for children and women, inadequate access to quality health services, including family planning, immunisation and medical services and poor access to sanitary facilities and potable water (13).

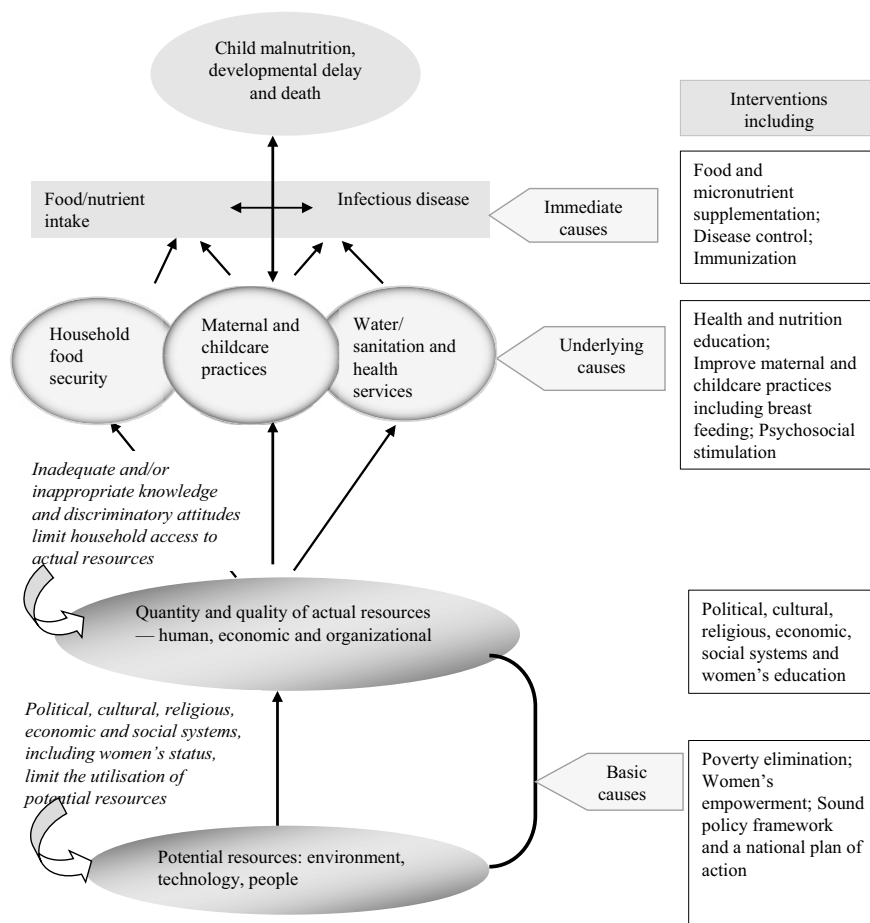
In Bangladesh, about 99% of infants aged less than 12 months are breast fed and prevalence of exclusive breast feeding among children less than 6 months is reportedly 64 % and the median duration of breast feeding is 33 months (19) (Table 2). However, complementary feeding starts too early or too late and foods that are offered are often inappropriate (15). The most commonly used complementary foods of children aged 6-9 months are those made from grains such as rice or wheat, e.g. porridge (over 60 percent); one-third of the children in this age group received fruits and vegetables rich in vitamin A. Sixteen percent received meat, fish, poultry, or eggs (22). The proportion of the population using improved drinking water sources is around 86 % in urban and 78% in rural areas; using improved sanitation facilities is 56 and 52% in urban and rural areas respectively (18).

Table 2. Breast feeding and complementary feeding practices in 2011 (19)

Feeding practices	
Breast feeding among infants <12 months	99%
Exclusive breast feeding (EBF) <6 months	64%
Median duration of breast feeding	32.8 months
Median duration of EBF	1.8 months
Infants <2 months:	
Milk other than breast milk (fresh or powdered cow's milk, infant formula, etc.)	17%
Other liquids	6%
Infants aged 6-9 months:	
No solid or semi-solid food in addition to breast milk	25%

Bangladesh has made good progress in increasing the per-capita income but the income inequality between the rich and the poor and between urban and rural populations, and the decline in food consumption could, in part, explain the slow improvements in nutritional status after 2000. The food

consumption pattern has, however, improved in 2005 compared to 2000 (15).



Source: Adopted from UNICEF Conceptual Framework (20, 21)

Figure 2. Determinants of child malnutrition and development

## Child development

### Growth and development

Child growth may be defined as "a change in size," whereas development may be seen as "changes in complexity and function" (23). For practical purposes, the term "child development" is used to refer to both child growth

(as measured by anthropometric indicators) and child development (characterised by the mental development index, the physical development index, or the social development index).

The working definition of child development may be “a process of change in which the child learns to handle more complex levels of moving, thinking, feeling and interacting with people and objects in the environment” (23, 24).

Child development is *multi-dimensional* and includes cognitive, motor, social and emotional domains, all of which are interdependent with changes in one domain affecting the others (25). The process of development begins prenatally and continues throughout life. It occurs in interaction with people and things. Several dimensions of child development are interrelated and must be considered together; changes along one dimension both influence and are influenced by development along the others (23).

### Early child development: 0-3 years are important

The first three to four years of life are the most important years for a child's survival, growth and development. During this period the child's brain develops rapidly through generation of neurons, axonal and dendritic growth, synaptogenesis, synaptic ‘blooming and pruning’, myelination, and gliogenesis, which helps the child to learn more quickly than at any other time (5, 26). These ontogenetic events happen at different times and build on each other, such that any small interruption in these processes can have long-term effects on the brain's structure and on child socio-emotional development (5, 27).

### The need for early intervention

Child development depends on the synergistic effects of environment; adequate access, quality, preparation and consumption of healthy foods; interactive bonding and emotional and intellectual nurturance from caregivers; supportive social and educational structures, and community, economic and political support (27).

Brain development is modified by the quality of the environment. Remarkable recovery is often possible with early interventions despite the vulnerability of the brain to early insults (5).

### Risk factors for impaired child development

Children's development is *multi-determined* being affected by psychosocial (e.g. level of stimulation in the home, quality of maternal-child interaction) and biological factors (e.g. health and nutritional status), child characteristics (e.g. temperament) and by genetic inheritance (5, 25) (Figure 3).



## **Biological risk factors**

*Effect on central nervous system:* Malnutrition impairs brain development by decreasing the number of cell replication cycles, reducing total brain DNA, and restricting dendritic arborization thus reducing the connections between neurons. Synaptic connectivity is particularly affected if malnutrition occurs after birth but before the third year of life (28, 29).

*Cognitive deficits and motor skills:* Motor skills are generally found to be affected (3) but there is insufficient evidence to identify specific cognitive deficits. However, there are reasonably consistent findings of affecting reasoning and perceptual-spatial functions (3, 25). Inter-sensory integration and the acquisition of Piagetian milestones are also found to be delayed in younger children (3).

*Activity and behaviour:* Severely malnourished children demonstrate marked behavioural abnormalities in the acute stage. They are more apathetic, less active, fussy and less happy and explore their environment less than better-nourished children or the children who are ill with other diseases (3, 25, 30). Malnourished children were observed to play with toys only for shorter periods and stay closer to their mothers and to be more unresponsive when given a task. In addition, they reported had less emotional control and be less active and more obedient (3).

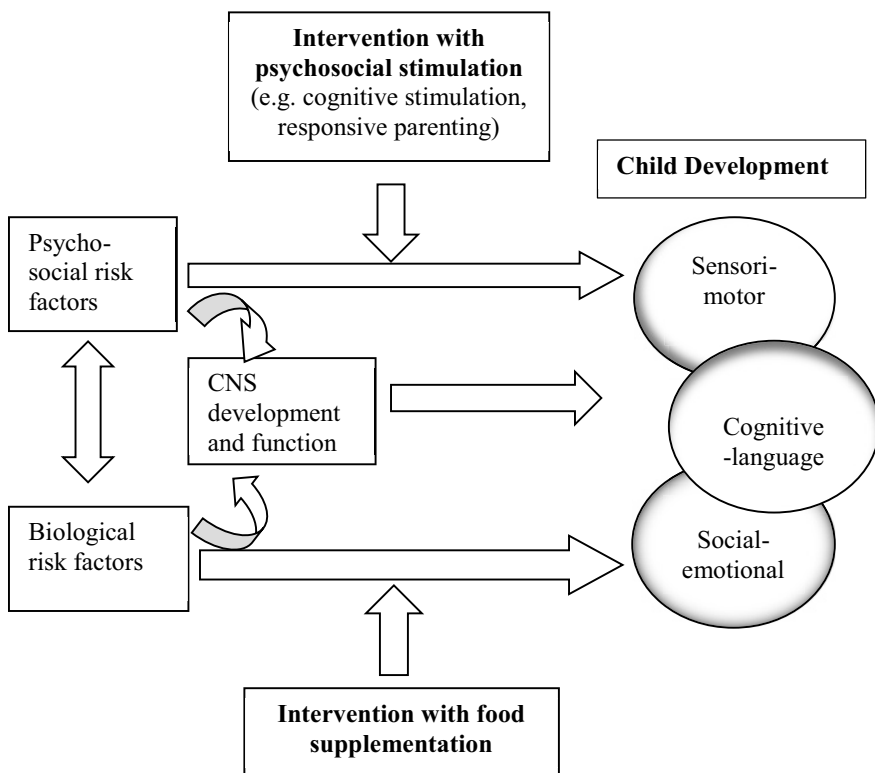
*School performance:* Stunted children from low-income countries often have poor academic abilities (31-33). Evidence from Jamaica and Brazil has shown that stunted children had significantly lower scores in arithmetic (34), spelling, word reading and reading comprehension than the non-stunted children (30).

