# Determinants of Child Malnutrition in Rural Bangladesh

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## ABSTRACT

From the longitudinal demographic surveillance programme in Matlab, Bangladesh, Mid-upper Arm Circumference (MUAC) measurement of about 9,000 children was considered cross sectionally to see the effects of diarrhoea, breast feeding and birth spacing on child nutritional status. The results suggest that age is one of the most significant factors for child nutrition. The younger children aged less than 2 years had significantly higher malnutrition compared to the children aged over 2 years. Children who had diarrhoea during the last year had a nutritional status which was significantly lower ($p < 0.001$) than that of children who did not suffer from diarrhoea. Children who were born with a longer interval between births (24+months) and who were breast fed for a longer duration (2-3 years) were more likely to be less malnourished than those who were born with a short birth interval or who terminated breast feeding before 2 years of age. The mother's education, housing space, family size, religion, and sex of the child have been found to have a significant effect on child nutritional status.

# INTRODUCTION

Improving the health of children under five is now one of the main objectives of basic health services in most developing countries. The World Health Organization (WHO) has set a goal of "Health for All by the Year 2000". This goal, however, will be unattainable, particularly for children, if comprehensive primary health care programme in developing countries does not include serious attempt to improve the nutritional health of mothers and young children.

One of the most influential international health organizations, WHO, has concluded that diarrhoea is often the major cause of malnutrition in developing countries (1). Much has been written about the relationship between diarrhoea and malnutrition. The association between these is so common in developing countries that the concept of a diarrhoea-malnutrition cycle, with diarrhoea leading to malnutrition and malnutrition predisposing diarrhoea, is appealing (2). Of these two interactions, the hypothesis that diarrhoea is a major causative factor in malnutrition relies on a limited number of studies.

Several studies have shown that malnourished children have the higher incidence of diarrhoea (3-4) and that it lasts longer (5), and is severe (6-8), and has a higher case fatality rate. A study in Bangladesh, however, failed to demonstrate that nutritional status was associated with the subsequent risk of diarrhoeal diseases (9).

The purpose of this analysis is to investigate the effects of some demographic, socioeconomic factors, and diarrhoea on child nutrition after controlling for confounding variables, breast feeding and the presence of a younger sibling using a easily mesurable indicator, Mid-upper Arm Circumference (MUAC).

In this analysis, the relationship between diarrhoea and malnutrition has been examined using cross-sectional measurements of MUAC to detect children at high risk of malnutrition in Matlab, a rural area of Bangladesh. Multivariate regression is used to estimate the effect of diarrhoea on child nutritional status for controlling breast feeding and birth intervals. Demographic and socioeconomic factors are also considered to understand the impact of diarrhoea on child nutrition.

# LITERATURE REVIEW

## Diarrhoea and Malnutrition

Diarrhoea associated with malnutrition is probably the most common cause of death in young children in developing countries (10). Diarrhoea has been found to have an adverse effect on growth of children and to be an important cause of malnutrition (11). At the same time, malnourished children have a greater severity of diarrhoea (3,12) and an increased risk of death from a variety of infectious diseases, including diarrhoea (13-14). As the prevalence of diarrhoea is a function of its incidence and duration of episodes, it is desirable to know if malnutrition influences one or both of these components.

In an urban community in Gambia, over 35% of the deaths in children aged 0-3 years were found to be caused by diarrhoea coupled with malnutrition (15). Taking into consideration the diarrhoeal morbidity on the day of assessment and diarrhoea during the previous week, Bairagi (16) also found that the diarrhoeal morbidity increases the discriminating criteria of subsequent malnutrition over a one-year period.

In Guatemala, higher diarrhoea attack rates among the malnourished children aged 1-4 years were reported in comparison to their better-nourished counterparts (8,17). In El Salvador, a strong association was found between the nutritional status and the reported occurrence of diarrhoea during a 12-month period (18).

A study in rural Bangladesh found poor nutrition was associated with longer duration of diarrhoea (10). In the same area Chowdhury (4) showed that severe malnutrition was strongly associated with the risk of longer diarrhoeal illness in a 2-month interval in the age group 24-60 months; but no such association for malnutrition was found in the younger (6-23 months) age group.

One of the major causes of childhood malnutrition in developing countries is the withdrawal of food during diarrhoea. A significant reduction in the consumption of all types of food during diarrhoea was reported in a study in Bangladesh (19).

Diarrhoea often causes the deterioration of nutritional status and poor nutritional status increases the duration of diarrhoeal illness. It is possible that the children who suffer from diarrhoea eventually constitute a special group who are at the higher risk of subsequent diarrhoea and who fall into a vicious cycle with higher risk of death (4). The effects of nutritional status on the incidence of diarrhoeal episodes, which are usually determined by environment and personal hygiene, are more varied; the same applies to the severity of diarrhoea. Thus, there are important nutritional implications for both prevention and management of diarrhoea in children. But as nutritional needs change with age and because persistent diarrhoea (duration more than 14 days) carries a greater risk than acute diarrhoea, nutritional requirements are specific to age and duration of diarrhoeal episode (20).

