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Introduction

Child development consists of several interdependent domains of sensory-motor, cognitive-language, and social-emotional function (Grantham-McGregor et al., 2007; Walker et al., 2007). Children's development is affected by psychosocial and biological factors through changes in brain structure and function, and behavioral changes (Wachs, 2000). Experiences in the first few years of life are of particular importance because vital development occurs in all the domains during this period, and the interaction between early environments and genetics influences this development and human behavior (Committee on Integrating the Science of Early Childhood Development, 2000). The brain growth occurs rapidly through neurogenesis, axonal and dendritic proliferation, synaptogenesis, cell death, synaptic pruning, myelination, and gliogenesis (Grantham-McGregor et al., 2007). Brain development can be modified by the quality of the environment (Grantham-McGregor et al., 2007). Independent animal research suggests that early under nutrition, iron-deficiency, environmental toxins, stress, and poor stimulation and social interaction can affect brain structure and function (Black et al., 1998; Liu et al., 2000; Meaney, 2001; Morgan et al., 2001; Rodier, 2004; Webb et al., 2001; Wilson et al., 2000). In both humans and animals, variations in the quality of maternal care, a part of home environment, can yield changes in stress reactivity, anxiety (Gunnar, in press), and memory function in the offspring (Grantham-McGregor et al., 2007). In later childhood the affected children will subsequently have lower levels of cognition and education. It is mentionable that remarkable recovery is often possible with early intervention through more nurturing environment with adequate stimulation, despite the vulnerability of the brain to early insults (Black et al., 1998; Bredy, 2003).

It is estimated that over 200 million children under 5 years of age in developing countries (low-income and middle-income countries) are not attaining their developmental potential, primarily because of poverty and associated health, nutritional deficiencies, and unstimulating home environment, and most of them live in south Asia and sub-Saharan Africa (Grantham-McGregor et al., 2007; Walker et al., 2007). Stunting, inadequate cognitive stimulation, iodine deficiency, and iron deficiency anemia are identified as key risk factors, where the need for intervention is urgent, that prevent millions of young children from fulfilling their developmental potential (Walker et al., 2007; Walker et al., 2011). In low-income and middle-income countries, 34% of children younger than 5 years have linear growth retardation or stunting (Walker et al., 2011) resulted from poor nutrition often accelerated by infectious diseases (Walker et al., 2007). It is reported that patterns of growth retardation are identical across countries (Shrimpton et al., 2001). Although the vacillation in growth starts in utero or in the first 12-18 months, continue to around 40 months (Martorell et al., 1995), but most children having stunting remain stunted through to adulthood (Grantham-McGregor et al., 2007). On the other hand, poverty and stunting are identified for indicators

of poor development because they represent different types of biological and psychosocial risks. Poverty is related to inadequate food, and poor sanitation and hygiene that increase infections and stunting in children. Poverty is also connected to poor maternal education, increased maternal stress and depression (Bradley & Corwyn, 2002; Hamadini & Grantham-McGregor, 2004; Baker-Henningham et al., 2003), and deficient stimulation in the home (Schady & Paxson, 2005). All these factors deleteriously affect child development which, in turn, produces poor school achievement, which is further worsened by poor family support (Grantham-McGregor et al., 2007). Risk factors associated with poverty frequently happen together, and degree of development becomes lower with the number of risks factors (Rutter, 1989). Deficits in child development are often occurred in infancy (Feinstein, 2003; Espy et al., 2001) and increase further with age (Richter et al., 1998; Walker & Grantham-McGregor, 1990; Lozoff & Teal, 2004). Several longitudinal studies have found substantial association between socioeconomic status and parental wealth at birth, and cognitive attainment (Sigman et al., 1991; Stein et al., 2005). Poverty and sociocultural background increase children's exposure to psychosocial risks that influence development through behavioral changes (Walker et al., 2007).

