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Use of Mid-upper Arm Circumference for Evaluation of Nutritional Status of Children and for Identification of High-risk Groups for Malnutrition in Rural Bangladesh

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ABSTRACT

Measurements of mid-upper arm circumference (MUAC) of 8,881 children were considered cross-sectionally to determine the effects of diarrhoea, breast-feeding, and birth-spacing on the nutritional status of children in rural Matlab, Bangladesh. It was observed that age was one of the most significant determinants of child nutrition. The younger children (<2 years) had significantly higher levels of severe malnutrition than the children aged 2 years or older. Children who had diarrhoea during the last 12 months prior to the study had significantly (p<0.001) higher severe malnutrition than the children who did not suffer from diarrhoea. Children born with a longer interval after birth of an elder sibling (24+ months) and who were breastfed for a longer duration (2-3 years) were less likely to be severely malnourished than those who were born with a shorter birth interval or who terminated breast-feeding prior to 2 years of age. Education of mothers, housing space, family size, religion, and sex of children had significant effects on the nutritional status of children. Results of the study suggest that MUAC is a potential anthropometric indicator of child nutrition.

Key words: Child nutritional status; Anthropometry; Child nutrition disorders; Breast-feeding; Birth interval

INTRODUCTION

Improving health of children, aged less than 5 years, is now one of the main objectives of primary healthcare services in most developing countries. The goal of the World Health Organization (WHO), 'Health for All by the Year 2000,' seems not to be attainable, particularly for children, in the absence of comprehensive primary healthcare programmes in developing countries to include a provision for improving the nutritional status of mothers and young children.

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Much has been written about the relationship between diarrhoea and malnutrition. The association between malnutrition and diarrhoea is so common in developing countries that the concept of a diarrhoea-malnutrition cycle, with diarrhoea leading to malnutrition and malnutrition predisposing diarrhoea, demands more attention (1).

Several studies have shown that malnourished children have a higher incidence of diarrhoea (2-5) and a higher case-fatality rate than do sufficiently-nourished children (6). These studies have also found that malnutrition resulted from diarrhoea lasts longer (3,7,8) and is more severe (9-11). It has been observed that diarrhoea has an adverse effect on growth of children, and is an important cause of their malnutrition (12). At the same time, malnourished children suffer from diarrhoea of greater severity (2,13), and are at an increased risk of death from a variety of infectious diseases (14,15). One study conducted in Bangladesh, however, failed to demonstrate that nutritional status is associated with the subsequent risk of diarrhoeal illness (16).

For the management of diarrhoea in children aged less than 6 months, continued exclusive breast-feeding is the most important component. Exclusive breast-feeding is recommended for the first 4-6 months of life, particularly because it can help prevent diarrhoea by minimizing the exposure of infants to diarrhoeal pathogens. Breast-feeding alone, however, is not sufficient to support continued growth after 4-6 months of age. After this age, the nutritional status improves among those children who are partially breastfed and given weaning food (17-19). Continued breast-feeding is recommended up to the second year of life with an increasing volume and varieties of suitable weaning foods (20).

One of the major causes of malnutrition among children in developing countries is the withdrawal of food and discontinuation of breast-feeding when a child has diarrhoea (21). In such cases, mothers usually stop breast-feeding because of the belief that breast-milk harms an ill child (22). Cessation of breast-feeding may have considerable impact on child nutrition, particularly in countries where discontinuation of breast-feeding is more common in an early age.

Child health is also affected by maternal age, number of living children, and span of interval between successive births (23-25). Malnutrition is considered to be the underlying cause or the exacerbating factor in many (if not most) postneonatal and child deaths in developing countries (26). Longer spacing between two births allows for the optimum use of parent time inputs and resources for each child, which, in turn, improve child health. However, a study by Roy *et al*. in the same area did not find any relationship between previous birth interval and nutritional status (Roy N *et al*., unpublished, 1993). Huffman observed that birth-spacing differs by religion due to differential weaning practices (27).

Findings of other important studies on diarrhoea and nutrition (1,7,11,28,29) reveal that the incidence, types, and duration of diarrhoea have both short- and long-term negative effects on nutritional status of children. These studies were specially designed to measure the impact of diarrhoea on nutrition, and moreover, these studies used anthropometric measures of weight-for-age and height-for-age that can not easily or inexpensively be measured.