Findings of some important diarrhoea-nutrition studies *(Appendix-1)* reveal that the incidence of diarrhoea, types of diarrhoea and the duration of diarrhoea have short or long-term negative effects on child nutrition. It might be noted that these were the studies that were designed especially to measure the impact of diarrhoea on nutrition.

These studies used anthropometric measures of weight and height that are not easily and inexpensively measured. Many studies did not have control over the effects of potential confounding variables, such as breast feeding, demographic and socioeconomic status, which may affect both diarrhoea and nutritional status of children.

Mid-upper Arm Circumference (MUAC) is an easy and inexpensive way to detect childhood malnutrition. It is being increasingly used in developing countries for rapid and extensive nutrition surveillance and screening programmes (21).

**Breast Feeding and Malnutrition**

Exclusive breast feeding is recommended for the first 4-6 months of life, particularly because it can help prevent diarrhoea by minimising the infant's exposure to diarrhoeal pathogens. For the management of diarrhoea in children of this age, continued exclusive breast feeding is the most important nutritional aspect of management. Breast feeding alone, though, is not sufficient for continued growth after 4-6 months of age. Cesar (22) found that the prevalence of malnutrition was the smallest in those children who fully breast fed for 3 to 6 months, but after this age nutritional status appeared to be worse in those exclusively breast fed children. It is recommended that breast feeding continue into the second year of life with an increasing intake of suitable weaning foods (20).

Boerma (23) found that under the conditions of universally high rates of breast feeding up to 2 years of age, there may not be a relationship between the length of birth interval and nutritional status. A hospital study in Ghana, however, found that breast feeding beyond the age of 19 months was associated with malnutrition. The study concluded that prolonged breast feeding can reduce the total intake and, thus, predispose to malnutrition (24).

In developing countries, it is common for mothers to stop breast feeding when children have diarrhoea (1). In some countries, mothers stop breast feeding, believing that breast milk is harmful to an ill child (25). In contrast, a study in Matlab, Bangladesh found that discontinuation of breast feeding during diarrhoea was an infrequent phenomenon and only 2% of mothers stopped breast feeding their child before presentation for care (26). Cessation of breast feeding may be of considerable importance to child nutrition, particularly in countries where discontinuation of breast feeding is more common in early age.

**Birth Intervals and Malnutrition**

The implication of family formation patterns for the health and survival of children has received particular attention throughout the world. Child health is affected by maternal age, number of living children and the length of the interval between successive births (27). Malnutrition is considered to be the underlying cause or the exacerbating factor in many, if not most, postneonatal and child deaths in developing countries (28).

Research in developed and developing countries indicate that short birth intervals are associated with an increased risk of mortality (29-30). Generally, an increased risk of mortality in the neonatal and postneonatal period is reported for children with short retrospective birth intervals, particularly if the interval is less than two years. No relationship was found between the birth interval and the nutritional status of children in Kenya (23). A study in Bangladesh found that children aged 12-36 months of whose mother gave birth to another child within 24 months were three times more likely than other children to be malnourished, even at the age of 3 years. There was, however, no relationship between previous birth intervals and the nutritional status (31).

Hindu and Muslim religious groups have different patterns in nutritional behaviour in Matlab. Huffman (32) observed that birth spacing differs by religion due to differential weaning practice.

A study by Wary and Aguirre (33) in Colombia found that a short succeeding birth interval had an adverse effect on the nutritional status of children. Another study by Christriansen (34) also found an association between the nutritional status of children and a short succeeding birth interval. The purpose of the analysis also is to assess the relationship between the length of preceding and subsequent birth intervals and the nutritional status of children aged 12-59 months in a rural area of Bangladesh.

# DATA AND METHODS

Data for this analysis came from the ongoing Maternal and Child Health Family Planning (MCH-FP) project in Matlab, a treatment area of the Demographic Surveillance System (DSS) maintained by the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B), since 1963. A description of the study area is given elsewhere (35-36).

A total of 12,513 children aged 12-59 months at the time of MUAC measurements, born between January 1983 and December 1986 in the treatment area, has been considered for this analysis. The choice of this reference period is based on several considerations. First, the past pregnancy histories of women who gave birth during the above mentioned period are available beginning in 1977 and subsequent histories can be found through the end of December 1987. Second, since the data relating to MUAC and diarrhoea are from the first quarter of 1987, children who were born in the above period should have been in the age group 1-4 years by the end of 1987. Thus, the chosen birth cohort represents an unique setting in the linked and edited data files which are available and, therefore, appropriate for an analysis which requires information on the length of previous as well as subsequent birth intervals.