## **Psychosocial risk factors**

Adequate nutrition is not enough to promote optimal child development. Research from high-income countries has identified three aspects of parenting that are consistently related to young children's cognitive and social-emotional competence: cognitive stimulation, caregiver sensitivity and responsiveness to the child, and caregiver affect i.e. emotional warmth or rejection of child (4) (Figure 3). These child-rearing dimensions affect children from high- and low-income countries in similar ways. The mother may have poor nutrition because of poverty, low educational attainment, low wages, and this may affect her opportunities to an optimal parenting.

There is considerable evidence that mothers or primary caregivers of malnourished children living in a poor socioeconomic environment may be less sensitive to the child's needs, less emotionally responsive, provide less

stimulation in the home and have poorer quality of maternal-child interaction than mothers of adequately or well-nourished children (35-37).



*Figure 3.* Risk factors and domains of child development (modified from Walker et al. 2007) (4)

Maternal depression and depressive symptoms are other important risk factors for impaired child development. Infants of depressed mothers in low-income countries are more likely to have lower birth weight, higher rates of diarrhoea, more frequent infectious illnesses and hospital admissions and are less likely to be immunized (38-42). Mothers with depressive disorders are often intrusive or withdrawn in their interactions, rather than sensitive and responsive (43), resulting in language and cognitive problems, insecure attachment, social interactive difficulties, and behavioural problems (37, 38). This in turn can have consequences for long-term emotional and psychological health of the child (44, 45).

## Psychosocial stimulation

A strong maternal-infant (or caregiver-infant) bond provided through psychosocial stimulation (PS) is essential for positive child development. PS refers to the extent the environment provides physical stimulation through sensory input (e.g., visual, auditory, tactile), as well as emotional stimulation provided through an affectionate caregiver-child bond (42).

## Child play

Play is a means by which humans and animals explore a variety of experiences in different situations for diverse purposes (46). By age, play promotes the child's development in both cognitive, physical, language, social and emotional dimensions when playing with others. There are different types of play, which are categorised or depend largely on the age of the children, who are involved. These types are; sensory pleasure, play with motion, rough and tumble, language play, dramatic and modelling, games, rituals and competitive play (24).

## Intervention studies in low-income countries

In the past decades, several studies have analysed the effectiveness of interventions to promote growth and cognitive development under poor socio-economic and environmental conditions. Moreover, when these interventions are implemented simultaneously, there is even greater impact. Research shows that parental feeding behaviours of practicing 'responsive feeding' can influence the quality and quantity of children's dietary intake and that parental psychosocial support, such as providing learning materials or conversing with young children, also significantly affect development (47).

## Evidence from food supplementation studies

Several studies have examined the effect of food supplementation during pregnancy or after child birth on physical growth and psychological development of children (47).

Evidence of both short and long-term effects of supplementation comes from follow-up studies of the supplementation trials in Guatemala. The participants were provided either with a high-calorie, high-protein supplement (Atole) (11.5 g of protein; 163 kcal) or a low-calorie supplement (Fresco) (59 kcal). Rivera and colleagues (48) reported that children from villages that received a high protein-energy supplement (Atole) from birth to

3 years of age were taller and heavier both in childhood and adolescence than children from villages that received a low-energy, no protein supplement (Fresco). Another study reported that children aged 6–24 months, who were moderately wasted and consumed more than 10 percent of the daily recommended intake of energy from supplements recovered over a three month period, and much of this recovery was attributable to the supplement. Children who had received a low-energy supplement were significantly less likely to recover (49).

Pollitt et al. (50) have compared the differential effects of exposure in childhood (0-7 years) on performance on a battery of psychoeducational and information-processing tests in adolescence and young adulthood (11-24 years). The participants who received a high-energy protein supplement (prenatally and in early childhood) performed better on numerical knowledge, functional knowledge, vocabulary and reading achievement in adolescence than those who received a low-energy, no protein supplement.

In Indonesia, 90 days of supplementary feeding provided 10.66 kJ (400 kcal) energy and 5 g protein/day to the children aged 6–20 months and found significant improvements in children's weight-for-age and motor development but no statistically detectable effect on length or mental development. The author concluded that the duration of the intervention was too short to have an effect on linear growth (51).

## Effect of psychosocial stimulation

Over the past few decades many studies have investigated the effect of psychosocial stimulation on development of undernourished children in low-income countries and all found significant short and long-term effects of such intervention (52).

In Jamaica, a group of severely malnourished children aged 6 to 24 months received structured play activities daily while in the hospital and then visited weekly at home for two years and fortnightly for a third year. The control group was severely malnourished children, who were admitted to the same hospital the previous year and received standard care without play intervention, and a group of adequately nourished children who had been hospitalized for other reasons. Six months after start of intervention, the intervened children had significantly higher Developmental Quotients (DQs) than the malnourished control children, who did not receive intervention but still lagged behind the adequately nourished group (53). After 2 years, children who had received intervention showed marked improvements in cognitive development. They had higher scores in every subscale of DQ than the control children and in two subscales (hearing and speech, and performance subscales) than adequately nourished children. Both groups of

malnourished children remained behind the adequately nourished children in nutritional status and locomotor development (54). The effect of the intervention on cognitive development sustained 3 years after cessation of the intervention (55) and at 7, 8, 9, and 14 years after leaving the hospital (56). A rural study in Bangladesh has reported improvement in mental development and behaviour of moderately and severely underweight children receiving psychosocial stimulation provide structured play sessions at home over a year (57).

There is substantial evidence from low-income countries that early interventions that support caregivers and provide developmentally appropriate learning opportunities for young children lead to significant effects on multiple outcomes in later life, e.g. higher cognition and school achievement, less grade retention, less crime and less violent behaviour, lower rates of teenage pregnancy and increased earnings and less dependence on welfare in adulthood (52).

### Combined nutrition and stimulation interventions

Home-based interventions with food supplementation and psychosocial stimulation have resulted in concurrent (58, 59) and long-term cognitive benefits (60-65) to malnourished children in low-income countries.

In Bogota (58), the independent and combined effects of food supplementation and psychosocial stimulation (maternal education) on physical growth and development were examined. The intervention continued from the prenatal period until the age of 3 years and the nutrition component consisted of a package of foods delivered to the home as well as vitamin and micronutrient supplements. Children from 3-12 months were supplemented with whole powder milk and commercially high protein vegetable mixture (Durya), and children over 12 months including all family members were supplemented with enriched bread, dried skimmed milk and cooking oil. The results of the study revealed significantly beneficial effects of full supplementation on children's development for scores on locomotor, personal-social, speech and language, eye-hand coordination and performance subscales and general quotient and a small benefit from stimulation (maternal education) for the speech and language subset only. No significant effect was found at 3 years of age from supplementation of the mothers in pregnancy and the children up to 6 months of age (early supplementation) (58). At 3 years of age, supplementation significantly increased height and weight, by 2.6 cm and 642 grams, respectively, compared with the controls. Three years after intervention (age 6), the effect of supplementation sustained and the attained height and weight differed by

2.3 cm and 536 grams. At this point, however, children who had been visited at home were also larger than controls, by 1.7 cm and 448 grams (66).

Malnourished children can make a remarkable improvement in cognitive development with trans-cultural adoption (3). However, it is difficult to replicate this level of intervention. In early studies, severely malnourished children who stayed in hospital for long periods where they received play activities regularly by professionals showed only transient developmental benefits (3, 56). Possible reasons to this lack of effect were that long hospital stays that may have detrimental effects on children's emotional development, and mothers were not involved in the stimulation.

## Rationale for the studies of the thesis

The current management of severely malnourished children in Bangladesh mainly focus on food and micronutrient supplementation. In spite of recommendations by the World Health Organisation (7), psychosocial stimulation has generally not been incorporated into the management of malnourished children. There is evidence that combined stimulation and nutrition programmes that emphasize appropriate feeding practices (food and micronutrient supplementation) and responsive parenting (e.g. proactive stimulation and appropriate responses) are more effective in promoting growth and positive child development than nutritional programmes without a psychosocial component (42).

