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THE RELATIONSHIP BETWEEN MATERNAL ANTHROPOMETRY AND CHILDHOOD MALNUTRITION IN RURAL BANGLADESH

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Abstract: ***Objective:*** *To test whether there is a relationship between childhood malnutrition and mothers' Body Mass Index (BMI) in Bangladesh and to examine whether knowledge of the nutritional status of the household has policy implications for combating childhood wasting and stunting in Bangladesh.* ***Design:*** *To evaluate the relationship between children's wasting, stunting and underweight and mothers' BMI in five rural areas of Bangladesh. A household was classified as malnourished if the child had a weight-for-height Z-score of <-2 while <-1.5 was used as at risk of malnutrition. The BMI of the mother was used to signify adequate household food availability.* ***Results:*** *Just over 36% of mothers were malnourished (BMI <18.5) while 13.4% and 48.5% of their children were wasted and stunted respectively. Children at risk of wasting and stunting were 31.5% and 66.5% respectively. Mothers from better-off households tended to be taller, heavier and have higher BMIs. There were mainly low-to-moderate positive correlations between mothers BMI and child's Z-scores. After taking into account variation in socio-economic variables, the distribution of households on the combined basis of maternal BMI and child nutritional status did not suggest that low maternal BMI was associated with increased levels of childhood wasting, stunting or underweight.* ***Conclusions:*** *The household-based approach to combating childhood malnutrition indicates that the main priority in Bangladesh is improving personal hygiene, provision of adequate water supply and sanitation as well as educating mothers about parental care; food availability is of importance but less so.* ***Sponsorship:*** *The research was supported by a World Bank Consortium under the 4th Population and Health Project.*

Keywords: *Childhood malnutrition; Body mass index; Anthropometry; Public health.*

Introduction

James, Ferro-Luzzi, Sette and Mascie-Taylor (1999) suggested that childhood malnutrition results from inadequate food availability, poor parental care and/or the need for improving public health measures. By examining the nutritional status of the mother and child they suggested that it might be possible to distinguish between these alternative

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causes. They used the body mass index (BMI, kg/m^2) of adult women as an index of the household food availability (with a BMI cut off at 18.5). Children were classified as wasted or stunted if their Z-score fell below -2 standard deviations of the median of weight-for-height and height-for-age respectively in relation to the WHO reference charts. Four types of households were envisaged resulting from the different mother-child anthropometry combinations are shown in Table 1. Using data from India, Ethiopia and Zimbabwe they suggested that the principal problem in India was of food security, whereas in Zimbabwe food household security was rarely apparent, and public health measures and maternal care were the main problems. In Ethiopia there was a mixture of needs.

Table 1. Policy implications of anthropometric analyses.

Children's nutritional status assessed from the Z-score of weight-for-height	Mother's Body Mass Index	
	< 18.5	≥ 18.5
Poor i.e. <-2.0 Z-score	Food availability important	Public health measures, maternal education important
Adequate i.e. ≥ -2.0 Z-score	Maternal care good despite food deprivation	Low priority

This paper extends the analyses of the relationship between mother-child nutritional status to rural Bangladesh and examines the extent to which childhood stunting, wasting and underweight can be predicted by maternal BMI after taking into account background socio-economic variables.

Methods

The research was conducted in five discrete geographical areas all located within a radius of about 80kms from Dhaka, the capital of Bangladesh. The five areas were chosen as part of a knowledge, awareness and practice (KAP) survey of the public health significance of intestinal parasites, water and sanitation facilities and personal hygiene (Mascie-Taylor et al. 2003). The households were first surveyed to see if they had a child within the desired age-range (7 to 13 years), and if so, the census number of the household was noted. Households were randomly selected on the basis of the census number and then the index child was randomly chosen from all eligible children in the household. Approximately 1 in 4 households within each of the five areas participated in the study. The vast majority of householders were Muslim (93%), 6% were Hindu and 1% were Christian. The aims and objectives of the project were explained to the parents and a consent form was signed.

Maternal and child anthropometric measurements were obtained on 1032 pairs from the five areas using trained and standardised personnel. Subjects were measured barefoot in minimal clothing, for which allowance was made. Intra- and inter-observer coefficients of reliability were between 0.96 and 0.99 for all measurements which is well within the region of acceptable technical error (Ulijaszek and Lourie 1994). Maternal BMI (weight (kg)/height^2 (metres) was calculated and Z-scores of weight-for-age (WAZ), height-for-age (HAZ) and weight-for-height (WHZ) were determined using the international growth

reference charts. Height-for-age (stunting) and weight-for-height (wasting) can be used to discriminate between chronic and acute malnutrition respectively. Age of the child was provided by the mother and checked using a locally developed calendar.