The data collection system in the Matlab MCH-FP area represents a level of completeness and accuracy in the recording of vital events which is unprecedented in a society characterized by such low levels of socioeconomic development. Health workers use a field register to record information fortnightly on the eligible women they visit and their children under five years of age. MUAC data are collected quarterly, during the fortnightly family visit by Community Health Workers (CHWs). During their visits mothers are given nutritional education, and severely malnourished cases (MUAC $<110$ mm) are referred to the nutrition rehabilitation unit in the nearby sub-centre or hospital by CHW.

A longitudinal record of each under five child in the study area are maintained by the Record Keeping System (RKS) along with health-related information (MUAC, diarrhoeal illness, management of diarrhoea, immunization status, etc.) and their background characteristics. A separate longitudinal record of each woman's monthly reproductive, contraceptive, and lactation status is also available together with other health-related information, and background data. These prospective records are computerized monthly and form a valuable database for the investigation of diverse health and family planning issues.

Children aged 12-59 months at the time of MUAC measurement, were included in this analysis. Children who died, migrated out, or were absent during MUAC measurement were excluded. Multiple births were also excluded from this analysis, because their nutritional status may depend on other factors. The records of 8,881 children were eventually included in this analysis.

A plastic measuring tape was used for obtaining arm circumference in millimetre. Information on each child's MUAC was collected every three months by CHW's during home visits.

Every fortnight, a trained field worker visited households and collected information on diarrhoeal morbidity from statements given by the mothers. During the 15 days prior to the field worker's visit, children who had three or more loose watery motions with or without mucus in any 24-hour period were determined to have watery diarrhoea. Non-watery diarrhoea was categorized by three or more semi-solid loose motions without blood. A child was determined to have dysentery diarrhoea if blood was present in the stool. In this analysis, two 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 two weeks prior to the visit day. Microbial cultures were not taken, and antibiotic therapy was not administered. A new episode of diarrhoea was defined as diarrhoea beginning after a minimum of 2 days without diarrhoea. If a child was away from home for some days in a month, those days and any occurrence of diarrhoea during that period were excluded from the calculation of the incidence and the duration of diarrhoea.

The information on breast feeding was based on how many months this child was breast fed during infancy and childhood whether full or partial.

Where crude analysis was performed using cross tabulation, the net effects were estimated by multivariate logistic regression, using the SAS and Stata package for statistical analysis. Data for the measurement of MUAC were compared with the sex-specific standard mean MUAC data of WHO (37). Measurements were expressed as Z-score, a multiple of the standard deviation (SD) from the WHO reference population:

Z = [(Observed MUAC - Reference MUAC for age)/SD of reference MUAC)]

For the screening of severely malnourished children in a large population, a MUAC cut-off point of <-2 Z-score or a traditional cut-off point of <125 mm of different age groups of the children aged less than five years are not suitable. Since the measurement included both the moderate and severely malnourished children so, to differentiate the severely malnourished children, <-3 Z-score is used in this analysis which seems to be most appropriate *(Appendix-2)*.

The logistic regression method was used by defining dichotomies for nutritional status as dependent variable: Z-score <-3 = 1 for undernourished if a child was malnourished and zero otherwise.

The independent variables used include: sex of the child, education of the mother, family dwelling space, diarrhoeal experience during the last one year, number of days suffered if the child had diarrhoea, how many months the child was breast fed during infancy, previous and subsequent birth intervals of the mother. Three categories of mother's education were used: no education (63%), primary education, and above primary level. The total dwelling space has been found to be one of the best proxies for a family's economic condition in the area (38).

The dwelling space is used broadly for classifying the families into lower (<170 sq.ft.), medium (170-349 sq.ft.), and higher (350+ sq.ft.) economic groups. The information on these variables and other socio-economic factors were extracted from the 1982 census in this study area.

The independent variables were also entered into the logistic regression as dichotomies to analyze the effects associated with the worst level of individual variables.

Like other areas in Bangladesh, Matlab area is predominated by the Muslim religion. Eighty-three per cent of the children were from the Muslim families which is little lower than the general population (86%) of Matlab.

# RESULTS

## Bivariate Analysis

Table 1 represents the total number of children aged 1-4 years initially enrolled in this study by their exit status. Of the total children 29% were excluded because of either death (4.6%), migration out (8.6%), birth as a twin (1.2%), or absence at the time of MUAC measurement (15%). Of total enrolled children 71% were eligible for this analysis and were termed 'index children'.

**Table 1.** Distribution of children aged 1-4 years according to their exit status

| Exit status of children | No. of children (n=12,513) | Percentage |
|---|---|---|
| Alive and MUAC measured | 8,881 | 71.00 |
| Absent | 1,826 | 14.59 |
| Out-migration | 1,081 | 8.60 |
| Died | 575 | 4.60 |
| Twin birth | 150 | 1.21 |

The index children are classified using the WHO reference standard (Table 2), which showed that about 12% of the children were malnourished (Z-score = <-3).