Although height can be measured with a plastic tape, it is used for measuring stunting which is age-dependent and also in the cumulative effect of chronic malnutrition. However, mid-upper arm circumference (MUAC) is a useful tool for a fast assessment of nutritional status. It is an easy and inexpensive way to detect childhood malnutrition, and is increasingly used in developing countries for rapid and extensive nutrition surveillance and screening programmes (30).

The present study investigated the effects of some demographic and socioeconomic factors and diarrhoea on child nutrition after controlling for confounding variables, such as breast-feeding and the presence of a younger sibling. This was done using an easily-measurable indicator–MUAC.

METHODS AND MATERIALS

Data for this analysis came from the erstwhile Maternal and Child Health-Family Planning (MCH-FP) Project in Matlab. Matlab is a treatment area of the Health and Demographic Surveillance System (HDSS) maintained by the ICDDR,B: Centre for Health and Population Research. Details of the study area are described elsewhere (31,32). Data-collection procedures are briefly described below.

Every fortnight a trained fieldworker visited the households to collect information on vital events, such as births, deaths, migration-in, migration-out, marriages, etc. They also collected information on mother's and child health issues, such as tetanus toxoid (TT) immunization to mothers, child immunization, child morbidity, child nutrition, etc.

For quality assurance of data collection, a 3-tier supervisory system has been maintained in the Matlab fieldsites. After the visit of the fieldworker, a Senior Field Research Assistant (SFRA) revisited and collected data from 5% of the sample households, and enquired whether the fieldworker had visited the households and collected necessary information. If any discrepancies were found, the SFRA asked the fieldworker to revisit the household. Upper-level supervisors, either Field Research Officers (FRO) or Senior Field Research Officer (SFRO) monitored data collection by spot-checking quarterly or twice a year.

In total, 8,881 children in the treatment area, born between January 1983 and December 1986 and whose measurements of MUAC were taken at the last quarter (October–December) of 1987 were considered for this analysis. A longitudinal record of each child aged less than 5 years and his or her mother in the study area was maintained by the Record-keeping System along with health-related information, such as MUAC, diarrhoea, management of diarrhoea, immunization status, breast-feeding status, and background characteristics. These prospective records were computerized monthly, and formed a valuable database for the investigation of diverse health and family-planning issues.

A plastic measuring tape was used for obtaining arm circumference in millimeter. Data for all children aged over 6 months with MUAC <120 mm were collected each month, and MUAC greater than 120 mm were collected quarterly. If the fieldworker found any child absent at the time of the first fortnightly visit, another effort was made to collect information in the next visit. If the child was also not found in the subsequent visit, MUAC information was treated as missing for that particular quarter only.

Children, who died, migrated out, or were absent during measurements of MUAC in the last quarter of 1987, were excluded from the analysis. Multiple births were also excluded, because, in such cases, nutritional status would be influenced by other factors. Demographic and socioeconomic characteristics of the excluded children did not differ from the study children as the children were from the treatment area where the ICDDR,B is providing healthcare facilities in addition to the government facilities. In the comparison area, only the government facilities are available.

During the fortnightly visit, the fieldworkers visited each household and collected information on diarrhoeal morbidity from statements given by mothers. Children who had 3 or more loose watery motions with or without mucus in any 24-hour period were considered to have watery diarrhoea. A child was considered to have dysentery if blood was present in the stool. In this analysis, 2 types of diarrhoea were considered: simple (watery and non-watery diarrhoea) and dysenteric diarrhoea. The episodes of diarrhoea were recorded on each day of occurrence within 2 weeks prior to the day of visit.

Information on breast-feeding was based on how many months a child was breastfed during infancy and childhood (full or partial breast-feeding was included). If any child was absent at the time of fortnightly visit, another effort was made to get the breast-feeding information in the next visit by the health worker as done in measuring MUAC.