A structured questionnaire was used to collect information on household ownership of a radio and television, the husband's occupation and his educational level. Occupation was graded into five categories from the lowest paid group (daily labourer), followed by agricultural worker, non-agricultural worker, regular service worker and small businessman. Five educational levels of non-attendance at school, 1–5 years of schooling, 6-10 of schooling, secondary education, and higher and graduate as a single group were used. Finally houses were placed into one of four categories from the least expensive, mud with a thatch roof, through mud and a tin roof, all tin and brick, the most expensive.

In the analyses maternal BMI was treated as a continuous variable as well as a categorical variable using either 5 categories of <16, 16-16.9, 17-18.4, 18.5-24.9 and 25-29.9 which correspond to chronic energy deficiency (CED) grades of III, II, I normal and Grade 1 obesity respectively (Shetty and James 1994), or as 2 categories of <18.5 and ≥18.5 signifying CED grades III to I and normal + obese, respectively. For the children the usual Z-score cut-off of -2 SD was used as indicating malnutrition and following James et al (1999) a cut-off of -1.5 SD was also used to signify children at risk of malnutrition.

The statistical analyses used comprised simple χ^2 tests, t-tests , oneway analyses of variance, correlation analysis and sequential binary logistic regression analyses.

Results

Maternal height ranged between 127 and 173 cm (mean 149.2, SD 5.7), weight from 23 to 73kg (mean 44.2 SD 7.4), BMI from 12.3 to 29.6 (mean 19.8, SD 2.9) and MUAC (mid-upper arm circumference) from 14 to 37 cm (mean 23.9 SD 2.9). There were small differences between areas but these were accounted for by variation in socio-economic variables and so the analyses presented here are based on the entire sample. Just over a third (36%) of the women were classified as suffering from malnutrition (CED III, 7.3%, II, 9.5%, I, 19.2%), 58.9% were normal and 5.1% were Grade I obese.

The mean weight-for-age and height-for-age Z scores of the children were very similar -1.91 (SD 0.71) and -1.89 (SD 1.06) respectively while mean weight-for-height was -1.09 (SD 0.89). There was evidence of considerable growth deficit and thinness and only about 5% of children had Z-scores above 0 for HAZ, while for WAZ and WHZ the percentages were 1% and 12% respectively.

About three-quarters of households (Table 2) did not own either a radio or a television; most lived in houses constructed of the poorest materials (mud and thatch) and only 4.1% of houses were constructed of brick. Just over half the husbands had no education and only about 11% had received secondary or higher education. Nearly half the husbands worked as either a daily labourer or in agriculture while about 25% of husbands were engaged in small businesses.

Table 2. Associations between Maternal & Child Anthropometry and selected socio-economic variables (percentages in each category are shown in brackets).

	Maternal								Child					
Variable	Height (cm)	p	Weight (kg)	p	BMI (kg/m^2)	p	MUAC (cm)	p	Height-for-age	p	Weight-for-age	p	Weight-for-height	p
Radio		0.032		<0.001		<0.001		<0.001		0.010		0.002		NS
No (70.5%)	-0.83		-3.17		-1.19		-1.07		-0.187		-0.150			
Yes (29.5%)	0		0		0		0		0					
Television		<0.001		<0.001		<0.001		<0.001		0.001		0.001		NS
No (79.4%)	-1.56		-4.52		-1.58		-1.34		-0.272		-0.218			
Yes (20.6%)	0		0		0		0		0					
Dwelling Type		NS		0.001		<0.001		<0.001		0.041		NS		NS
Mud/thatch (54.5%)			-4.88		-1.52		-2.56		-0.214					
Thatch & tin roof (32.5%)			-4.05		-1.21		-2.46		-0.297					
All tin (9.0%)			-1.94		-0.55		-1.95		0.110					
Brick (4.1%)			0		0		0		0					
Husband's education		<0.001		<0.001		<0.001		<0.001		0.003		0.001		NS
None (50.3%)	-1.13		-7.16		-2.90		-2.75		-0.377		-0.369			
1–5 years (23.5%)	-1.05		-4.67		-1.82		-1.70		-0.144		-0.194			
6–10 years (15.5%)	-0.27		-5.44		-2.36		-1.92		-0.284		-0.271			
Secondary (5.6%)	+2.31		-1.65		-1.38		-0.93		0.005		-0.160			
Higher & graduate (5.2%)	0		0		0		0		0		0			
Husband's occupation		0.045		<0.001		<0.001		<0.001		0.006		NS		NS
Daily labourer (12.2%)	-0.51		-2.90		-1.14		-1.11		-0.193					
Agricultural (35.8%)	-0.05		-2.59		-1.14		-1.03		0.004					
Non-agricultural (8.0%)	-0.44		-2.98		-1.20		-1.16		0.004					
Regular service (17.2%)	+1.30		+0.69		-0.02		+0.24		0.273					
Small business (26.8%)	0		0		0		0		0					