**Table 2.** Distribution of children by their nutritional status (WHO reference standard)

| Exit status of children | No. of children (n=12,513) | Percentage |
|---|---|---|
| <-3 | 1,053 | 11.86 |
| -3 to <-2 | 4,192 | 47.20 |
| -2 to <-1 | 3,171 | 35.71 |
| >=0 | 465 | 5.23 |

Table 3 shows that there is a strong association between the age of children and their nutritional status ($p<0.001$). Malnutrition is lower among the older age group (24+ months), whereas malnutrition is higher among the female children ($p<.001$). Malnutrition is higher among children from Muslim families compared to the children from Hindu families (13% vs 8%) and the difference is significant ($p<0.001$).

Children from larger families (i.e. 3+ living siblings) are more likely to be malnourished than those of the smaller families (i.e. 1-2 living siblings). However, mother who had no living sibling, their children were also more likely to be malnourished than those with 1-2 living siblings. These differences are significant at the 5% level.

Too many people in a small house may lead to overcrowding and disease infection in children of that family. Table 3 shows that 30% of children came from families living in small (<170 sq.ft) house. About 15% children living in small house families are malnourished compared to 8% children in larger house families and the difference is highly significant ($p<0.001$).

**Table 3.** Percentage of malnourished children for different demographic characteristics

| Variable | No. of children | Percentage malnourished | Relative malnourished |
|---|---|---|---|
| **Age of children in months** | | | |
| 12-17 | 1,264 | 22.23 | 1.00 |
| 18-23 | 1,011 | 20.87 | 0.94 |
| 24-35 | 2,378 | 10.98 | 0.49 |
| 36-47 | 2,041 | 7.45 | 0.34 |
| 48 + | 2,187 | 6.77 | 0.30 |
| | $Chi^2 = 302.71(4), p < .001$ | | |
| **Sex** | | | |
| Male | 4,488 | 10.54 | 1.00 |
| Female | 4,393 | 13.20 | 1.25 |
| | $Chi^2 = 15.07(1), p < .001$ | | |
| **No. of living siblings** | | | |
| None | 966 | 12.94 | 1.00 |
| 1-2 | 3,887 | 10.68 | 0.83 |
| 3-5 | 3,176 | 13.04 | 1.01 |
| 6+ | 808 | 11.39 | 0.88 |
| | $Chi^2 = 10.67(3), p < 0.05$ | | |
| **Dwelling space** | | | |
| < 170 sq.ft | 2,414 | 14.62 | 1.00 |
| 170-349 sq.ft | 4,733 | 11.51 | 0.79 |
| 350+ sq.ft | 1,069 | 8.04 | 0.55 |
| | $Chi^2 = 32.67(2), p < 0.001$ | | |
| **Religion** | | | |
| Muslim | 7,401 | 12.65 | 1.00 |
| Hindu | 1,480 | 7.91 | 0.63 |
| | $Chi^2 = 26.53(1), p < 0.001$ | | |

More than 49% of the children had diarrhoea (Fig. 1) during the last one year prior to the MUAC measurement. About 39% of the children had simple diarrhoea and 19% had dysentery. The difference between all diarrhoea and types of diarrhoea is due to overlapping of the diarrhoeal episodes.

Table 4 shows that there is a strong relationships between episodes of diarrhoea, days suffered due to diarrhoea, and the nutritional status of the children. Of the children who did not suffer from diarrhoea, 9% were malnourished compared to 15% ($p<0.001$) of those with diarrhoea.

Table 4 also shows the percentage of malnourished children suffering from diarrhoea and types of diarrhoea by number of days during the previous year. Twenty-three per cent of the children who suffered 15 days or more with diarrhoea were malnourished.