In Bangladesh, there are few facilities that manage severely malnourished children. Despite successful management of malnourished children at Dhaka Hospital of ICDDR,B, follow-up attendance is not satisfactory and home- or community-based management of these severely malnourished children is potentially more feasible and less expensive.

We aimed to integrate a low-cost programme of psychosocial stimulation with or without food supplementation into the management of severely malnourished children both in NRU at the hospital and at community clinics, which would be sustained by mothers at home, and to assess the effects on their children's growth and development. Such a program, if successful, could be scaled-up and integrated into Government programs.

# Aims of the thesis

The overall aim of these studies was to evaluate the effects of hospital and community-based interventions with food supplementation and psychosocial stimulation on growth and development of severely malnourished children in Bangladesh.

## Specific objectives

1. To determine the effect of hospital- and home-based psychosocial stimulation on growth and development of severely malnourished children in a nutrition rehabilitation unit (Paper I)
2. To evaluate the effect of a clinic-based intervention with food supplementation and psychosocial stimulation on growth and development of severely malnourished children (Paper II)
3. To evaluate the effect of a clinic-based intervention providing psychosocial stimulation and food supplements to severely malnourished children on the quality of home environment and child-rearing practices (Paper III).
4. To assess the effect of a clinic-based intervention providing psychosocial stimulation and food supplements to severely malnourished children on the level of maternal depressive symptoms (Paper IV).

# Methods

## Study site

The studies were conducted at Dhaka Hospital of International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B), an international health research organisation located in Dhaka, Bangladesh. The ICDDR,B Hospital provides treatment for around 100,000 patients per year, ~60% of whom are under-5 children. Each year ~3000 severely underweight (WAZ <-3) under-5 children are admitted to the hospital's nutrition unit (67). These children are managed according to a standardised treatment protocol (68), based on WHO recommendations (7). An acutely ill child with severe malnutrition undergoes the acute phase treatment that lasts on an average of 3-5 days. Upon recovery from the acute illness such as diarrhoea or pneumonia, the most severely malnourished children (WAZ <-4 and/or WLZ <-3SD with or without oedema) are treated in NRU of ICDDR,B until they have achieved a WLZ >-3SD, or WAZ >-4SD, are oedema free, and have a good general condition. This usually takes 2-3 weeks. Children having relatively lesser degree of malnutrition (WAZ >-4 and <-3 SD, WLZ >-3SD and no oedema) receive initial management and are subsequently managed as outpatients at the HNFU, where they receive dietary counselling, micronutrient supplementation and growth monitoring for about 6-8 months.

## Study design and subjects

### Hospital-based study (Paper I)

The study was conducted from October 2002 to June 2004 at NRU of Dhaka Hospital of the ICDDR,B. The study participants were the severely malnourished children of 6–24 months of age, admitted at NRU, living in an area accessible from the hospital. There were two groups of children, one enrolled before and one after the establishment of a psychosocial stimulation programme. In the first phase, 186 children were admitted to the NRU, but only 56 (30%) fulfilled the enrolment criteria and 13 of these left hospital early leaving 43 enrolled controls. A total of 244 children were admitted to the NRU during the second phase; 77 children (32%) fulfilled the enrolment criteria and 23 of these left hospital early leaving 54 enrolled in the new



intervention. Reasons for exclusion from the study were mainly age (<24 months), living far from the hospital or refusal to participate and the distribution of these reasons were similar between the two groups. We conducted a study with a before-and-after design, where the group enrolled initially served as control group, followed by the intervention group.

### Community-based study (Paper II-IV)

The study was conducted from June 2005 to June 2007 at the Dhaka Hospital of the ICDDR,B and 4 community clinics in 4 outlying districts (thanas) of the city (Demra, Gulshan, Sabujbagh, and Mirpur thanas), where ~70% of the severely malnourished patients admitted to the Dhaka Hospital reside. These communities are located 8 to 15 km from the hospital, and travel times to the hospital generally range from 30 to 60 minutes, using public transportation, at a cost of 35 to 70 taka (US \$0.50– \$1.00) per round trip. As part of the current project, CNFUs were established within existing community clinics in each of the four above-named thanas. A female health worker (HW), trained by the research team was assigned to each CNFU, where she conducted a follow-up clinic from 9 AM to 4 PM 5 days per week.

The study participants were the hospitalised children without acute infections, who were admitted at the Dhaka hospital of ICDDR,B, aged 6-24 months, of either sex, with a WAZ <-3SD, residing in one of the above mentioned four selected slums of Dhaka city (Table 3).

Upon discharge from the hospital and after obtaining parental consent, the eligible children were randomly assigned to one of five groups as follows: psychosocial stimulation (PS), food supplementation (FS), PS along with FS (PS+FS), clinic control (CC): fortnightly i.e. every second week follow-up care at CNFU and received growth monitoring, health education, micronutrient supplementation but no additional food supplementation or psychosocial stimulation; and, hospital-control (CH): fortnightly follow-up care at HNFU of ICDDR,B and received the same management as CH group. A researcher not involved in the study performed the randomisation.

Table 3. Designs, participants and outcomes in four papers of the thesis

	Study design	Participants	Outcomes
Paper I	Time-lagged intervention (before-and-after design)	Severely malnourished children, aged 6–24 months, admitted to the Nutrition Rehabilitation Unit of Dhaka Hospital of ICDDR,B	Effect of psychosocial stimulation on growth and development of the children
Paper II	Randomised controlled trial	Severely under-weight (WAZ<-3) hospitalised children without acute infection at ICDDR,B, aged 6-24 months were randomly allocated on discharge to five groups: PS, FS, PS+FS, clinic control (CC) and hospital control (CH).	Effect of food and psychosocial stimulation on growth and development of children
Paper III	Same	Same	Effect of intervention on the quality of home environment (HOME) and child rearing practices of mother
Paper IV	Same	Same	Effect of intervention on the level of maternal depressive symptoms

Abbreviations: PS=psychosocial stimulation, FS=food supplementation, HOME= Home Observation for Measurement of the Environment

## Follow-up

In the hospital-based study, on leaving the NRU both groups were asked to attend the HNFU seven times over the next 6 months (two visits in the first month and then monthly). At the HNFU, both groups received health and nutrition education. In addition, the intervened group received home visits: two in the first month, three in each of the following 2 months and one in each of the last 3 months. Thus, the intervened children participated in a total of 18 supervised play sessions either in the HNFU or at home, whereas the control group had seven routine HNFU visits and no home visits.

In the community-based study, for the first three months, the mothers/caregivers and their children were followed-up fortnightly at the assigned CNFU or hospital nutrition follow-up unit (HNFU). For the final three months, the follow-ups were monthly. At the end of the third and the

sixth months, mothers/ caregivers were asked to bring their children to HNFU for anthropometric and developmental assessments.

## Interventions

### Psychosocial stimulation (PS)

The PS comprised of play sessions and parental education for one hour using a semi-structured curriculum (57) conducted by trained female health workers (play leaders) with 8-10 years of schooling.

In the hospital-based study, mothers and children of the intervention group participated daily in a half-hour group session (Figure 4) and a half-hour individual play session in the hospital. After leaving the hospital, the intervention group was visited at home by the play leaders. During the home visits, play leaders demonstrated developmentally appropriate play activities and left toys with the child that were replaced at each visit. A supervisor observed the visits regularly.



*Figure 4. Group session with the mothers in the hospital-based study  
Photo: Baitun Nahar*

In the community-based study, mothers and children of PS and PS+FS group received parenting education and structured play session (Figure 5) for one hour at community-clinics for six months. The parenting sessions were conducted with one mother/child pair, but occasionally if more than one pair attended at the same time two or three mother/child pairs were combined.

The mothers were encouraged to play with their children at home between the visits.



*Figure 5. Play session at community clinic. Photo: Baitun Nahar*

Play sessions were carried out with every child and mother using low-cost, culturally appropriate homemade toys (Figure 6). Mothers were fully engaged in the activities. They were encouraged to chat with their children, to give positive feedback and continue the activities between sessions.

During the parenting sessions, the play leaders discussed early child development and the importance of being responsive to their infants to play, chat, sing, and to show love and praise the child. They demonstrated how to chat and incorporate play into daily activities such as feeding and bathing, in order to promote optimal child development. The mothers were discouraged from using physical punishment. The sessions were participatory and mothers were encouraged to share their views and suggestions. We also aimed to improve the self-esteem of mothers through praising them, listening to them and assisting them in getting new skills.