The relationship between maternal BMI (continuous) and these socio-economic variables was examined (Table 2) with one category within each socio-economic variable acting as a reference (set to zero). Mothers from better-off households (owning radio, television and living in a better dwelling) tended to be taller, heavier and have higher BMI and MUAC values than mothers from less well off households. Mothers whose husband had either regular service work, were small businessmen or had secondary or higher education were also taller, heavier and generally had higher BMI and MUAC values than mothers whose husbands were daily labourers or who had little or no education.

The relationship between Z-scores and the socio-economic variables was also examined. For HAZ and WAZ, children living in households without a radio or television had, on average, lower means while children with a secondary or higher educated father had significantly better HAZ and WAZ scores on average than children of none or little educated fathers. No significant differences in WHZ means were found with any of the socio-economic variables although the results were in the expected direction with more well-off children having, on average, better means than less well-off children.

Using the five maternal BMI cut-offs there was a trend of increasing ownership of a radio or television from maternal CED III to grade 1 obesity (17.3% to 44.2% for radio ownership and 12% to 38.5% for television ownership). As level of husband's education increased so the percentage of wives in CED grade III decreased from 55.4% (no education) to 2.7% (higher education and graduate). There was no significant relationship between BMI cut-offs and type of dwelling.

The correlations between child Z-scores and maternal anthropometry were all positive and modest except for the small negative association between maternal height and WHZ (Table 3).

Table 3. Correlations between maternal anthropometry and child Z-scores.

	Maternal Anthropometry							
	Height (cm)		Weight (kg)		BMI (kg/m^2)		MUAC (cm)	
Child	r	p	r	p	r	p	r	p
Weight-for-age	+0.082	<0.01	+0.240	<0.01	+0.231	<0.001	+0.154	<0.001
Height-for-age	+0.210	<0.001	+0.161	<0.001	+0.071	0.023	+0.082	<0.001
Weight-for-height	-0.142	<0.001	+0.162	<0.001	+0.263	<0.001	+0.130	<0.001

Table 4 shows that the percentage of children underweight (WAZ) wasted (WHZ) and stunted (HAZ) (using either -2 or -1.5 SD Z-score cut-off) varied significantly between the five maternal BMI categories. There was a tendency for the percentages of children <-2 or <-1.5 for WAZ and WHZ to increase from maternal grade 1 obese to CED grade III. For example, nearly one third of children with mothers in CED grade III were wasted (-2 cut-off) compared with about 1 in 18 children whose mothers were grade 1 obese. No trend was observed for HAZ using the -2 cut-off, and between one third and about a half of the children were stunted in each of the 5 maternal BMI categories. When a HAZ -1.5SD cut-off was used the significant heterogeneity was mainly attributable to the lower

percentage (48.1%) found with grade 1 obese mothers compared with higher percentages (ranging from 65.3% to 74.5%) found in the other four categories.

Table 4. The percentage distribution of households on the basis of 5 maternal BMI categories and child Z-scores of either below -2 or below -1.5.