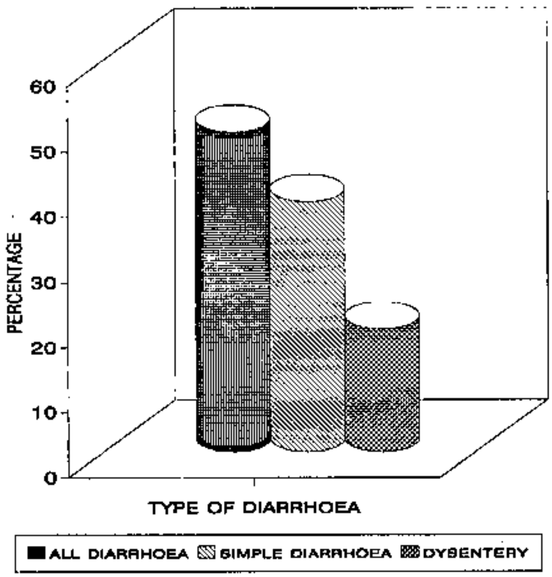


**Fig. 1.** Percentage of malnourished children by type of diarrhoea

**Table 4.** Percentage of malnourished children by diarrhoeal morbidity

| Variable | No. of children | Percentage malnourished | Relative malnourished |
|---|---|---|---|
| **Diarrhoea (all) during last one year** | | | |
| No | 4,486 | 9.03 | 1.64 |
| Yes | 4,363 | 14.78 | 1.00 |
| | $Chi^2 = 70.06(1), p < 0.001$ | | |
| **No. of days suffered from diarrhoea during last one year** | | | |
| Not suffered | 4,486 | 9.03 | 1.00 |
| 1-7 days | 2,732 | 13.03 | 1.44 |
| 8-14 days | 1,198 | 15.78 | 1.75 |
| 15+ days | 433 | 23.09 | 2.56 |
| | $Chi^2 = 107.81(3), p < 0.001$ | | |
| **Diarrhoea (simple) during last one year** | | | |
| No | 5,436 | 9.77 | 1.00 |
| Yes | 3,413 | 15.21 | 1.56 |
| | $Chi^2 = 59.30(1), p < 0.001$ | | |
| **No. of days suffered (simple diarrhoea) during last one year** | | | |
| Not suffered | 5,436 | 9.77 | 1.00 |
| 1-7 days | 2,600 | 14.19 | 1.45 |
| 8-14 days | 670 | 15.67 | 1.60 |
| 15+ days | 143 | 31.47 | 3.22 |
| | $Chi^2 = 98.15(3), p < 0.001$ | | |

Contd....

Table 4. *(Contd.)*

| Variable | No. of children | Percentage malnourished | Relative malnourished |
|---|---|---|---|
| **Dysentery during last one year** | | | |
| No | 7,165 | 11.04 | 1.00 |
| Yes | 1,684 | 15.38 | 1.39 |
| | $Chi^2 = 24.56(1), p < 0.001$ | | |
| **No. of days suffered from dysentery during last one year** | | | |
| Not suffered | 7,165 | 11.04 | 1.00 |
| 1-7 days | 862 | 12.76 | 1.16 |
| 8-14 days | 629 | 17.65 | 1.60 |
| 15+ days | 225 | 19.69 | 1.78 |
| | $Chi^2 = 36.73(3), p < 0.001$ | | |

Fig. 2 shows that 31% and about 20% of the children suffered for more than 15 days for simple and dysenteric diarrhoea respectively during the last one year prior to MUAC measurement.

Again, when classified by the type of diarrhoea, it was found that malnutrition was higher among the children, especially the younger age groups, who suffered from simple diarrhoea (Fig.3).

The average number of diarrhoeal episodes of the children who experienced diarrhoea is shown in Fig. 4. Although the difference in the number of

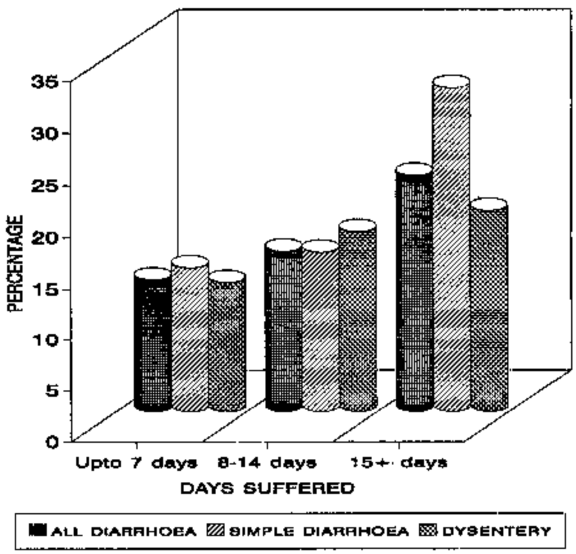


**Fig. 2.** Percentage of malnourished children by duration and type of diarrhoea

episodes by nutritional status is not large, there are significant differences between malnourished and well-nourished group up to the 4 years of age, and after that no significant difference have been observed.

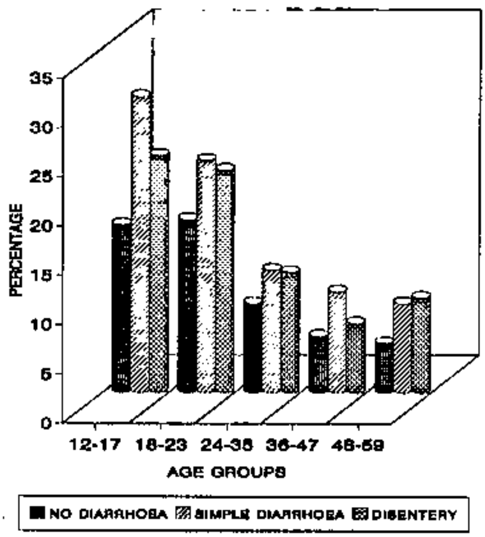


Fig. 3. Percentage of malnourished children by type of diarrhoea and by age groups