*Figure 6. Home-made toys used in the play sessions. Photo: Baitun Nahar*

### Food supplementation (FS)

In the community-based study, the children assigned to FS and PS+FS groups received cereal-based food packets (Figure 7) when leaving the

hospital and at each of the follow-up visits at CNFU for the first three months. One and two packets/day was offered to children aged 6–11 and 12–24 months respectively. The mothers/caregivers were taught about preparation of the packets. Food packets were also provided to other under-five sibling(s) to minimize food sharing. Each of the packets (known as ‘*Pushti Packet*’ in Bangladesh) contained 20 g toasted rice powder, 10 g toasted lentil powder, 5 g molasses, and 3 g soybean oil (total energy per packet ~150 kcal, with 11% of energy from protein and 20% of energy from fat). Mothers were asked to mix each packet of the precooked foods with 30mL (6 tea spoonful’s) plain water, which resulted in a porridge-like product with a final prepared energy density of ~2.2 kcal/g (69).



*Figure 7. Food supplementation packet distributed in community-based study.  
Photo: Baitun Nahar*

All children received routine medical care: growth monitoring, health education for the mothers, micronutrient supplementation with multivitamin drops (containing vitamin A, vitamin D, thiamine, riboflavin, pyridoxine, nicotinamide, calcium and ascorbic acid), zinc dispersible tablets, and iron and folic acid as ferrous fumarate tablet (during weeks 2 to 12). All study children were immunised according to the Expanded Programme of Immunisation guideline (70) and children older than one year were dewormed with a single dose of albendazole if they had not received this treatment in the previous six months.

## Assessment of outcome

*Development:* The children's mental and psychomotor development was assessed with the revised version of Bayley Scales of Infant Development (BSID-II) (71) at HNFU by a trained tester, blinded to the child's treatment group. The BSID-II includes Mental Development Index (MDI) and Psychomotor Development Index (PDI).

*Behaviour:* The children's behaviour during the tests was rated on five 9-point scales. The scales expressed response to the examiner (with ratings ranging from avoiding =1 to friendly and inviting =9) in the initial 10 min, activity level (motor activity, very still=1 to overactive=9), emotional tone (unhappy for long periods =1 to radiates happiness =9), vocalization (very quiet=1 to constant vocalization=9) and cooperation with the tester (resisting all suggestions=1 to always complying=9) throughout the assessment (Paper 1).

*Anthropometry:* The children's weight, length/height and head circumference were measured at each test session by a research assistant at HNFU using standard procedures (72). Mother's weight and height were recorded to calculate their body mass index (BMI).

*Maternal depressive symptoms:* Maternal depressive symptoms were assessed using a questionnaire based on the modified version of Centre for Epidemiologic Studies-Depression Scale (CES-D) (73).

*Stimulation in the home:* Quality of stimulation at home was measured using a modified version of Home Observation for Measurement of the Environment (HOME) inventory (74, 75).

*Child-rearing practices:* Trained research assistants blinded to treatment groups assessed mother's child-rearing practices using a questionnaire (57, 76).

*Socio-economic background:* Information on the families' wealth, standard of housing, family structure and parental characteristics was collected by a research assistant.

## Statistical analyses

Data were analysed using SPSS version 18 (SPSS Inc, Chicago). Differences among the groups in baseline characteristics were examined using ANOVA

for continuous variables and  $\chi^2$  test for dichotomous variables. A *p*-value less than 0.05 was considered statistically significant.

In the hospital-based study, mental and psychomotor raw score of the children was very low in comparison to the children of the community-based study. About 23% and 54% children scored below 50 in mental and psychomotor development respectively, the lowest level at which MDI and PDI could be calculated. Therefore, mental (MRS) and motor (PRS) raw scores were used instead of the indices (MDI and PDI) in the analyses **(Paper I)**.

In the hospital-based study, treatment effect was examined in a series of hierarchical multiple regression treatment analyses of each outcome variable controlling for all the covariates related to the outcome. The final developmental scores (MRS, PRS and behaviour ratings) or final anthropometry were the dependent variables. Age and the relevant initial scores were entered in the first step, all background variables associated with the outcome variables were offered in the second step, and group (control =0, intervention =1) was entered in the third step. Initial WAZ and LAZ were highly correlated ( $r=0.82$ ) and both were correlated with PRS therefore in the regression on PRS we only entered WAZ which was highly correlated. We calculated the effect size for any significant treatment effect by dividing the regression coefficient for group by the standard deviation of the dependent variable.

In the community-based study a longitudinal approach (GLM repeated measures) was used including assessments at baseline, 3 and 6 months, controlling for covariates for intention to treat analyses of five randomised groups **(Paper II)**. Analysis of covariance (ANCOVA) was used to control for baseline HOME and child rearing practices scores. Adjustment was made for age at final test and the factors differing between the groups on enrolment and between lost and analysed children i.e. maternal education and depression score at baseline and father's occupation **(Paper III and Paper IV)**.

## Ethical considerations

Both studies were approved by the research and ethical review committees of ICDDR,B. Written informed consent was obtained from the caregivers on enrolment.

In the hospital-based study, we conducted a time-lagged controlled study with a control group enrolled initially, followed by an intervention group. Both groups (control and intervention) received routine nutritional and



health care in hospital, whereas the intervention group also participated in stimulation sessions.

In the community-based study, the children were enrolled at the time of discharge after recovering from acute illness and randomly assigned either to intervention groups receiving psychosocial stimulation with or without food supplementation or to the control groups who received routine medical care, growth monitoring, micronutrient supplementation but no additional food supplementation or psychosocial stimulation. During each follow-up visit, mothers irrespective of randomised groups were counselled by the health workers on the importance of breast-feeding, use of safe water and hygienic practices, and preparation of nutritious, low-cost diets using locally available food items.

During the inpatient period, all the children received the same services and their mothers received hands-on training on preparation of energy-dense, local recipes of rice, lentils, and vegetable oil (khichuri, 1.4 kcal/g; and halwa, 2.5 kcal/g) that provide 200 to 250 kcal/kg/day. The mothers were also encouraged to continue breast feeding.

Enrolment into the study did not pose any added risk to a child. As psychosocial stimulation does not involve any invasive procedure, it is devoid of adverse effects to our knowledge. The parents had the rights to decide for or against participation of their children in the study, and also the rights to withdraw their children from the study at any time. Written, informed consent of the parents/guardian of the children were taken before enrollment into the study. Children not participating in the study as well as those prematurely withdrawn from the study received the standard treatment of the Dhaka Hospital of ICDDR,B.

# Results

## Hospital-based study (Paper I)

### Participation

In the hospital-based study, more of the intervention group than the control group was lost to follow-up (39% vs. 14%,  $p=0.006$ ).

### General characteristics of study participants

The mean age (standard deviation-SD) of the children who participated in the hospital-based study (**Paper I**) was 12.4 (4.6) months and boys comprised 54% of the population. The children were extremely malnourished with a mean (SD) of WAZ -4.4 SD and 46% had oedema. The mean (SD) of the mother's age in years was 27.6 (9.4) and body mass index (BMI) was 19.8 (2.6). Sixty one percent of mothers had not attended any school, 39% had schooling more than 5 years and most of them were housewives.

### Treatment effects

In the hospital-based study, children who received the stimulation intervention had significantly higher scores in mental ( $p<0.001$ ) (Figure 8) and motor development ( $p=0.047$ ) (Figure 9) after six months of intervention) but there were no significant group differences in the behaviour ratings. The effect size was 0.52SD in mental development and 0.37SD in motor development.

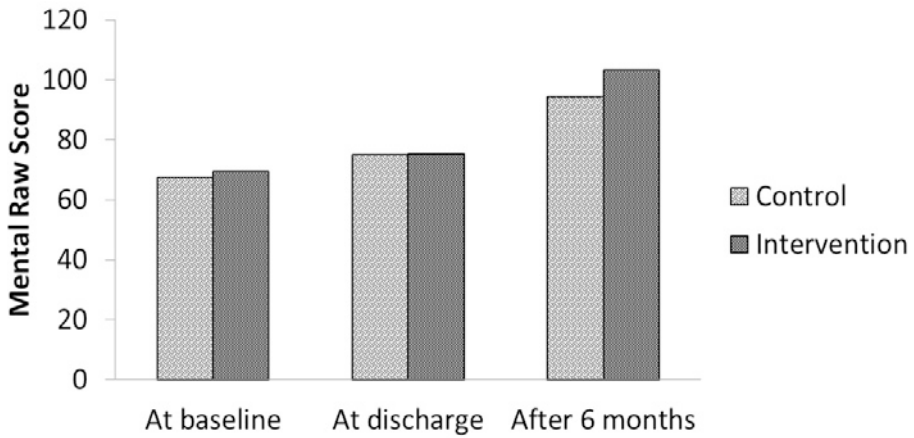


Figure 8. Mental development score of the children at different time point in hospital-based study

Treatment also had a significant effect on growth in WAZ (effect size 0.39 standard score ( $p=0.03$ )). Initial scores were also significant and maternal employment was negatively associated with WAZ. In a further series of regressions of MRS and PRS we used the same models but also entered the final WAZ, and the treatment effect remained significant and was only slightly reduced.