Parenting factors like cognitive stimulation or learning opportunities facilitates early cognitive development. Several studies examined the effect of stimulation or intervention on children from developing countries, including children living in poverty, which strongly supports the importance of early cognitive intervention for facilitating better cognitive and non-cognitive outcomes (Grantham-McGregor et al., 1991; Gardner et al., 2003; Eickmann et al., 2003; Kagitcibasi et al., 2001; Magwaza, 1991). Research revealed three aspects of parenting associated to young children's cognitive and social-emotional competence: cognitive stimulation, caregiver sensitivity and responsiveness to the child, and caregiver affect (National Research Council and Institute of Medicine, 2000). Regarding maternal sensitivity and responsivity several researches reported that these factors are associated with more secure infant attachment (Posada et al., 1999; Eomlinson et al., 2005) and higher cognitive ability (Agarwal et al., 1992) respectively. Appropriate caregiver-child interactions facilitate early social-emotional development and learning materials promote age-appropriate language and problem-solving skills (Walker et al., 2007). Furthermore, maternal depression is another risk factor that causes reduced levels of cognitive function and higher levels of behavior problems (Patel et al., 2003). These factors discussed above are the part of maternal cognitive function which implies that there might be a link between factors evolved from maternal cognitive state and child development. Rubalcava and Teruel (2004) showed that maternal cognitive ability works as an important factor in progressing her children's height, even after controlling for child's age and gender, parental age, mother's and father's years of schooling and mother's height.

Iodine deficiency and iron deficiency anemia threatens the development of many children. Recent research highlights the evidence for other risk factors encompassing intrauterine growth restriction, malaria, lead exposure, HIV infection, institutionalization, and exposure to societal violence (Walker et al., 2011). Notably, breastfeeding and higher

maternal education are emerged as protective factors in new research, which attenuate adverse consequences of risk factors that compromise children's development. It is worth mentioning that substantial improvement in development is unlikely to be made without also increasing early learning opportunities (Black et al., 2005), though there has been recent attention to the effect of nutrition on development (Victora et al., 2008). Non-US intervention studies showed that cognitive benefits were better in case of interventions having stimulation and education components compared with those involving nutrition or economic assistance only (Nores & Barnett, 2009). In Bangladesh, research revealed that almost 60% children are exposed to risk of insufficient development caused by high prevalence of LBW (22%), stunting (41%), and poverty (43%), and lack of early stimulation due to low parental knowledge (UNICEF, 2005; Hamadini et al., 2010). Most of the data from developing countries including Bangladesh mainly focused on cognitive and motor outcome with less emphasis on maternal cognitive ability. This is why, in addition to the existing information, we need to assess maternal cognitive ability and neurobehavioral development in order to prepare appropriate intervention particularly for disadvantaged children living in poverty in Bangladesh.

It is clear from the previous studies on poor populations that disadvantaged children require not only good health, nutrition, and wealth but also supportive and caring environments at home and cognitive stimulation in order to achieve their developmental potential as in the case of Bangladesh. According to Lancet review, most disadvantaged children get the maximum benefit of intervention (Engle, 2011). Cognitive function of parents, especially mothers, is crucial for having the optimum outcome from intervention. However, little is known regarding the importance of mother's cognitive functioning influencing different domains of her young children's neurobehavioral developmental outcome mediated by parenting, particularly who are from disadvantageous community in Bangladesh, residing in poverty. We know of no other study, however, that directly emphasizes maternal cognitive function on different domains of development of disadvantaged children in Bangladesh.

We, therefore, plan to examine the association of disadvantaged children's neurobehavioral development i.e., communication, motor skills, problem-solving, and personal-social skills and mother's cognitive function.

Hypothesis: Mothers with better cognitive function will have children with better neurobehavioral development.

Objectives: The specific objectives of the study are (a) to measure the maternal cognitive function, (b) to assess the neurobehavioral development of children.

Methods

Participants

A total of 200 mother-child dyads will participate in the study. Data will be collected by the researcher. Age range of children will range from 12-42 months residing in the slum area located in the city of Dhaka.

Inclusion criteria

Age: 12-42 months on enrolment
Sex: both male and female
Nutritional status: weight-for-age z score (WAZ)>-3SD
Consent: written consent provided by parents

Exclusion criteria

Any child with –

Developmental anomalies,
Known chronic illnesses like epilepsy, tuberculosis,
Twins and multiple births,
Parents not consenting

Sample Size Calculation

Sample size is calculated assuming 5% level of significance, 80% power, an improvement of 0.30 SD neurocognitive developmental scores of children between high and low scorer mother's group, and 15% drop outs, based on the formula below:

$$n = \frac{2(sd)^2}{(M_1 - M_2)^2} \times f(\alpha\beta)$$

Where,

n = sample size per group,

sd=Standard deviation of population=1,

M_1-M_2=Difference between the groups assumed=0.30 SD,

$\alpha\beta$ =80% power and 5% significance=8

We need to enroll 150 mother-child dyad.