Crude analysis was performed using cross-tabulation, and the net effects were estimated by multivariate logistic regression, using the SAS and Stata package for statistical analysis. Data for the measurements of MUAC were compared with the WHO age- and sex-specific standard mean MUAC data (33). Measurements were expressed in terms of z-score of MUAC-for-age (MAZ), a multiple of standard deviation (SD) from the WHO reference population:

MAZ= {(Observed MUAC - reference MUAC-for-age)/SD of reference MUAC)}

For screening severely-malnourished children in a large population, a MUAC cut-off point of MAZ <-2 score or a traditional cut-off point of MAZ <125 mm among different age groups of children (<5 years) is not suitable. The measurement included both moderately- and severely-malnourished children. It is also expected that children with MAZ <-3 are also likely to have weight-for-age z-score (WAZ) <-3 and/or weight-for-height z-score (WHZ) <-3 (not calculated in this analysis). Therefore, to differentiate the severely-malnourished children, MAZ <-3 score was used in the analysis (Appendix).

Logistic regression was used by defining dichotomies for nutritional status as a dependent variable: MAZ score <-3=1 for severely-malnourished children and zero otherwise. The independent variables used included: sex of children, education of mothers, family-dwelling space, diarrhoeal episode during the last one year, number of days suffered if the children had diarrhoea, number of months the children were breastfed, and previous and subsequent birth intervals.

RESULTS

Table 1 shows a significant relationship among the children in different age groups. As the age of children increased, the proportion of children with severe malnutrition decreased. A higher proportion of the female children suffered from severe malnutrition than the male children. Families with fewer children (1-2 children) had a lower proportion of severely-malnourished children than the families with more than 3 children. A higher proportion of children was severely malnourished who were from the household with small dwelling spaces compared to the children from the household with larger spaces. Religion also played an important role in nutritional status of children. In the study area, the Muslim families had a higher proportion of severely-malnourished children compared to the non-Muslim families.

A higher proportion of severely-malnourished children was observed among those children who suffered from diarrhoea during the last one year prior to the measurements of MUAC (Table 2). Proportion of malnourished children was higher among children who suffered from diarrhoea for a longer period. The pattern did not change even when it was classified as simple diarrhoea and diarrhoea with dysentery.

Table 3 shows the proportion of severely-malnourished children according to the maternal characteristics. Age of mothers had a significant relationship with the nutritional status of their children. The older age groups of mothers had a higher proportion of malnourished children. Of the children who were breastfed for a longer period (24+ months), a small proportion suffered from severe malnutrition than those who were breastfed for less than 24 months. Previous birth interval did not show any significant relationship with child malnutrition. However, a higher proportion

Table 1. Percentage of children with MAZ <-3 for different demographic characteristics

Variable	No. of children	Percentage MAZ <-3	Relative risk of malnutrition	95% CI
Age of children (in months)				
12-17	1,264	22.23	1.00	
18-23	1,011	20.87	0.92	0.79-1.18
24-35	2,378	10.98	0.43	0.58-0.83
36-47	2,041	7.45	0.28	0.47-0.71
48+	2,187	6.77	0.25	0.45-0.68
		χ^2=302.71(4), p<.001		
Sex				
Male	4,488	10.54	1.00	
Female	4,393	13.20	1.29	0.98-1.27
		χ^2=15.07(1), p<.001		
No. of living siblings				
None	966	12.94	1.00	
1-2	3,887	10.68	0.80	0.73-1.13
3-5	3,176	13.04	1.01	0.81-1.24
6+	808	11.39	0.86	0.70-1.25
		χ^2=10.67(3), p<0.05		
Dwelling space (sq ft)				
<170	2,414	14.62	1.00	
170-349	4,733	11.51	0.76	0.77-1.02
350+	1,069	8.04	0.51	0.58-0.97
		χ^2=32.67(2), p<0.001		
Religion				
Muslim	7,401	12.65	1.00	
Hindu	1,480	7.91	0.59	0.65-0.97
		χ^2=26.53(1), p<0.001		

CI=Confidence interval

of severely-malnourished children was observed among children whose mothers experienced another birth within second birth day of the study children. A higher proportion of children suffered from severe malnutrition whose mothers were illiterate than the children whose mothers were literate.