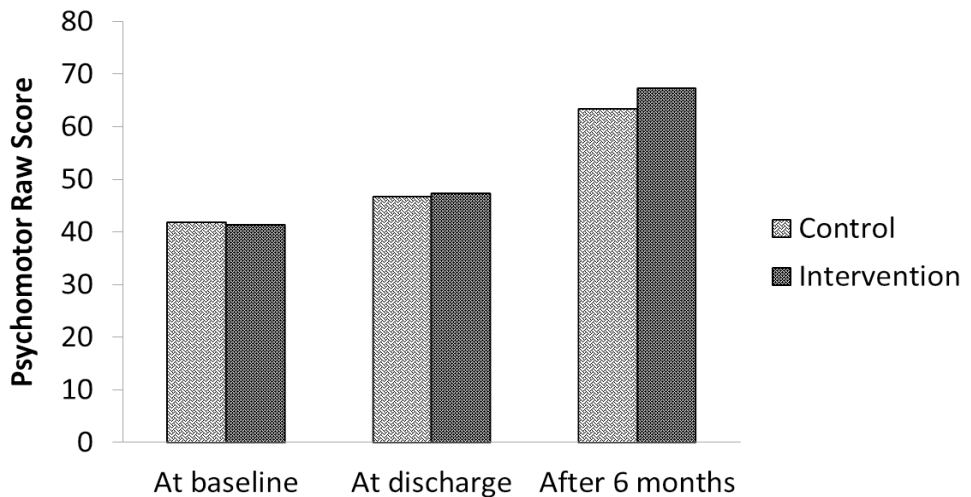


Figure 9. Psychomotor development score of the children at different time point in hospital-based study

## Community-based study (Paper II-IV)

### Participation

In the community-based study, a total of 185 children (36%) were lost before the final assessment. There was significantly less attrition in children receiving food supplementation compared to other groups ( $p=0.029$ ). Children of mothers with higher education were more frequently lost in PS+FS group ( $p=0.003$ ) and children with lower educated mothers were more frequently lost in the CH group (0.057). In the PS group there was a significantly higher loss to follow-up of children of fathers with unstable jobs ( $p=0.053$ ). Children of less depressed mothers were more frequently lost in the PS group ( $p=0.004$ ).

### General characteristics of study participants

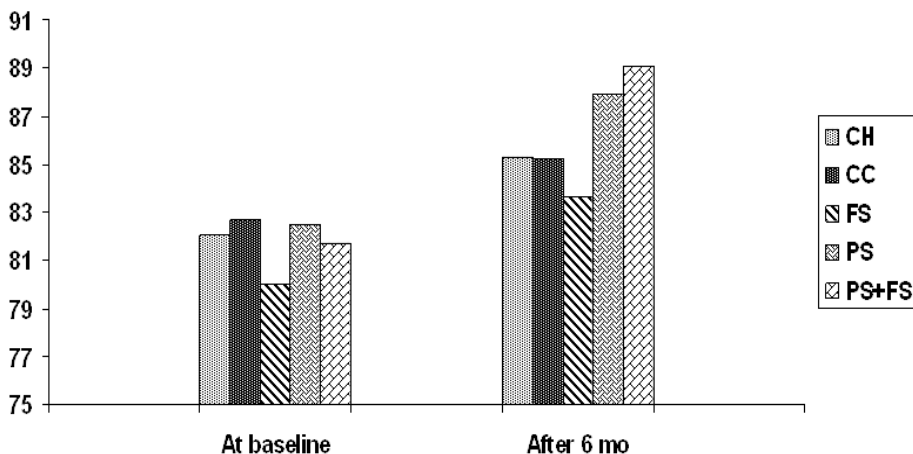
The mean age (SD) of the children who participated in the community-based study (**Paper II-IV**) was 12.7 (4.1) months. Nutritional and developmental status of the children was very low: mean (SD) of WAZ -3.9 (0.6), LAZ -3.5 (1.0), MDI 69.7 (13.5) and PDI 61.5 (13.7). The mean (SD) of the mother's age in years was 23.9 (5.6) and among them 20% were teenage mothers. Mean Body Mass Index (BMI) of the mothers was 19.6 (3.0) and 47% had BMI less than 18.5 (indicating chronic energy deficiency). The mothers were less educated with 37% without any schooling. The mean number of years (SD) of schooling was 3.6 (3.5) and they were mostly housewives (82%). Fifty percent of the fathers did not have any stable job. Eighty-seven percent of the families had total family income per month less than one US dollar. The overall family income [median (inter-quartile range)] was 4000 (3000-6000) BDT per month (1 US dollar=68 BDT during the study period).

### Treatment effects

There was a significant effect of stimulation after six months of intervention on children's mental development index (group\*session interaction  $p=0.037$ , effect size=0.37 SD) and weight-for-age (group\*session interaction  $p=0.02$ , effect size=0.26 SD). There was no effect on motor development or linear growth.

The PS+FS and PS groups had higher scores in total Home Observation for Measurement of the Environment (HOME) inventory, in two HOME subscales (maternal involvement and play materials), and in child rearing practices scores.

HOME score: After six months of intervention, the PS+FS group had 4.0 points differences in total HOME score compared with CH, 4.8 points compared with CC and 4.5 points compared with FS ( $p<0.001$  for all). The PS group had 2.4 points differences compared with CH ( $p=0.035$ ), 3.3 points compared with CC ( $p=0.004$ ), and 2.9 points compared with FS ( $p=0.006$ ). The above effect size varied from 0.66 to 0.33 SD (Figure 10).



CH=hospital-control, CC=clinic-control, FS=food supplementation, PS=psychosocial stimulation, PS+FS=both food supplementation and psychosocial stimulation

Figure 10. Home score at baseline and after 6 months of intervention in community-based study

*Maternal involvement:* The PS+FS group improved by 2.2 points in ‘Maternal involvement’ compared with CH, 2.1 points compared with CC and 2.2 points compared with FS ( $p<0.001$  for all). The PS group improved by 1.6 points compared with CH ( $p=0.001$ ), 1.5 points compared with CC ( $p=0.001$ ), and 1.6 points higher compared with FS ( $p<0.001$ ). The effect size varied from 0.8 to 0.55 SD (Table 4).

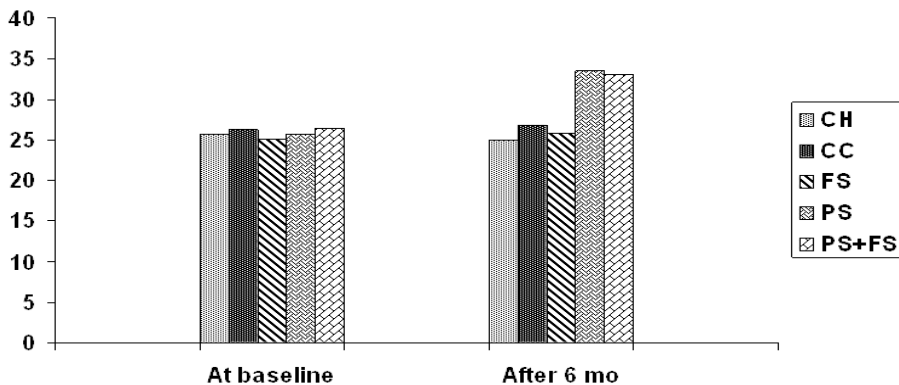
*Play materials:* The PS+FS group differed by 1.2 points in ‘Play materials’ compared with CH ( $p=0.007$ ), 1.6 points compared with CC ( $p=0.001$ ) and 1.5 points compared with FS ( $p<0.001$ ). The PS group improved 1.2 points more compared with CC ( $p=0.009$ ) and 1.2 points more compared with FS ( $p=0.007$ ). The effect size varied from 0.46 to 0.6 SD. There was no significant difference between PS and CH group (Table 4).