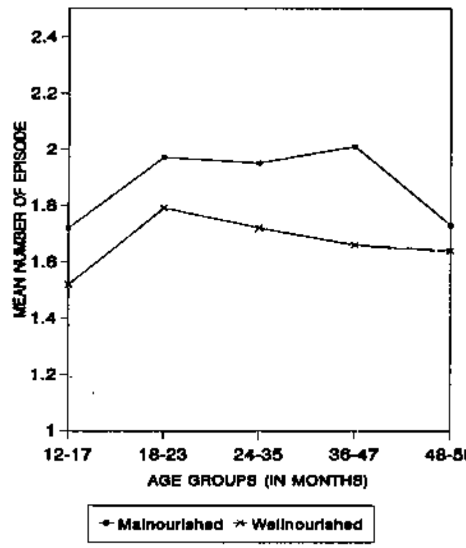


Fig. 4. Mean number of diarrhoea episode by age groups

Table 5, shows the data relating directly to the mothers: mothers' age, education (years of schooling), breast feeding, and birth spacing. When grouping the nutritional status of the children according to their maternal age, it was found that the younger group of mothers (<25 years of age) are the most successful with regard to their child's nutrition and the highest rate of malnutrition is in children whose mothers are aged more than 35 years, and the association is highly significant (p<0.001).

**Table 5.** Percentage of malnourished children for different maternal characteristics

| Variable | No. of children | Percentage malnourished | Relative malnourished |
|---|---|---|---|
| **Mother's age (in years)** | | | |
| <25 | 4,316 | 10.13 | 1.00 |
| 25-35 | 3,705 | 13.36 | 1.32 |
| 36+ | 860 | 14.07 | 1.39 |
| | $Chi^2=24.43(2), p<0.001$ | | |
| **Breast feeding** | | | |
| Up to 12 months | 523 | 15.87 | 1.00 |
| 12-23 months | 3,098 | 18.04 | 1.17 |
| 24+ months | 4,690 | 7.57 | 0.43 |
| | $Chi^2=4.35(3), p<0.23$ | | |
| **Previous birth interval (PBI)** | | | |
| No PBI | 913 | 13.14 | 1.00 |
| <24 months | 914 | 13.24 | 1.01 |
| 24+ months | 7,054 | 11.51 | 0.88 |
| | $Chi^2=3.92(2), p<0.15$ | | |
| **Subsequent closed birth interval (SBI)** | | | |
| No SBI | 6,235 | 12.70 | 1.00 |
| <24 months | 474 | 11.81 | 0.93 |
| 24+ months | 2,172 | 9.44 | 0.74 |
| | $Chi^2=16.42(2), p<0.001$ | | |
| **Mother's education** | | | |
| No education | 5,416 | 13.76 | 1.00 |
| Primary | 2,303 | 9.08 | 0.66 |
| Primary & above | 842 | 6.53 | 0.47 |
| | $Chi^2=58.84(2), p<0.001$ | | |

It was also found that 93% of the children were breast fed during their infancy. A significant difference ($p<0.001$) was observed among the children who were breast fed for less than two years compared to the children who were breast fed for more than two years.

About 11% of the women did not experience any previous birth (i.e. index is the first birth), and only 5% of the women have their subsequent birth within the two-year period of this birth. The effect of short and long previous birth interval upon child nutritional status did not show any significant relationships with the child nutritional status. On the other hand, it was found that nutritional status varied significantly ($p<0.001$) with the interval between a given child and the following sibling who was born within two years and more than two years apart.

There is a strong positive relation between the mother's education and the nutritional status of their children ($p<0.001$). Children of the illiterate mothers are more likely to be malnourished than those of their literate counterparts.

## Multivariate Analysis

The results of the logistic regression analysis using nutritional status as the dependent variable [a dummy variable with value 1 if Z-score<-3 (malnourished) and 0 if Z-score >= -3 (not malnourished)] is shown in Table 6. The results are shown in terms of odd ratios obtained by taking the exponential function of the estimated regression coefficients.

**Table 6.** Adjusted odds ratios from logistic regression of different covariates on nutritional status of children aged 1-4 years

| Covariate | Odds ratio | | | |
|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 |
| **Diarrhoea** | | | | |
| No | 1.00 | | | |
| Yes | 1.71*** | 1.70*** | 1.67*** | 1.67*** |
| **Child's age (in months)** | | | | |
| 12-17 | 1.00 | | | |
| 18-23 | 0.87 | 0.84 | 0.93 | 0.92 |
| 24-35 | 0.40*** | 0.51*** | 0.54*** | 0.47*** |
| 36-47 | 0.27*** | 0.36*** | 0.36*** | 0.28*** |
| 48-59 | 0.26*** | 0.34*** | 0.36*** | 0.27*** |
| **Sex** | | | | |
| Male | 1.00 | | | |
| Female | 1.30*** | 1.30*** | 1.37*** | 1.35*** |
| **Religion** | | | | |
| Muslim | 1.00 | | | |
| Hindu | 0.62*** | 0.62*** | 0.54*** | 0.55*** |
| **Breast feeding (in months)** | | | | |
| Up to 12 months | | 1.00 | | |
| 13-23 months | | 1.20 | 1.13 | 1.09 |
| 24+ months | | 0.79* | 0.71** | 0.75* |
| **Mother's education** | | | | |
| No education | | | 1.00 | |
| Primary | | | 0.63*** | 0.63*** |
| Secondary+ | | | 0.46*** | 0.47*** |

