AMOUNT OF STIMULATION RECEIVED AT HOME AND GROWTH DURING INFANCY HAVE POSITIVE ASSOCIATION WITH PSYCHOMOTOR DEVELOPMENT OF POOR URBAN BANGLADESHI INFANTS

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Summary

Biological and psychosocial factors along with cumulative environmental factors have effect on the later childhood development. The detrimental effect of these factors on development varies from studies to studies in different geographical regions with variation in the causality. LBW (Low birth weight) children (birth weight<2500 g) generally have poorer levels of development compared to NBW (Normal birth weight) infants. The development of term-LBW/SGA (Small for gestanational age) or IUGR (Intrauterine growth reterdation) infant is more complex and controversial. To assess the factors influencing cognitive development of Bangladeshi infants, from poor socio-economic background. This study was conducted using pooled data derived from a previously done randomized control trial on 400 pregnant women. To find the biological and socio-environmental factors that associated with development, we broke down the randomization. A house-to-house survey was carried out in a defined poor urban area and all women who were 5 to 6 months pregnant were enrolled and the gestational period was ascertained by the report of LMP (Last menstrual period) given by mothers. Data of 249 mother-infant dyads who completed the study and had all the measurements up to 10 months were used for this analysis. The detailed information regarding enrolment and findings from the main study has been published elsewhere. Distribution of each variable was checked for normality, and where necessary appropriate transformations were made. Bivariate correlations between the developmental variables and socioeconomic measures were assessed. To examine the effect of biological and psychosocial factors on development of infants, series of multiple linear regression analyses were performed where each of the developmental variables was treated as a dependent variable. Family wealth and play material available for the child at home have a strong positive influence on both mental and psychomotor development whereas overcrowding exerts a negative impact on development. Similarly younger infants, being female, having larger head at birth and greater increase in head size over 10 month were found to have better mental developmental index, while taller children at birth had better psychomotor development at 10 month. Birth length and head-circumference and growth in head-circumference in the early months affect child development even after controlling for social background.

Key words

Cognitive development; motor development; psychomotor development; overcrowding

Introduction

There is no single factor uniquely influences early intellectual development independently.[1] Studies done in the past two decades found that biological and psychosocial factors along with cumulative environmental factors have got effect on the later childhood development. [2] The detrimental effect of these factors on development varies from studies to studies in different geographical regions with variation in the causality. For example, in developed countries maternal smoking plays important role to cause of LBW whereas in developing country maternal malnutrition is identified as a major contributing factor.

A review of 80 studies, mostly in developed countries, showed that LBW children (birth weight<2500 g) generally have poorer levels of development compared to normal birth weight (NBW) infants[1].

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The development of term-LBW/SGA or IUGR infant is more complex and controversial. Evidence suggests that although these infants have a better chance of survival, subsequently they are at risk of behavioural problems[3], language difficulties[4], attention-deficit and poor school performance, with or without effects on their intelligence scores[5]. Strauss and colleagues[6] showed that SGA affects future cognitive development particularly when it is associated with lower head circumference. Growth during early life is also an important predictor of future development and SGA children who managed to catch up on growth showed catch-up of developmental delay.[7] However, usually SGA infants are usually shorter and lighter adolescents compared to their normal gestational age counterparts[8]. It is established that severe malnutrition during early life impairs cognitive development although controversy remains about mild or moderate malnutrition[9].

Studies in developing countries are usually confounded by environmental disadvantages. This makes it difficult to isolate the independent effect of LBW/SGA on development with certainty. Due to a large loss of sample[7] over time, long-term follow-up of these infants is difficult in developing countries[10] although it is moderately consistent that these infants suffer from some sort of developmental delays. It is possible that these infants are more vulnerable to the adverse, impoverished and non-stimulated environment than NBW infants. The Jamaican study showed that the associated delay in development of term LBW infants could be minimized with psychosocial intervention[11]. Some studies support that psychosocial stimulation rather than nutrition is important for brain development[12]. In a recent study conducted on severely malnourished children in "hospital nutritional rehabilitation unit" independent effect of stimulation on growth was observed[13]. Some studies also suggest that in addition to LBW or SGA, socio-environmental factors (e.g. maternal education) also influence development of these infants unless the deficit is severe[14].