Table 4. Maternal involvement and Play materials scores at baseline and after 6 months of intervention by groups

	Maternal involvement		Play materials	
	Mean (SD)		Mean (SD)	
	At baseline	After 6 months	At baseline	After 6 months
PS+FS	15.5 (2.6)	18.4 (1.8)	15.0 (2.1)	16.8 (2.8)
PS	15.1 (2.3)	17.7 (2.1)	15.0 (2.4)	16.8 (2.8)
FS	14.9 (2.1)	16.0 (2.8)	14.3 (2.1)	15.3 (2.5)
CC	15.6 (2.7)	16.5 (2.9)	15.0 (2.3)	15.6 (2.4)
CH	15.4 (2.6)	16.2 (2.7)	15.0 (2.3)	15.9 (2.4)

CH=hospital-control, CC=clinic-control, FS=food supplementation, PS=psychosocial stimulation, PS+FS=both food supplementation and psychosocial stimulation

Child-rearing practices: Child-rearing practice scores of the PS+FS group improved 7.7, 6.4 and 6.6 points and the PS group improved 8.5, 7.2 and 7.4 points more than CH, CC and FS, respectively ( $p<0.001$  for all). The effect size varied from 1.5 to 1.1 SD (Figure 11).



CH=hospital-control, CC=clinic-control, FS=food supplementation, PS=psychosocial stimulation, PS+FS=both food supplementation and psychosocial stimulation

Figure 11. Child-rearing practices scores at baseline and after 6 months of intervention in community-based study

There was no effect on the level of maternal depressive symptoms after six months of intervention after adjusting for baseline score and covariates e.g. maternal education, father's occupation and age of the child at final test session.

## Discussion

The studies of this thesis were conducted on severely malnourished Bangladeshi children, living in urban slums and who were admitted to Dhaka hospital of ICDDR,B, and participated in a clinic- and household-based intervention programme providing psychosocial stimulation with or without food supplements. The analyses focused on the effect of intervention on growth and development of the children (**Paper I and II**), and on improvement of the home environment, mother's child-rearing practices (**Paper III**) and level of depressive symptoms (**Paper IV**). The results of the studies demonstrated that psychosocial stimulation with or without food supplementation have significant effects on children's growth and development, quality of home environment and child-rearing practices but not on maternal depressive symptoms.

The thesis describes the findings of two main studies; a nonrandomised hospital-based study (**Paper I**) and a randomised community-based study (**Paper II-IV**). In the hospital-based study, the intervention group differed by 0.52 SD in Mental Raw Score. This effect is substantial and probably of clinical importance. The effect was less in Psychomotor Raw Score (effect size 0.37 SD). In the community-based trial there was a significant treatment effect of stimulation on Mental Development Index (effect size 0.37 SD) (**Paper II**). In both studies the children showed significant differences in growth in weight but we cannot be certain about the functional importance. The community-based intervention was also associated with a marked improvement in total HOME score (depending on the comparison group, effect sizes varied from 0.66 to 0.33 SD); two HOME subscales: maternal involvement (effect sizes: 0.8 to 0.55 SD) and play materials (effect sizes: 0.46 to 0.6 SD), and child-rearing practices scores (effect size: 1.5 to 1.1 SD) (**Paper III**). The intervention failed to get a treatment effect on maternal depressive symptoms (**Paper IV**).

## Methodological considerations

### Strengths and limitations

There was considerable attrition of the children in both the hospital and community-based studies. More of the intervention than the control group was lost from the hospital-based study. Receiving food packets may have been attractive for these poor families, hence less losses in FS groups in the community-based study. More frequently children with more educated mothers were lost in PS+FS group and with lower educated mother lost in CH group. Both losses may have contributed to decrease the size of the effect of intervention. Children of fathers with unstable jobs were lost to a larger extent in PS group but there was no association between fathers' occupation and children's outcome. We employed a conservative approach controlling for the group differences in background variables. Moreover, in the community-based study, the protocol was changed by increasing the frequency of visits for 35% of the sample although it was not associated with the overall outcomes. Differing the length of this intervention i.e. food supplementation for 3 months and stimulation for six months is a fault of the design and in a true sense the 6 month evaluation was concurrent for the stimulation group and follow-up for the supplementation group.

In the hospital-based study we followed a before-and-after (intervention) design. A randomised trial was not possible because it was considered unethical to withhold the intervention from some children and not others in the same hospital ward. In the community-based study, the participants were randomly allocated to different packages of treatment. The testers and the interviewers in both studies were blind to the treatment groups.

All the tools used for data collection were piloted and field-tested at the beginning of the study. The test-retest reliability and inter-observer reliability between trainer and tester was good and acceptable. Data collection was checked and rechecked for missing values and/or inconsistencies. The PLs were efficiently trained to provide the intervention. They met with the supervisor weekly to review the visits and the children's progress to ensure that the activities were at an appropriate level. The supervisor accompanied the PLs on monthly visits. The research assistants were also trained for interviews and other methods of data collection. The research team made unannounced visits to the field to monitor activities. In addition, regular meetings with the research team and refresher training were arranged.

In the hospital-based study, many children (23 and 54% in MDI and PDI, respectively) scored below 50, the lowest level at which MDI and PDI could



be calculated. We therefore used the mental (MRS) and motor (PRS) raw scores adjusted for age instead of the MDI and PDI in the analyses (77). To deal with the confounding issues we included the relevant important covariates in the data analyses that were found to be associated with the outcome of interest.

## Study setting

In the present thesis, both the studies were conducted among the population living in the urban slum, which is a heavily populated urban area, characterized by poverty and substandard housing. In Dhaka city the number of slum communities are about 4,966 (78). The slum dwellers are the most vulnerable, floating and disadvantaged group. They often move from one place to another for economic reasons. Therefore conducting long-term research and follow-up studies in the slum population is a big challenge.

In both of our studies, the reason for extensive loss to follow-up was mostly migration out of the residential area. They all moved to other places without leaving any address. In the earlier intervention study conducted in rural Bangladesh, loss to follow-up of the participants was only 4.5% (57) compared to 36% in our community-based study.

## Generalization

The findings from this thesis are relevant for slum areas in Bangladesh. The socio-demographic characteristics of the participants are similar to many other urban slums in the country. The research question of this thesis have also been investigated previously in Bangladesh (57) and many low and middle-income countries (52).

The findings of this thesis may also be relevant for similar areas in South Asia. There are strong justifications for establishing community-based management of malnourished children. In this thesis, we evaluated one community-based approach of delivering food and psychosocial stimulation through existing primary health care services in the local urban communities. But in rural communities, the intervention programme should be modified when the structure of home environment is different and more support could be given to the child. We hired low-paid health workers to run the intervention program but it should also be possible to train staff members who already run the primary health clinics. More community-based approaches in different settings are required to identify feasible intervention programmes that could be scaled-up in Bangladesh and elsewhere.

## Relation to other research

### Effect on child development

In the hospital-based study, the intervention group differed by 0.52 of a standard score in MRS. This effect is substantial and probably of functional importance. In the community-based study, the effect size was moderate in MDI (0.37 SD). Considering the relatively low intensity and short duration of the intervention, the results are encouraging. It should be noted, however, that the overall level of development scores was very low. In a previous study with undernourished community children in Bangladesh, the effect size of MDI was one-third of a standard score (57). Larger effects (effect size 0.8 SD) were found on mental development in several Jamaican studies with undernourished children (79), low birth weight infants (effect size 0.38 SD in performance IQ and 0.53 SD in visual spatial memory) (80, 81) and with moderately stunted children (effect size 0.4 to 0.6 SD) (63, 64). But all of these studies involved home-visiting for as long as 1-2 years and the children were less malnourished compared to our study. The children differed less in motor development (effect size 0.37 SD) in the hospital-based study but intervention had no effect on PDI in the community-based study. In the previous Bangladeshi study (57), stimulation in undernourished children had effect mental more than motor development.

### Psychosocial stimulation with or without food supplementation

Evidence shows that early stimulation with or without nutritional supplementation either in hospital or community settings, has both short (53, 54, 58, 59, 82) and long-term effects on children's growth, development and psychosocial functioning (55, 56, 60-64), even until adult life (65). The results of our studies (**Paper I and II**) are also similar to these intervention studies where stimulation found superior to nutritional supplementation. However, the period of food supplementation in our studies was short, and the effect sizes were comparatively small in both hospital and community-based studies.

#### *Hospital-based intervention*

In our hospital-based study, intervened mothers and children participated in daily group meetings and individual play sessions for 2-3 weeks in hospital and were visited at home for 6 months. The intervention was delivered by trained health workers. But the duration of intervention in our study was less compared to the Jamaican hospital-based study (53, 54). In Jamaica, severely malnourished children of the intervention group were provided with psychosocial stimulation in the hospital and then visited at home weekly for two years and fortnightly for a third year by community health aides

(Jamaican government health paraprofessionals). Unlike the Jamaican study we did not have any adequately nourished group to compare with.

After six months of intervention, the children in the intervention group had moderate effect on mental development and small effect on motor development and weight. In Jamaica, the children who had received intervention improved significantly compared with the other groups, and after 6 months had significantly higher cognitive development than the malnourished children, who did not receive intervention but still lagged behind the adequately nourished group (53). After the end of the 2-years intervention, the malnourished children who had received the intervention were ahead in every subscale of cognitive development compared to the malnourished control group and were ahead in two subscales (hearing and speech, and performance subscales) of cognitive development compared to the adequately nourished children. Both groups of malnourished children remained behind the adequately nourished children in nutritional status and locomotor development (54).