Table 4 shows the average number of diarrhoeal episodes by age groups of children who had experienced diarrhoea prior to the measurements of MUAC. Although the difference in the number of episodes by MAZ scores was not large, there were significant differences between the severely-malnourished (MAZ <-3) and not-severely malnourished (MAZ $\geq$-3) children, aged up to 4 years. After that, no significant differences were observed.

The results of logistic regression analysis, using nutritional status as the dependent variable [a dummy variable with a value of 1 if MAZ score <-3 for severely malnourished and 0 if MAZ score $\geq$-3 for not severely malnourished] are shown in Table 5. The results are shown in terms of odds ratios obtained by taking the exponential function of estimated regression coefficients and 95% confidence interval.

A higher correlation-coefficent (r=0.65) was observed between age of a child and duration of breast-feeding. As the duration of breast-feeding increased, the age of children obviously increased but the reverse might not necessarily be true. This implies that breast-feeding, in fact, was confounded by the age of children. In the logistic regression, the age of children was excluded from the regression model.

Children who experienced diarrhoea during the last one year prior to the measurements of MUAC, likelihood of suffering from severe malnutrition was 65% higher than the children who did not suffer from any diarrhoea, and the difference between the 2 groups was highly significant (p<0.001). The female children were significantly (p<0.001) more severely malnourished than the male children. The children of the Muslim families were significantly (p<0.001) more likely to be malnourished compared to the children of the Hindu families. Likelihood of a lower percentage of severely-malnourished children in the Hindu families might be explained by the fact that, at the age of sixth month of a child, most Hindu families celebrate a religious festival by giving cereal food for the first time to the baby. So, the children of the Hindu families depended largely on exclusively breast-feeding for about 6 months after their birth, and continued breast-feeding for a longer period with additional weaning food.

A significantly lower (p<0.001) percentage of children became severely malnourished who were

Table 2. Percentage of children with MAZ <-3 score by diarrhoeal morbidity

Variable	No. of children	Percentage MAZ <-3	Relative risk of malnutrition	95% CI
Diarrhoea (all types) during the last one year				
No	4,486	9.03	1.00	
Yes	4,363	14.78	1.75	1.12-1.45
		c^2=70.06(1), p<0.001		
No. of days suffered from diarrhoea during the last one year				
Not suffered	4,486	9.03	1.00	
1-7 day(s)	2,732	13.03	1.51	1.03-1.39
8-14 days	1,198	15.78	1.89	1.09-1.59
15+ days	433	23.09	3.02	1.26-2.07
		c^2=107.81(3), p<0.001		
Diarrhoea (simple) during the last one year				
No	5,436	9.77	1.00	
Yes	3,413	15.21	1.66	1.09-1.42
		c^2=59.30(1), p<0.001		
No. of days suffered (simple diarrhoea) during the last one year				
Not suffered	5,436	9.77	1.00	
1-7 day(s)	2,600	14.19	1.53	1.04-1.39
8-14 days	670	15.67	1.72	1.01-1.59
15+ days	143	31.47	4.24	1.30-2.70
		c^2=98.15(3), p<0.001		
Dysentery during the last one year				
No	7,165	11.04	1.00	
Yes	1,684	15.38	1.46	1.01-1.37
		c^2=24.56(1), p<0.001		
No. of days suffered from dysentery during the last one year				
Not suffered	7,165	11.04	1.00	
1-7 day(s)	862	12.76	1.18	0.87-1.33
8-14 days	629	17.65	1.73	1.02-1.58
15+ days	225	19.69	1.98	1.00-1.88
		c^2=36.73(3), p<0.001		

CI=Confidence interval

breastfed for more than 2 years compared to the children who were breastfed for only one year. Children who were breastfed for 13-23 months were also more vulnerable than those children who were breastfed up to 12 months. The reason behind this fact might be that these children were mainly dependent on breast-feeding, and were not given weaning food properly. Education of mothers was found to be a highly significant factor in relation to the nutritional status of children. A significantly (p<0.001) lower percentage of severely-malnourished children was observed among the children of literate mothers compared to the children of illiterate mothers. Too many people living in a small area results in overcrowding and disease infection among the children of that family. The effect of household area on the nutritional status of children was highly significant (p<0.01 and p<0.001), indicating that children of poor families were more vulnerable than those of well-to-do families. A child whose birth was followed by the birth of a sibling with an interval of less than 2 years faced a significantly higher (p<05) risk than a child whose younger sibling was born after a longer birth interval.