Child	Mother's Body Mass Index (kg/m^2)						
	<16	16–16.9	17.0–18.4	18.5–24.9	25.0–29.9	Total	p
<-2.00							
Weight-for-age	37.3	58.2	52.3	48.3	32.7	48.4	0.008
Height-for-age	61.3	69.4	54.3	44.1	25.0	48.8	<0.001
Weight-for-height	32.0	24.5	12.2	10.4	5.8	13.4	<0.001
<-1.5							
Weight-for-age	69.3	74.5	69.5	65.3	48.1	66.4	0.016
Height-for-age	86.7	90.8	81.2	71.2	51.9	75.2	<0.001
Weight-for-height	52.0	46.9	37.6	25.8	15.4	31.5	<0.001

Table 5 shows the classification of households using maternal BMI (<18.5 and ≥18.5) and children's Z-scores. Just over half the households are in the advantageous position of having children within the normal range for WHZ and mothers with BMI ≥18.5. If the coexistence of normal or overweight mother in the same household as a malnourished child is taken to signify that food availability is not the primary problem, then 6.4% of the households have children with very low WHZ scores implying impaired child care and/or the problem of infections arising from poor sanitation or low immunisation rates.

Table 5. The percentage distribution of households on the basis of two maternal BMI categories and child Z-scores of either below -2 or below -1.5.

Child's Z-score	Maternal BMI <18.5	≥18.5	Total (%)
Height-for-age			
<-2.00	18.4 (25.6)	30.1 (40.9)	48.5 (66.5)
≥-2.00	17.7 (10.5)	33.8 (23.0)	51.5 (33.5)
Weight-for-age			
<-2.00	21.6 (30.6)	27.3 (44.6)	48.9 (75.2)
≥-2.00	14.5 (5.4)	36.6 (19.3)	51.1 (24.8)
Weight-for-height			
<-2.00	7.0 (15.5)	6.4 (16.0)	13.4 (31.5)
≥-2.00	29.1 (20.6)	57.5 (47.9)	86.6 (68.5)

Percentages for -1.5 are shown in brackets.

There was no evidence that the children with these very low WHZ scores had elevated prevalences or intensities (as measured by eggs/g in faeces) of roundworm, whipworm and hookworm. No data were available on immunisation rates or chronic diseases. Only about 1 in 14 households have a food availability problem based on low weight-for-height and low maternal BMI. Use of -1.5 cut-off for WHZ reduced the advantageous households to just below 50% but, as with a cut-off of -2, about half of the wasted children (total 31.5% at Z-score of -1.5 and 13.4% at -2) are found in households where the mother has normal BMI (16.0% and 6.4% for Z-scores of -1.5 and -2, respectively).

Overall nearly half the children were stunted, but stunting was much more common in households where the mother had a normal BMI (30.1%) than in households where the mother was of low BMI (18.4%). Use of the -1.5 cut-off indicated that two-thirds of children were at risk of stunting with the majority of such children being in households where the mother had normal BMI.

Sequential binary logistic regression analyses were used to test whether there was an independent effect of maternal BMI on child HAZ, WAZ and WHZ scores (<-2 and ≥-2.00) after removing the effects of the five socio-economic variables. Two sets of analyses were undertaken, one using the two maternal BMI categories the other using the five BMI categories. The results of both sets of analyses did not show that the addition of maternal BMI led any significant improvement in prediction of underweight, wasted or stunted children.

The relationship between maternal BMI and childhood wasting was originally investigated in five locations (three from Ethiopia, Sidama, South Shoa and Northern Region, and one each from India and Zimbabwe, James et al. 1999) and a highly significant (p=0.007) linear regression was found between the average weight-for-height Z-score of each community and the average maternal BMI for the same community. When the Bangladeshi data are added (Figure 1) they lie midway between the Indian and Zimbabwean values and the regression remains very significant (p=0.002) with only a small change in regression line (Z-score = -6.46 + 0.28 x BMI, Figure 1) to that obtained without Bangladesh (Z-score = -6.63 + 0.284 x BMI).

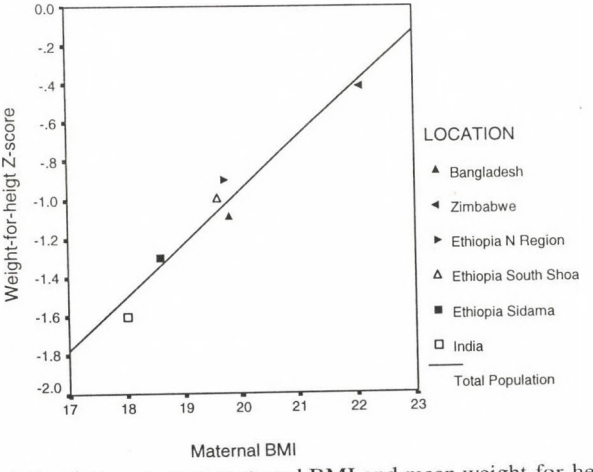

Figure 1: The association between mean maternal BMI and mean weight-for-height Z-score of children in six Third World locations.