Measurements

The following measurements will be applied upon all enrolled children's mother:

Bayley Scales of Infant and Toddler Development (BSID-III): Neurobehavioral development of children will be assessed on the revised version of questionnaires of BSID-III. It will be used to assess cognitive, language and motor development of the children. The test has been used in many developing countries, and has been the instrument of choice for child development and nutrition research at this age in other countries like Indonesia and Brazil. It usually takes about an hour to test the children.

The Bangla Adaptation of Mini-Mental State Examination (BAMSE): The Bangla adaptation of Mini-Mental State Examination (BAMSE) will be used to assess the cognitive function of mothers. BAMSE is the Bangla adaptation of Mini-Mental State Examination (MMSE). MMSE (Folstein et al., 1975) is a commonly used brief global instrument that measures cognitive abilities having orientation to time and place, memory and attention, language

skills, and visuo-spatial abilities. A good association (r=0.57) was found between the MMSE and BAMSE instruments (Kabir & Herlitz, 2000). Test-retest reliability of BAMSE was satisfactory (r=0.70) and BAMSE was found to be less sensitive to age and education than the MMSE (Kabir & Herlitz, 2000).

Anthropometry: Weights, heights, Mid-upper arm circumference (MUAC), and head circumference of all the study children and their mothers will be measured according to standard techniques (Lohman et al., 1989; WHO, 1983). Afterwards these anthropometric measures will be converted into height-for-age (HAZ), weight-for-height (WHZ), and weight-for-age (WAZ).

Socioeconomic status (SES): Information will be obtained on the families' house-hold possessions, standard of housing, family structure, and parental education and occupation. The indices described will be calculated to measure the socioeconomic status of the family: 1) housing, on the basis of the condition of the roof and walls of the house and presence or absence of electricity in the house; 2) sanitation, according to ratings of type of latrine and availability of water inside or outside the house; 3) assets, based on the possession of certain household items; and 4) crowding, composed of the number of people per room.

Procedures

Data Acquisition

Standard data collection procedures will be followed in the study. The author of this research proposal will conduct a house-to-house survey in the study area. At first, the general purpose of the study will be briefed to the parents. After having written consent from the parents, they will be asked for information about their children's development (extended ASQ), and their cognitive function (BAMSI). Anthropometric measures will be taken both for mothers and their children in order to have Body Matched Index (BMI). After administration of the all questionnaires, mothers will be interviewed to obtain information on socio-demographic characteristics. Thus data collection will be completed approximately in three months.

Data Analysis

Participants' responses will be scored according to the scoring systems of the ASQ, BAMSE, and other measures. Data will then be fed to a personal computer and analyzed using the SPSS, version 20. Transformations will be used to normalize the variables when necessary. Data will be analyzed in multiple regression analysis in order to see the relationship between maternal cognitive ability and different domain of child development.

Expected Result and Impact

It is expected that the impact of maternal cognitive function on neurobehavioral development will be considerable.

Although there are few national data for mother's cognitive ability and child's development in Bangladesh, but it can be said that many disadvantaged children are exposed to various

risks for poor development including poverty, malnutrition, poor health and un-stimulating home environment or lack of learning opportunities. Due to poor development, children do poorly in school and subsequently transfer poverty to the next generation. The second UN Millennium goal is to ensure that all children complete primary schooling. The result will help policymakers to take appropriate intervention programs to improve early child development, which, in turn, will achieve satisfactory educational performance. To reach the MDG and to stop the intergenerational transmission of poverty the findings of proposed study will play an important role.

Currently, there are no accepted indicators for child development in Bangladesh. The expected result will help develop country's indicators for child development. Furthermore, the result will provide information to help the setting programs and policies for early childhood development to benefit the disadvantaged children and reduce the persistent inequalities in child development. The proper child development will help make economical and social development of the country.

Time Line

The time plan of the study is described as under

Works	Year								
	1			2			3		
	Quarters			Quarters			Quarters		
	1	2	3	1	2	3	1	2	3
Preparatory works (Manual, SOP, questionnaire preparation)	x								
Site selection	x								
Training		x							
Screening of 1-3.5yr old children & enrolment		x							
Assessment		x	x						
Data entry, cleaning & preliminary analysis				x					
Start writing introduction & method section					x				
Synthesize results & thesis writing						x			
First draft of the PhD thesis							x		
First Seminar								x	
Review & rewrite the thesis								x	
Second Seminar									x
Submission of PhD thesis									x
Dissemination									x

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