DISCUSSION

Our findings contribute to the understanding of the relationship between diarrhoea, breast-feeding and birth interval, and nutritional status of children in several ways. Firstly, severe malnutrition was higher among the younger children and decreased with age. Children who had diarrhoea during the previous year were at a higher risk for severe malnutrition. The longer the duration of diarrhoea, the higher were the negative effects on nutrition among children aged less than 5 years. This indicates that, other than diarrhoea, there are factors

Table 3. Percentage of children with MAZ <-3 score for different maternal characteristics

Variable	No. of children	Percentage MAZ <-3	Relative risk of malnutrition	95% CI
Mother's age (in years)				
<25	4,316	10.13	1.00	
25-35	3,705	13.36	1.37	1.00-1.31
36+	860	14.07	1.45	0.98-1.46
		χ^2=24.43(2), p<0.001		
Breast-feeding				
Up to 12 months	523	15.87	1.00	
12-23 months	3,098	18.04	1.17	0.83-1.38
24+ months	4,690	7.57	0.43	0.54-0.90
		χ^2=4.35(2), p<0.23		
Previous birth interval (PBI)				
No PBI	913	13.14	1.00	
<24 months	914	13.24	1.01	0.77-1.32
24+ months	7,054	11.51	0.86	0.76-1.15
		χ^2=3.92(2), p<0.15		
Subsequent closed birth interval (SBI)				
No SBI	6,235	12.70	1.00	
<24 months	474	11.81	0.92	0.72-1.29
24+ months	2,172	9.44	0.72	0.74-1.02
		χ^2=16.42(2), p<0.001		
Mother's education				
No education	5,416	13.76	1.00	
Primary	2,303	9.08	0.63	0.69-0.96
Primary and above	842	6.53	0.44	0.53-0.93
		χ^2=58.84(2),p<0.001		

CI=Confidence interval

Table 4. Mean number of diarrhoeal episodes by age groups of children and their MAZ scores

Age group (in months)	Mean number of diarrhoeal episodes MAZ <-3	MAZ $\geq$-3
12-17	1.72	1.52
18-23	1.97	1.79
24-35	1.95	1.72
36-47	2.01	1.66
48-59	1.73	1.64

contributing to malnutrition of children. Secondly, the average duration of breast-feeding in Matlab is high, ranging from 30 to 34 months (34). It is also shown in our study that children who were breastfed for more than 2 years were less-severely malnourished than those who were breastfed for less than 2 years. Finally, the strong effects of breast-feeding extending to the toddlerhood are not surprising, given the condition in the study area characterized by poverty, poor sanitation, and a riverine environment.

The children of mothers with no older siblings had nutritional status almost equal to those children born 2 or more years after an older sibling. Mother's inexperience in child-rearing could be an explanation in this regard. A subsequent birth interval of less than 24 months had a significant effect on the nutritional status of children. Short birth intervals may have an adverse effect on child nutrition because of 2 factors. First, as the number of children increases, competition for both maternal attention and care and for the available food increases. Second, an early subsequent conception coincides with earlier termination of breast-feeding and higher risk of malnutrition to the previous child.

Children born to women with low-educational attainment or living in a small house are more likely to be severely malnourished than children born to women with higher education and economical solvency. There are evidences that low-educational attainment and certain religious customs predispose to diarrhoea, presumably because of behavioural factors. Interrupting the transmission of diarrhoeal disease depends primarily on improved hygiene and facilities, such as water supply and latrines, which facilitate improved hygiene (35).