Finally the data on wasting and stunting from the six locations using the four mother-child categories were compared (the percentages are presented in Table 6 for ease of comparison). A contingency chi-square showed that there was very significant heterogeneity between locations ($p<0.001$) and in particular very marked differences between India and Bangladesh.

Table 6. Percentages in the four mother-child combinations by Location.

Location	<-2 Z-score & <18.5 BMI	<-2 Z-score & ≥18.5 BMI	≥-2 Z-score & <18.5 BMI	≥-2 Z-score & ≥18.5 BMI
		Wasting (weight-for-height)		
Sidama, Ethiopia	18.3	16.0	32.8	32.8
South Shoa, Ethiopia	5.8	13.1	17.2	63.8
Northern Region, Ethiopia	11.8	20.5	15.3	52.5
Zimbabwe	1.2	6.6	6.1	86.1
India	33.3	13.8	23.0	29.9
Bangladesh	7.0	6.4	29.1	57.5
		Stunting (height-for-age)		
Sidama, Ethiopia	38.6	37.9	12.1	11.4
South Shoa, Ethiopia	16.6	55.2	6.4	21.8
Northern Region, Ethiopia	18.1	47.1	8.9	25.9
Zimbabwe	1.2	6.6	6.1	86.1
India	33.3	13.8	23.0	29.9
Bangladesh	18.4	30.1	17.7	33.8

Discussion

The use of adult anthropometric measurements as a proxy for food availability raises the issue of direct measurement of food consumption in relation to body weight and heights. However food intake is notoriously difficult to measure and attempts to monitor individual women's intake is a major problem because of under-reporting (James and Shetty 1982, Black et al. 1993). Furthermore differences in physical activity patterns and basal metabolic rate (Bogardus et al. 1986) can further complicate the issue. Ferro-Luzzi et al. (1994) suggested that it is reasonable to infer that low adult BMIs reflect inadequate food intakes although, alternative explanations include severe trace element deficiencies, HIV and chronic intestinal parasitic infections and diseases (Montresor et al. 2002). In Bangladesh data on these alternative explanators is generally lacking in adults but a survey of women tea pluckers with, on average, low BMIs did not find any evidence for high intensities of helminth infections as measured by eggs/g in faeces (Gilgen et al. 2001).

Although for both HAZ and WHZ there was evidence of significant increases in the percentage of stunted and wasted children from grade 1 obese mothers to CED grade III, the correlations between children's Z scores and maternal BMI were generally low-to-moderate. After correcting for associations with background socio-economic variables low maternal BMI (either <18.5 and ≥18.5 or CED grades III to I, normal and obese

grade 1) did not improve the prediction of children with <-2 Z-scores. These results are in keeping with previous studies (James et al. 1999) in suggesting that factors other than food availability are important.

Overall in Bangladesh stunting is between three and four times more prevalent than wasting (48.5% vs.13.4%), but stunted children are much more likely to be found in households where the mother is not malnourished (30.1% vs. 18.4%, for maternal BMI ≥ 18.5 and <18.5 respectively) which again highlights the need for public health measures and maternal education. Further support for such measures comes from the KAP surveys carried out in the five Bangladeshi villages which found evidence of poor personal hygiene and sanitation facilities and where knowledge of the health significance and transmission of intestinal parasites was very limited (Mascie-Taylor et al. 2003).

Comparison of the data from Bangladesh and India revealed marked heterogeneity in the distribution of households on the combined basis of maternal BMI and children nutritional status. In rural India there is clear evidence that food availability is a problem with a third of the sample having mothers below 18.5 BMI and their children wasted and stunted whereas the corresponding wasting and stunting figures for Bangladesh are 7% and 18.4% respectively. In Bangladesh wasting is found more or less equally in households where the mother is below or above 18.5 (7% and 6.4% respectively) indicating that some households are in need of more food while for others greater public health measures and education is desirable.

In conclusion the analyses of mother-child anthropometry suggests that the main priority in combating childhood malnutrition in rural Bangladesh is through improvement in public health measures and maternal health education. Food availability does not appear to be of prime importance.

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