Objective

We had earlier conducted a study on effect of fish-oil supplementation during pregnancy on infant's development. We took the opportunity presented to this study to assess the factors influencing cognitive development of Bangladeshi infants, from poor socio-economic background.

Materials and methods

This was a randomized control trial conducted on 400 pregnant women to see the effects of fish oil or soy oil supplementation on pregnancy outcomes along with the subsequent development of their infants at 10 months of age. To find the biological and socio-environmental factors that associated with development, we broke down the randomization and conducted secondary-data-analysis using the pooled data.

The study population was chosen from the part of Dhaka city, where illiteracy, poverty, overcrowding, poor housing and poor hygiene are the common features. The community was poor but not the poorest. Most of them were overcrowded with houses of concrete floor, bamboo walls and tin roofs. Almost all of them had tap water supply, electricity and semi-sanitary latrines. Fifty-nine percent of fathers and 35% of mothers had the education more than grade five. Sixty-six percent fathers and 14 % mothers had regular job with average monthly family income of $105.

A house-to-house survey was carried out in a defined poor urban area and all women who were 5 to 6 months pregnant were enrolled and the gestational period was ascertained by the report of LMP given by mothers. Data of 249 mother-infant dyads who completed the study and had all the measurements up to 10 months were used for this analysis. The detailed information regarding enrolment and findings from the main study has been published elsewhere[15].

Measurements

Developmental assessment: We assessed cognitive and motor development at the age of 10 months (+15 days) using the Bayley Scales of Infant Development II (BSID-II). It has two sub-scales: mental development index (MDI) and psychomotor development index (PDI)[16]. Infants were assessed in a quiet room in the presence of their mothers at the Dhaka Hospital of ICDDR,B. Two female psychologists, unaware of their group assignment, tested the kids. Sick infants were treated and tested after recovery. The inter-observer agreement between the testers and the trainer assessed on 30 infants before the study was high (intra-class correlation: $r > 0.98$ for both MDI and PDI).

Infant's behaviour: Infant's behaviour was rated during the test using a modified five-scaled tool, designed by Wolke[17]. Each of the scales had 9-point ratings and included infants' activity (very still=1 to over-active=9), emotional tone (unhappy=1 to extremely happy=9), responsiveness to examiner in the first 10 minutes (avoiding=1 to inviting=9), cooperation with the test procedure (resists all suggestions=1 to always complies=9), and vocalization (very quiet=1 to constantly vocal=9). The inter-observer reliability was r >0.92 for all five behaviour ratings.

Quality of stimulation at home: Quality of stimulation at home was assessed using Caldwell's Home Observation for Measurement of Environment (HOME)[18], which was modified for Bangladesh and was used in other studies by the same research team[19]. Two female interviewers interviewed mothers at their homes in the presence of their babies. The trainer observed 30 interviews before initiation of the study, and agreements between the trainer and the interviewers were high (>90%). The HOME consists of 6 subscales viz. a) Organization of physical and temporal environment, b) Maternal involvement, c) Stimulation, d) Play materials, e) Emotional and Verbal responsivity, and f) avoidance, restriction and punishment. The 6 subscales were also summed to calculate a total HOME score.

Socioeconomic status: Socioeconomic status was measured using a detailed questionnaire at enrollment. Several indices were constructed by using relevant information as follows: housing index (structure of floor, roof, and wall), crowding index (number of family members divided by number of rooms), and utility index (water, electricity, and latrine). Occupation of father (stable/unstable), occupation of mother (house-wife/working woman) and education of parents (up to grade 5 or more than grade 5) were used as dichotomous variables. An asset score was constructed by giving judged arbitrary values to family possessions, for example, possession of a radio was given a score of '2', whereas possession of a TV was scored as '6' taking into account that the price of a TV is three times more than that of a radio. In the same way, we scored all the possessions of the family according to the market values and then added these up to construct the asset score.

Anthropometry: Anthropometry was performed within 72 hours of birth and then monthly up to six months using the standard techniques and also at the time of Bayley test. Weight-for-age (WAZ), height-for-age (HAZ), and weight-for-height (WHZ) Z-scores were then calculated using NCHS reference data (WHO, 1983). Ponderal index (PI) was calculated using the formula: PI=(birth-weight in g/length cm^3)*100.

Ethics

The research and ethical review committees of ICDDR,B approved the study, and informed written consents were obtained from all mothers prior to their child's enrollment in the study.