This community-based investigations on the effects of diarrhoea, birth spacing, and breast-feeding on the nutritional status of children in Bangladesh has several limitations. First, the cross-sectionally-collected MUAC information analyzed in this study rather than repeated collection of MUAC information created the omission of a large number of children, although some longitudinal data (e.g. breast-feeding, duration of

Table 5. Odds ratios from logistic regression of different covariates on nutritional status of children aged 1-4 year(s) with MAZ <-3 score

Covariate	Odds ratios	95% CI
Diarrhoea		
No	1.00	
Yes	1.65*	1.43-1.89
Sex		
Male	1.00	
Female	1.35*	1.17-1.54
Religion		
Muslim	1.00	
Hindu	0.54*	0.44-0.68
Breast-feeding (in months)		
Up to 12	1.00	
13-23	1.41†	1.13-1.76
24+	0.52*	0.41-0.65
Mother's education		
No education	1.00	
Primary	0.66*	0.55-0.78
Secondary+	0.49*	0.36-0.65
Dwelling space (sq ft)		
<170	1.00	
170-349	0.76†	0.65-0.88
350+	0.54*	0.41-0.71
Subsequent birth intervals (months)		
<24	1.00	
24+	0.83§	0.70-0.99
Constant	-1.79*	
-2Log likelihood	5587	
N	8163	
χ^2	381	
df	10	

CI=Confidence interval; * p<0.001, † p<0.01, § p<0.05

diarrhoea, subsequent birth interval, etc.) were used for this analysis. Second, diarrhoea morbidity was obtained by fortnightly recall rather than daily, every 2 days, or weekly recall. The constraint of recall error could not be eliminated. Finally, diarrhoea was identified by the child's mother as a clinically apparent disease. Diarrhoeal infections may not be apparent, and bacteriologic and other diagnostic tests were lacking to identify the possible aetiologic agents. Other potential confounding variables, such as role of seasonal variation, environment, diet, and other factors of morbidity, were not controlled. Neither were more plausible effects of malnutrition on diarrhoeal mortality considered in this analysis.

The mean number of recorded diarrhoeal episodes was 1.70 per year, which is substantially lower than the 4-5 episodes per year reported in 2 earlier studies in Matlab (6,16). In 2 other studies (3,7), the number of episodes of diarrhoea (1.44 and 1.35) was comparable with the diarrhoeal episodes observed in this study. Differences in age distribution or in the frequency of home visits for diarrhoeal data collection could not explain the lower incidence of diarrhoea observed. In the present study, mothers probably reported only the most severe cases of diarrhoea. In the previous studies, carried out in the early 1980s using data from the mid-1970s, milder cases of diarrhoea were most likely recorded during the twice-weekly and weekly visits and included in the analysis.

In spite of the above limitations, this study has several policy implications. MUAC seems to be a potential anthropometric indicator of child nutrition. Measuring arm circumference is simple, and requires little time. It should, thus, be preferred to more complex-screening schemes for selecting children at a high risk of malnutrition. Prevention of diarrhoea will lead to better nutrition of children. Mothers should be encouraged to continue exclusively breastfeed up to 6 months of age to their new born child, and, in addition to weaning food, partial breast-feeding should be continued up to 2 and a half years of age of their children to prevent both diarrhoea and malnutrition. One of the major causes of childhood malnutrition in developing countries is the withdrawal of food during diarrhoea. To interrupt this debilitating cycle and to prevent large-scale of severe malnutrition among children, continuing feeding should be advocated during diarrhoea. Mothers should be informed of the increased nutritional needs of children during illnesses and convalescence, and perhaps, even more so with regard to diarrhoea. Mothers should also be advised to use contraceptives for spacing and limiting births. This will lead to a reduction in overall malnutrition, and thus, to better health among children.

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Appendix

Proportion of malnourished children by age and sex by traditional method and standardized MAZ scores

Age group (months)	Total no. of children		Traditional method cut-off point <125 mm		Sex-age-specific cut-off points compared to WHO standard MAZ <-2		MAZ <-3	
	Male	Female	Male	Female	Male	Female	Male	Female
12-17	619	645	27.63	42.95	68.01	68.22	21.00	23.41
18-23	527	482	25.33	35.06	64.65	67.84	19.47	22.41
24-35	1,197	1,181	18.55	25.91	56.06	60.20	9.19	12.79
36-47	1,018	1,023	8.64	13.29	51.28	55.13	6.68	8.21
48-59	1,125	1,062	4.53	6.78	57.16	56.87	5.51	8.10
All ages	4,488	4,393	14.84	21.85	57.91	60.23	10.54	13.20

AUTHOR’S CORRECTION

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At page 81, column 1, para 1, line 3, “89.7 dollar” should be read “189.6 dollar” as in Table 1.