*Contd....*

Table 7. *(Contd.)*

| Covariate | Odds ratio | | | |
|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 |
| **Dwelling space (sq. ft.)** | | | | |
| <170 | | | 1.00 | |
| 170-349 | | | 0.77** | 0.78** |
| 350+ | | | 0.62*** | 0.62** |
| **Subsequent birth intervals** | | | | |
| <24 months | | | | 1.00 |
| 24+ months | | | | 0.74* |
| **-2Log likelihood** | 3,032 | 3,023 | 2,654 | 2,648 |
| N | 8,849 | 8,849 | 7,907 | 7,907 |
| $X^2$ | 383 | 399 | 460 | 471 |
| df | 7 | 9 | 13 | 15 |

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 6 presents four different models when adjusted for different covariates to see the effects on the child nutritional status. In the first model, controlling for the child's age, sex and religion, it was found that, having had diarrhoea, the odds of being malnourished is 1.71 times ($p<0.001$) higher than the children who did not suffer from diarrhoea in the last one year prior to the MUAC measurement. Significantly less malnutrition are also evident among older age groups of children. When controlled for breast feeding along with the other factors in the Model 1, and compared between Model 1 and Model 2, only a slight difference to the odds of being malnourished having had diarrhoea is observed for the effect of breast feeding. The odds of being malnourished has reduced significantly in the different age groups. When examining the log likelihood ratio statistics (LRS) for the effect of diarrhoea controlling for breast feeding between the Model 1 and Model 2, it was found that even though the estimated association between diarrhoea and nutritional status did not differ, but the association between diarrhoea and malnutrition is still significant ($p<0.003$), indicating that the effect of child's age is, in fact, confounded by breast feeding.

As expected from the bivariate relationship, the length of previous birth interval has no effect on the above-mentioned measures of malnutrition. So, further result is not present due to lack of the relationship.

In the Model 3, socioeconomic variables household space, and mother's education are included as covariates. Significantly ($p<0.001$) higher nutritional risks evident among the children of the non-educated mothers. The effect of household area on child nutritional status is highly significant ($p<0.001$), indicating that children of the poor families are more vulnerable compared to the well-to-do families.

Relative to birth interval of two years or more, children born followed by birth intervals less than two years face significantly higher malnutrition which is 35% higher than the children born after longer birth intervals (Model 4).

## DISCUSSIONS AND CONCLUSIONS

This analysis, which is the community-based investigation of the effect of diarrhoea, birth spacing, and breast feeding on child nutrition in Bangladesh, has several limitations. First, diarrhoea morbidity was obtained by fortnightly recall rather than daily, every two days or weekly recall. The recurring constraint of recall error was not eliminated. Secondly, diarrhoea was identified by the child's mother as a clinically apparent disease. Diarrhoeal infections may not be apparent and there was a lack of bacteriologic and other diagnostic tests available to identify the possible etiologic agents. Other potential confounding variables, such as the role of seasonal variation, environment, diet and other morbidity were not controlled. The more plausible effects of malnutrition on diarrhoeal mortality were not considered in this analysis.

The mean number of recorded diarrhoea episodes was 1.70 per year, which is substantially lower than the 4-5 episodes per year reported in two earlier studies in Matlab (9-10). In two other studies, the number of episodes of diarrhoea 1.4 and 1.3 respectively (4-5) which are comparable to the estimate of diarrhoeal incidence of this study. Differences in age distribution of the children 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 earlier studies, done in the early 80s using mid 70s data, milder cases of diarrhoea were most likely recorded during the twice weekly and weekly visits and included in the analysis.

The findings of the present study contribute to the understanding of the linkage of diarrhoea, breast feeding and birth intervals and child nutritional status in several important ways. First, malnutrition is higher among the younger age-group children and decreases with age. Children who had diarrhoea during the last one year indicate a higher risk of malnutrition. The longer the duration of diarrhoea, higher the negative effects on nutrition of children aged less than five years. But the average diarrhoeal episodes (Fig. 4) are not significantly different among the different age groups of children who were malnourished and who were not. This indicates that, other than diarrhoea, there are other factors which influence the child malnutrition in the earlier age.

The average duration of breast feeding in Matlab appeared to be high which ranges from 30 to 34 months during 1978-1987 (39). It was also shown that children who are breast fed for more than 2 years are less malnourished than those are breast fed for less than 2 years. Strong effects of breast feeding exceeding to the toddler period are not surprising given the condition in the study area characterized by poverty, poor sanitation, and riverain environment.

The children whose mother did not experience any previous birth have nutritional status almost equal to the children who were born within 2 years of immediate elder siblings. Mother's inexperience of child rearing may be the possible explanation in this regard.

A subsequent birth interval of less than 24 months has a significant effect on the child nutritional status. Short-birth intervals may exert the nutritional effect by two mechanisms. First, where there are a number of children, there is higher competition both for maternal attention and care and for the available food. Second, with an early subsequent conception resulting in the termination of breast feeding and higher malnutritional risk to the index child.