Statistics

Data were entered and analyzed using SPSS for Windows (version 10; SPSS Inc., Chicago). Distribution of each variable was checked for normality, and where necessary appropriate transformations were made. Bivariate correlations between the developmental variables and socioeconomic measures were assessed.

To examine the effect of biological and psychosocial factors on development of infants, series of multiple linear regression analyses were performed where each of the developmental variables was treated as a dependent variable. In the first block, we entered age and sex. In the second block, we offered socioeconomic and biological variables that were significantly different between the groups and between the lost and the tested sample (family income, education of father, age of mother, body mass index (BMI) of mother, pedal oedema, systolic blood pressure, pregnancy weeks at enrolment, and number of children). In the third block, we offered the birth-related variables, which were significantly different between the lost and the tested sample and between the groups (gestational age, birth-weight, birth-length, head size, resuscitation of child at delivery, problem of mother during delivery). In the final block, we offered those variables, which were significantly associated with outcome variables (crowding, housing, and HOME).

Results

We pooled the data of these 249 infants, who completed the study, to find the relationship between different antenatal and postnatal factors affecting child development in this disadvantageous population. Table I shows all the baseline information regarding the maternal biological factors, socio-economic condition and parental education. Infant characteristics are shown in table II.

As age and sex were correlated with developmental outcome, to reduce the bias we used partial correlation controlling for age and sex to assess the correlations between Bayley scores and biological and Social Background variables (table III).

MDI correlated significantly with socio-economic factors like- Housing Index, crowding Index, asset, family income, total HOME, biological factors like- mother's weight at enrolment, maternal BMI, birth weight, birth length , birth head circumference , parental education and concurrent nutritional status of the child.

Similarly PDI was found to be significantly correlated with socio-environmental factors like Housing Index, Utility Index, Crowding Index,Asset index, Family income, Total HOME , Biological factors like mother's weight, Maternal Body mass Index, Gestational age at birth , birth weight, birth length , birth head circumference, concurrent nutritional status of infants, and parental education.

In addition, the total HOME and all its sub-scales except 'avoidance, restriction and punishment' were significantly associated with both MDI and PDI.

After controlling all possible confounder in multiple linear regressions economic indices like family assets and play-materials showed strong positive associations with both MDI and PDI, whereas over-crowding had negative association with MDI and PDI. In addition, age, sex, birth head size and infants' growth in head size up to 10 month had an independent effect on MDI and birth length showed an independent effect on PDI (Table IV).

Model:

Step 1: age and sex entered,

Step 2: Study group (Treatment) family income, father's education, housing index, crowding index, assets and HOME subscales offered for both MDI and PDI and in addition utility only for PDI.

Step 3: Ponderal index of child at birth, birth head circumference, birth length, 10 month's residuals of head circumference, 10 month's residuals of length, and 10 month's residuals of weight for both MDI and PDI was offered

Step 4: Head circumference of 10 month and weight for height z score of 10 month were offered for both MDI and PDI

Table I : Baseline Character of families- including social, economical and biological factors

Variables	Mean (SD) or percentage
Maternal Biological Characteristics at enrolment	
Mothers Age in years	22.71 (4.4)
Body Mass Index	21.52 (2.6)
MUAC	23.91 (2.4)
Pregnancy in wk (enrolment)	24.88 (1.2)
Maternal height in cm at enrolment	151.15 (5.3)
Normal Delivery	81%
Gestational Age in week	38.94 (2.5)
Socio-economic factors at baseline	
Crowding Index	4.06
Utility	8.31 (0.9)
Housing Index	3.50 (0.8)
Asset	24.34 (1.4)
Family Income in taka	5687 (2.0)
Parental Characteristics	
Mother's education > class 5	35%
Mother's occupation (housewife)	86%
Father education > class 5	59%
Father's occupation (stable job)	66%

Table II: Child characteristic at birth and at the time of testing

Child Characteristics at Birth	
Variables	Mean (SD) or percentage
Sex male	50%
Weight (kg)	2.71 (0.4)
Length (cm)	47.9 (2.1)
Head circumference (cm)	32.4 (1.7)
Ponderal Index	2.46 (0.2)
Breast feeding not at all	6.80%
Child Characteristics at testing	
Age of test (days)	300 (4.3)
Weight (kg)	7.78 (1.1)
Length (cm)	69.25 (2.6)
Head circumference (cm)	43.09 (1.4)