#### *Community-based intervention*

In our community-based study, the intervention groups received psychosocial stimulation at community clinics fortnightly for the first three months and then monthly for the next three months, delivered by the trained health workers. The intervention was short and did not use the home visiting approach that had been employed in other community-based studies in Bangladesh (57), Jamaica (59) and Colombia (58). In Jamaica, the stimulation was delivered at home, weekly over 2 years. In Bogota, Colombia, stimulation included twice weekly home visits over 3 years by paraprofessionals and activities focused on to stimulating psychological development of the children and maternal education. The intervention study in rural Bangladesh included group meetings at the community nutrition centres (weekly for 10 months followed by meetings every 2 week for 2 months) and home visits (twice weekly individual visits at home for 8 months followed by weekly home visits for 4 months) providing psychosocial stimulation focused on improving the mother-child interaction. Literate women from each village were trained to serve as play leaders to conduct the intervention activities.

Nutritional supplementation in the community-based study of the present thesis comprised of cereal-based food packets (total energy per packet was 150 kcal), one (<12 months of age) or two packets ( $\geq 12$  months) per day. In Jamaica, food supplementation comprised of 1 kg milk based formula per week. In addition, cornmeal and skimmed milk powder (1 kg of each) were also provided to the family in an attempt to reduce sharing of the child's supplement. In the Colombian study, food supplementation consisted of

enriched bread, dried skimmed milk and cooking oil for the entire family (all member of age > 1 year); whole powder milk and commercially high protein vegetable mixture (Durya) for children from 3-12 months, distributed weekly to the families at special centers resembling neighbourhood shops for consumption at home.

In our community-based study we found significant effects of psychosocial stimulation with or without food supplementation on mental development and weight gain (**Paper II**). In the Jamaican study (59), the intervention groups had improved developmental levels compared to the controls at the end of the intervention. The group that received the combined intervention showed the greatest improvements and was the only one to catch up to a matched group of 32 non-stunted children. Stimulation showed no concurrent effect on growth (82) or in the follow-up (83). The Colombian study (58) found a small effect by stimulation (maternal education) on speech and language. In the rural Bangladeshi study (57), intervention improved children's mental development, vocalization, cooperation, response-to-examiner, emotional tone and mothers' knowledge. At the end, undernourished controls had poorer mental and motor development, were more inhibited, fussier, less cooperative, and less vocal than better-nourished children. Intervened children scored lower only in motor development. The intervention found no effect on nutritional status of the children.

In our community-based study, we failed to get any effect of nutritional supplementation on growth or development after six months of intervention (**Paper II**). The children, who received food supplementation, had higher weight gain after 3 months of intervention compared to other groups as reported in another paper not included in this thesis (67). But this effect was not evident after the withdrawal of food supplementation. In Jamaica, the supplemented children had significantly increased length, weight, and head circumference (all  $p < 0.01$ ) after 12 months of intervention. At the end of the 2-year intervention, the supplemented group was 1.03 cm taller than the non-supplemented group ( $p < 0.05$ ) (82). In the Colombian study, there were significant differences in weight between supplemented and control groups beginning at age 3 months and in length beginning at age 6 months (84). Both in Jamaican and Colombian studies, nutritional supplementation had effects on children's motor and mental development. In Jamaica, some effect of supplementation on child IQ was still evident at age 7-8 years (especially for children of mothers with higher verbal IQ), but these effects were not maintained at age 11-12 years (61) or at age 17-18 years (62).

A prospective follow-up study in India evaluated the role of developmental stimulation and nutritional supplementation in rehabilitation of children (6-24 months) in the hospital and community settings (85). The children were

followed-up for 2 years (weekly for first 3 months then monthly for rest of the periods) compared to 6-months follow-up in our studies. In both hospital and community study, intervention with either stimulation package or nutritional supplementation providing precooked ready-to-mix cereal pulse, had significant positive impact on growth and development of severely malnourished children, where stimulation was found superior to food supplementation. In the hospital study, the well-nourished control group from high socioeconomic status had the highest overall scores compared to the well-nourished control from low socioeconomic status as well as the study groups (stimulation or food supplementation). In our studies, we also found that the children who received stimulation had higher mental (both hospital and community-based study), motor development (hospital-based study) and weight gain (both hospital and community-based study). Unlike the Indian studies (85), the children who participated in our studies were all severely malnourished and came from low socioeconomic background.

### Dietary supplement in hospital-based study

In Dhaka Hospital, ICDDR,B, the children in the nutritional rehabilitation unit receive food, which is low cost, culturally acceptable using locally available ingredients to provide 200-250 kcal/kg/day. Two main meals are “khichuri” (10-20g/kg/feed; 2-3 feeds/day), which is made of rice lentils, oil, potato and vegetables e.g. spinach, pumpkin etc. and “halwa” (10-20g/kg/feed; 2-3 feeds/day), consisting of wheat flour, lentils, soya oil, molasses. One hundred gram of cooked khichuri contains 145 kcal and 3 g protein and one hundred of cooked halwa contains 240 kcal and 5 g protein. Khichuri and halwa can easily be prepared at home and kept in room temperature for 6 hours. The children also receive a milk based diet “milk-suji” (10 ml/kg/feed; 2 hourly feed) or “milk-suji 100” (10 ml/kg/feed; 6 hourly feed). With these foods the children gain 7.5 g/kg body weight/day (86). In the hospital-based study, all the children (control and intervention) received the same hospital diet throughout the period of hospital stay.

In a 4 years retrospective cohort in Hyderabad, India, severely wasted children were provided with energy dense local foods at a hospital based nutrition rehabilitation unit. The child was initially put on a maintenance diet of about 100 kcal/kg/day which later on increased up to 170-220 kcal/kg/day. A typical diet of a child weighing 7kg, consists of 350ml of milk (fortified with oil to increase the energy density), 250g of *khichdi* (rice and dhal in 2:1 ratio with added oil), 1-2 slices of bread, 2 eggs and a banana, which provides around 170 to 200 kcal/kg/ day and 3 to 4 grams of protein/kg/day. Weight gain was higher by almost 40% and the diet based on local energy dense foods was found to be suitable for the nutrition rehabilitation of severely malnourished children though the rate of weight gain was moderate (87) .

## Nutritional supplementation in community-based study

For supplementing children who participated in the community-based study with food, we adhered to the national food supplementation programme. The National Nutrition Programme (NNP) of Bangladesh had been delivering a supplementary feeding program through community-based initiatives, which provided 2 packets/day of a dry food ration for 3 months to 6-24 months old severely malnourished children. However, the supplementary food provided was probably insufficient for these very severely stunted children and it may also have replaced other food at home that was not measured in the study. The food supplementation given to the severely children of the community-based study was less energy-dense and inadequate compared to the other community-based studies in India (88), Africa (89) and Bangladesh (90). All of these studies used either RUTF or locally made energy-dense food and catch-up growth was satisfactory.

Over the past decades, a growing number of countries and international relief agencies have adopted a community-based model for the management of acute malnutrition, called community-based therapeutic care (CTC) (9, 91). These programmes use nutrient dense, lipid-based Ready to Use Therapeutic Foods (RUTF) to treat most children suffering from severely acute malnutrition (SAM) as outpatients reserving inpatient care for the few with SAM and complications (92). RUTF is an energy-dense food enriched with minerals and vitamins, with a similar nutrient profile but greater energy and nutrient density than F100, the diet recommended by WHO in the recovery phase of the treatment of SAM (93). It is now locally made with local ingredients in Africa (Malawi, Niger and the Democratic Republic of Congo) and recently in Afghanistan, Sudan and Ethiopia and distributed in health-system settings (91). During the past decade, over 85% of SAM cases treated solely as outpatients have dramatically reduced mortality and increased coverage rates (94). Community management of acute malnutrition, with principles of community mobilisation and ensuring compliance and coverage with RUTF, has led to improved outcomes and recovery rate. There is consensus that such community management with use of locally produced RUTF is a key intervention strategy in food-secure population (95).

### **Catch-up growth**

The initial results of our community-based study after 3 months of intervention have been reported by one of the co-authors (67). Rates of weight gain were greater in groups PS+FS, FS, and PS (0.88-1.01 kg) compared with groups CC and CH (0.63-0.76 kg) but the median LAZ declined significantly in all of the 5 groups. Weight gain and change in WAZ and WLZ were greater in groups that received food supplementation

and linear growth was greater among children managed in the community. No significant effect of PS on any of the anthropometric indices was found after 3 months of intervention. Children were still underweight and severely stunted at the end of treatment period. After the end of 6-month interventions (**Paper II**), the effect of intervention on weight gain was highest in the group that had received combined intervention (PS+FS), followed by the PS group, but had declined in FS group and there was no difference of WAZ in FS, CC and CH group. The intervention overall had no effect on linear growth and all groups remained severely underweight and stunted after six months of intervention.