Children born to women of low educational attainment or living in a small house are more likely to be malnourished than children born to women of a higher education and economically solvent. There are evidences that low educational attainment and certain religious customs predispose to diarrhoea, presumably because of the behavioural factors. Interrupting the transmission of diarrhoeal disease depends primarily on improved hygiene and on improved facilities, such as water supply, and latrines which facilitate improved hygiene (40).

This study has several policy implications. MUAC seems to be a potential anthopometric indicator of child nutrition. Measuring arm circumference is simple and requires little time. It should 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 breast feeding 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 malnutrition in children, continuing feeding should be advocated during diarrhoea. Mothers should be informed of the increased nutritional needs of children during all illnesses and convalescence, including the case of diarrhoea. Mothers should also be advised to use contraceptives for spacing and limiting births. This will lead to a reduction of malnutrition and, thus, to better health of children.

The major health problems in this community are the diarrhoeal disease, tetanus, measles, fever, and respiratory disease. Malnutrition, high fertility, water and sanitation are other less direct but crucial underlying health problems of importance. The delivery of few selected basic immunizations and oral therapy for diarrhoea could eliminate 40% of the deaths, among children aged less than five years. Another substantial portion, not easily quantified, would be affected by nutrition, family planning, water and sanitation programmes. Most of the technologies required are already developed, available at low cost, and readily applicable. The challenge is to generate the political commitment, mobilize necessary resources, and organize the health-care providers and local communities.

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*Appendix 1*

## Effect of diarrhoea on child nutrition

| Diarrhoea indicators | Anthropometric indicators | Effect | Place of study |
|---|---|---|---|
| Incidence and duration of Shigella and E.coli | Velocity of height and weight gain | Negative (short-term) | Matlab Black (10) |
| Incidence and duration of Diarrhoea | Velocity of height and weight gain | Negative (short-term and long-term) | Matlab Bairagi (16) |
| Incidence and duration of Diarrhoea | Velocity of height gain | Negative (long-term) | Mirzapur Briend (2) |
| Incidence and duration of watery diarrhoea | Velocity of height gain | Negative (long-term) | Zimbabwe Moy (41) |
| Incidence and duration of watery and non-watery diarrhoea | Weight/age and height/age | Negative | Teknaf Alam (42) |

# *Appendix 2*

## Proportion of malnourished children by age and sex by standardised and traditional methods

| Age group | Total no. of children | | Traditional methods cut-off point | | Sex-age-specific cut-off points compared to WHO standard | | | |
|---|---|---|---|---|---|---|---|---|
| | | | < 125 mm | | <-2 Z | | <-3Z | |
| Month | 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 |

## A Brief History of ICDDR,B

| | |
|---|---|
| 1960 | Cholera Research Laboratory established |
| 1963 | Matlab field station started<br>First of a series of cholera vaccine trials launched |
| 1966 | Demographic Surveillance System established |
| 1968 | First successful clinical trials of Oral Rehydration Solution (ORS) |
| 1969 | Relationship between stopping breast-feeding and resumption of menstruation demonstrated |
| 1971 | Independence of Bangladesh |
| 1973 | Shift from Classical to El Tor cholera identified |
| 1977 | Maternal Child Health and Family Planning interventions began in Matlab |
| 1978 | Government of Bangladesh Ordinance establishing ICDDR,B signed |
| 1981 | New Dhaka hospital built<br>Urban Volunteer Programme initiated |
| 1982 | Classical cholera returned<br>Field testing of cereal Oral Rehydration Solution began<br>Clinical sub-centres established in Matlab<br>MCH-FP Extension Project began |
| 1983 | First issue of the Journal of Diarrhoeal Disease Research<br>Epidemic Control Preparedness Programme initiated |
| 1984 | ICDDR,B received UNICEF's Maurice Pate award |
| 1985 | Full Expanded Programme of Immunization activities tested in Matlab<br>WC/BS cholera vaccine trial launched |
| 1987 | ICDDR,B received USAID's "Science and Technology for Development" award |
| 1988 | Treatment of and research into Acute Respiratory Infection began |
| 1989 | The Matlab record keeping system, specially adapted for Government use, extended to the national family planning programme |
| 1990 | The new Matlab Health and Research Centre opened |
| 1992 | ICDDR,B-Bangladesh Rural Advancement Committee study commenced |
| 1993 | New laboratories built and equipped<br>New *Vibrio cholerae* 0139 - Bengal identified and characterized, work on vaccine development began |
| 1994 | Twenty fifth anniversary of ORS celebrated<br>ICDDR,B epidemic response team goes to Goma to assist cholera-stricken Rwandan refugees, identifies pathogens, and helps reduce mortality from as high as 48.7% to < 1%. |
| 1995 | Maternal immunization with pneumococcal polysaccharide vaccine shown to protect infants up to 22 weeks |