Disclosure

All the authors declared no competing interestes

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Table III : Partial Correlations of biological and social variables with MDI & PDI controlling age and sex

Variables	MDI	PDI
Housing Index	0.26 ***	0.22 ***
Utility	ns	0.20**
Crowding Index	-0.23***	-0.22 ***
Asset	0.32 ***	0.32 ***
Family income	0.20 **	0.13 **
Total HOME	0.28 ***	0.28***
Maternal involvement	0.17**	0.19**
Play materials	0.29***	0.28***
Emotional and verbal responsivity	0.15*	0.13 *
Stimulation	0.24***	0.25***
Organization of physical & Temporal environment	ns	0.14 *
Avoidance, restriction, punishment	ns	ns
Mother's age (yrs)	ns	ns
Mother's weight at enrolment (kg)	0.16 *	0.24***
Mothers height (cm)	ns	ns
Maternal Body mass Index	0.19**	0.23***
Gestational age at birth (mo)	ns	0.37 ***
Maternal education	0.17**	0.19*
Maternal Body mass Index	0.25***	0.23***
Father education	0.13 *	0.18*
Birth weight (kg)	0.27***	0.27***
Birth length (cm)	0.27***	0.31***
Birth Head circumference (cm)	0.28 ***	0.23***
Ponderal Index	ns	ns
Weight for height z score at 10 month	0.13*	0.14*
Weight for age z score at 10 month	0.25**	0.25*
Height for age z score at 10 month	0.25***	0.24***
Head Circumference at 10 month	0.32***	0.25***

Table IV: Significant standard scores ( ), and 95% confidence interval (CI) from regression of MDI and PDI

	MDI Model (F=11.5, R square=0. 25) B (SE,95% CI, p value)	PDI Model (F=15.8, R square= 0.21) B (SE,95%CI)
Age	-0.30 (0.11, -0.51 to-0.09)*	----------
Sex	3.49 (0.99,1.54 to 5.45)*	----------
Asset	8.99 (3.77, 1.57 to16.41)*	16.12 (4.80, 6.67 to 25.6)*
Crowding index	-0.60(0.30, -1.20 to-0.004)*	-0.85 (0.39, -1.62 to -0.08)*
Play material at HOME	0.65(0.22, 0.22 to 1.08)*	0.65(0.28, 0.09 to1.21)*
Birth length	----------	1.18 (0.28, 0.62 to1.74,)**
Head size at birth	1.02(0.27,0.50 to1.55)**	----------
Residuals of head size at 10 month	1.42 (0.5,0.43 to2.41)*	----------

**p<0.001, *p<0.05

Discussion

Our objective was to determine the biological and socio-environmental factors that predict development of infants born in disadvantageous poor urban communities of a developing country like Bangladesh.

The developmental tests that we used in this study had good test-re-test and inter-observer reliabilities although they were not standardized for Bangladesh.

The results of this study demonstrate that family wealth and play material available for the child at home have a strong positive influence on both mental and psychomotor development whereas overcrowding exerts a negative impact on development. Similarly younger infants, being female, having larger head at birth and greater increase in head size over 10 month were found to have better mental developmental index, while taller children at birth had better psychomotor development at 10 month.

These findings are in conformity with other studies that indicate strong influence of the economic status of the family on optimum development of infants of poor developing countries[14]. Our findings of larger birth head size, growth in head and being taller at birth are logical and have similarities with other reports[20, 21]. The significant association of growth in head- circumference in the first 10 months with cognition highlights the importance of adequate stimulation in early life. Interestingly we also found that even in poverty, amount of stimulation that the children receive at home is an important factor for their future cognitive development. When we offered the subsets of HOME scale in the model we found that out of all types of stimulation, availability of toy materials at home contributes most to children's intelligence. Studies in Jamaica have also shown that early stimulation with structured low cost play stimulation provides both short and long term cognitive benefit to the poor low birth-weight infants[22,23]. Therefore, along with nutrition, intervention with stimulation can contribute to the optimum development of children in poverty.

Conclusion

Birth length and head-circumference and growth in head-circumference in the early months affect child development even after controlling for social background. The findings suggest that prenatal and postnatal physical growth and provision of play materials at home have considerable potential on improving children's mental and psychomotor development. So to ensure optimum development of children in poverty intervention program should keep focus on both early nutrition and stimulation of young children.