The results of this intervention study indicate the need to provide both psychosocial stimulation and food supplementation for prolonged periods of time and to continue food supplementation for more than three months in the management of severely malnourished children.

#### *Evidence from other counties using RUTF and Local Foods*

A community-based study was conducted in an urban health clinic in Dhaka city of Bangladesh using day-care approach of management of children with severe malnutrition (90). The children received meals four times daily with two feeds of khichuri (10 g/kg), one feed of halwa (10 g/kg) , providing 240 kcal with 5 g protein/100 g) and one feed of milk-suji 100 (15 ml/kg). Mothers were provided with 3-4 feeds of milk-suji in a hot pot to feed their children at night. After two weeks, the children gained weight of 6 g/kg/day. In a clinical trial in severely malnourished children in Senegal, energy intakes (808 kJ/kg/day vs. 573 kJ/kg/day), rates of weight gain (15.6 g/kg/day vs. 10.1 g/kg/day) and time to recovery (17.3 days vs. 13.4 days) were all significantly greater in those receiving RUTF than in those receiving F100 (96). Trials in Malawi have also successfully used a take-home ration given to children in the recovery phase of the treatment of SAM. A take home ration of 730 kJ/kg/day (175kcal/kg/day) successfully rehabilitated HIV-negative, severely malnourished children, after early discharge from a nutrition rehabilitation units providing initial, phase-one care according to WHO protocols. Rates of weight gain were significantly better in the RUTF groups when compared with groups receiving a larger amount of energy from corn-soya-blend flour supplied by the World Food Programme (89). A study was conducted in Delhi, India among urban low to middle socioeconomic neighbourhoods, to compare the acceptability and energy intake of RUTF with cereal legume based *khichri* among malnourished children (88). The result shows that the proportion of children who accepted RUTF eagerly was 58% as compared to 77% for *khichri*. RUTF and *khichri* were both well accepted by study children.

## HOME and Child-rearing practices

In the community-based study, scores of total HOME and two of the HOME subscales- 'Maternal involvement' and 'Play materials' were significantly improved by PS+FS and PS interventions but not by FS alone, which is similar to the results of the Jamaican study (80, 81) and one Bangladeshi rural community-based parenting programme (97). A substantial number of studies have reported the effect of parenting education on subscales of the HOME, especially maternal involvement, play materials, and emotional and verbal responsivity subscales (98). In Jamaica, mothers with preterm low birth weight infants had higher scores on the total HOME and two specific HOME subscales 'Avoidance of restriction and punishment' and 'Maternal involvement'(80, 81). Bangladeshi mothers in a rural community-based parenting programme obtained higher scores on the total HOME and on 'Stimulation subscale' (sum of 14 items from the 'Play materials' and 'Maternal involvement' subscales) than control mothers (97). Our intervention did not affect the other subscales of HOME i.e. physical environment, stimulation, and emotional and verbal responsivity. All the families in the present study came from a low socioeconomic background, were dwelling in the slums and had few entertainment facilities at home. Moreover, the intervention was not home-based and did not aim at improving physical conditions of the home beyond efforts to increase safety. Therefore, we did not expect improvements in the 'Physical environment' and 'Stimulation' but lack of effect on 'Emotional and verbal responsivity' was not predicted.

In this study we reported the parenting practices of mothers who were young, had poor education level and mostly housewives. The opportunities provided for mothers to practice with their own children probably made the difference. If the mothers' behaviour is changed, the benefits to children's development are more likely to be sustainable (80).

## Maternal depressive symptoms

The community-based intervention providing PS with or without FS failed to influence the level of maternal depressive symptoms. To our knowledge very few studies in low-income countries have looked at the effect of psychosocial stimulation on maternal depressive symptoms. In a home-visiting intervention targeting undernourished children in Jamaica (99) there was a significant effect on maternal depressive symptoms (effect size 0.43 standard deviation) for mothers receiving 25 visits and over, while those receiving 0-24 visits did not differ from the control group. In a cluster-randomised trial in India, a group of mothers received monthly interventions for a total of 20 meetings in 3 years. There was no significant effect on maternal depression overall, although moderate depression was reduced by



57% (40). In South Africa, a home-based psychosocial intervention providing emotional support and guidance in parenting was delivered to women from late pregnancy and extended six months postpartum. The intervention reduced maternal depressed mood at 6 months but the prevalence of maternal depressive disorder was not significantly reduced (100).

The global burden of maternal depressive disorders increases the risk for nutritional and developmental problems in the next generation, particularly during infancy. Early identification, treatment and prevention of maternal depression may help in promoting child's growth and development in low-income countries. But there is a lack of awareness of mental health issues in low-income countries, and mental illnesses carry stigma that impedes treatment seeking and leads to a wide 'treatment gap'(101). Policies within the health system and financing arrangements need to be developed to protect and improve maternal psychosocial well-being. Our intervention focused on enhancing mother-child interaction and responsive parenting practices, which is proven as effective approaches to reduce maternal depression in low-income countries (41, 102). Higher intensity and/or longer duration of the interventions may be needed to affect maternal depressive symptoms.

## Public health implications

The public health importance of the findings for mental development, home environment and maternal child-rearing practices of the children is moderate but lack of improvement in the overall nutritional status in spite of food supplementation is disappointing. The poor developmental scores and nutritional status of the participating children are alarming, and is probably due to long term and severe malnutrition as well as extremely disadvantaged backgrounds. We are unaware of any study that included children with such severe degree of stunting and developmental delay. There is considerable evidence that stunting in early childhood can have long-term negative effects on cognitive development, school achievement, behaviour, economic productivity in adulthood and maternal reproductive outcomes (64, 103-105). Follow-up studies in Jamaica have shown that stunted children significantly had more anxiety and depressive symptoms and lower self-esteem in late adolescence than non-stunted participants and that this is reduced by psychosocial intervention (64, 65).

The concentration of poverty and adverse environmental circumstances within slums, particularly those in the cities of developing countries, are an increasingly important concern for both public health policy initiatives and

related programs in other sectors. There is an urgent need to incorporate several interventions in multiple context and settings, providing intensive psychosocial stimulation, and adequate, energy rich food supplementation to the children for a prolonged period of time. Evidence suggests that early childhood stimulation interventions generally affect those children who are most vulnerable and more disadvantaged (which included cash transfer, nutritional, educational and mixed interventions) than more advantaged children (52), particularly for schooling (23, 50) and cognitive development (50). However, contrary results are found for maternal education and there is some evidence that mothers with higher levels of education have more effect from early stimulation interventions. They understand the material better, are more able to implement the strategies they learn and are more compliant than the lower educated mothers (52). In Bangladesh, mothers with more assets and with higher levels of education benefited more from an intervention involving weekly group workshops in terms of the level of stimulation provided in the home (97).

Recently, the Government of Bangladesh, in the new Health, Population and Nutrition Sector Development Programme (HPNSDP, 2011-2016), has closed the National Nutrition Programme (NNP) and has decided to mainstream the nutrition services into the health system. At the community level, the basic nutrition interventions will now be provided through the community clinics, which the Government plans to establish country-wide—one clinic for 6,000 people (15). In the present study, we evaluated one community-based approach of delivering food and psychosocial stimulation through existing primary health care services in the local communities. For this model to be effective and successful in other settings, a sound policy framework and a national plan of action, followed by scaling up of effective nutrition intervention is required. The existing staffs of the community-clinic as well as the parents, especially mothers, who visit the clinic need to be trained and demonstrated on providing psychosocial stimulation. These could be implemented at scale through the public sector and NGOs. Group sessions for the mothers focus on enhancing mother-child interaction and child-rearing practices at community clinics could be the most feasible and possibly cost effective model. Less educated mothers may need more intensive interventions and/or interventions that involve more demonstration, practice activities and role-plays. It is also required to incorporate mother's mental health care promotion in the existing health care system for optimum child development and growth. In Bangladesh, the prevalence of exclusive breast feeding in infants less than 6 months has increased from 43% to 64% over 4 years (19) but the feeding practices after the age of six months when breast milk alone, is not appropriate. Moreover, the complementary feeding starts either too early or too late, leading to the high rates of childhood undernutrition in Bangladesh (15). A comprehensive nutrition intervention

programme should promote exclusive breast feeding for 6 months, continued breastfeeding; counselling of mothers on complementary feeding using energy-dense local foods; treatment for SAM at the facility and community levels with ready-to-use-therapeutic foods made from local food ingredients for scaling up nutrition among the severe and moderately malnourished children in Bangladesh.

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