Child Health

ARM CIRCUMFERENCE AND OTHER FACTORS IN CHILDREN AT HIGH RISK OF DEATH IN RURAL BANGLADESH

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Summary Mid upper arm circumference (MUAC) was measured monthly for 6 months in about 5000 children aged 6–36 months from rural Bangladesh. Children who would die within 1 month of screening could be identified with 94% specificity and 56% sensitivity—almost twice the sensitivity achieved by other anthropometric screening schemes for this level of specificity. Specificity was slightly improved when the absence of breast-feeding, concurrent diarrhoea, oedema, and acute respiratory infection were taken into account. Children at high risk of death can be detected by monthly measurement of MUAC, which may be used in poor communities where interventions have to be selective.

INTRODUCTION

THE cost of comprehensive primary health care is such that the goal of "Health for all by the year 2000" set by the World Health Organisation is unattainable in many poor countries.[1] The concentration of resources on a few people at high risk of serious disease or death (the "risk approach") has been proposed as a more realistic alternative, especially for mother and child care.[2] To reduce child mortality by this means, primary health care workers must be able to accurately identify high-risk children. For the past 10 years, anthropometric measures of nutritional status to detect children at high-risk have been examined, but proved to be imprecise.[3-6] A recent report, however, suggested that nutritional screening is more accurate when the risk of death is assessed over a short time.[7] We report here the use of monthly measurements of mid upper arm circumference (MUAC) to detect children at high risk of death in a rural community in Bangladesh.

SUBJECTS AND METHODS

Since 1966, the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) has maintained a demographic surveillance system in the rural subdistrict of Matlab.[8] At present the scheme covers 143 villages, with a total population of about 200 000. In half of this area demographic surveillance is done by female community health workers whose only health-related skill is the recognition of severe diarrhoea and its treatment with oral rehydration solution. The only ICDDR,B health intervention is the provision of oral rehydration solution and the treatment of diarrhoea in several special centres. Diarrhoea and acute respiratory infections are the most common causes of death in young children in this community.[9]

Every month 30 community health workers, covering a population of about 100 000, measured the MUAC of children aged between 6 and 36 months and asked the mother or guardian whether the child was still breastfed or had diarrhoea (at least three liquid stools within the previous 24 h). Diarrhoea was classified as watery or bloody; non-bloody diarrhoea was termed chronic if it had started more than seven days before the interview. Health workers also checked whether the child had acute respiratory infection, defined as the simultaneous presence of cough, fever, and tachypnoea. For critically ill children, families were offered referral to Matlab diarrhoea treatment centre. Before the study, health workers were taught for 2 h in groups of 10 how to measure MUAC[10] and how to recognise oedema and the symptoms of acute respiratory infection. Three refresher courses were held during the study.

Ethical approval was granted by the ICDDR,B ethical review committee on condition that the study would last no longer than the time needed to choose criteria for screening. The study was therefore conducted for only 6 months, and seasonal variations in the relations between nutritional status, diarrhoea prevalence, and mortality could not be examined. The study period from October, 1985, to March, 1986, included part of the pre-harvest lean season.[11]

Since almost all (98·8%) breastfed children received some food in addition to breast milk, data of exclusively and partly breastfed children were combined for analysis.

MUAC was measured to the nearest 2 mm with locally manufactured insertion tapes.[12] MUAC was chosen as the indicator of nutritional status because it is easy to measure in the community and compares favourably with other anthropometric indices for the assessment of the risk of death in children.[13,14] MUAC was not corrected for age or height since this adjustment does not improve the assessment of risk of death.[7,15]

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TABLE I—RELATIVE RISK OF DEATH, SENSITIVITY, SPECIFICITY, AND ATTRIBUTABLE RISK ASSOCIATED WITH VARIOUS FACTORS

Risk factor	No of child-months	No of deaths	Relative risk (95% CI)	Sensitivity (%)	Specificity (%)	Attributable risk (%) (95% CI)
Female gender	14 277	37	2·6 (1·5–4·7)	71·2	51·8	44·2 (20·4–60·8)
No breast-feeding	7673	22	2·1 (1·2–3·6)	42·3	74·2	22·0 (3·9–40·2)
MUAC ⩽100 mm	445	22	48·0 (35·1–65·7)	42·3	98·6	41·4 (27·8–55·0)
MUAC ⩽110 mm	1746	29	20·1 (13·7–29·5)	55·8	94·2	52·9 (38·6–67·3)
MUAC ⩽120 mm	6830	40	11·1 (6·6–18·5)	76·9	77·0	69·9 (55·1–84·8)
MUAC ⩽130 mm	17 652	47	6·3 (2·8–4·1)	90·4	40·3	76·1 (56·2–96·0)
Oedema	94	11	84·1 (60·8–116·5)	21·2	99·8	20·9 (9·7–32·0)
ARI	524	9	11·6 (6·6–20·4)	17·3	98·3	15·8 (5·3–26·2)
Any diarrhoea	3919	22	4·8 (2·9–7·9)	42·3	86·8	33·4 (18·0–48·9)
Watery diarrhoea	2457	4	0·9 (0·3–2·5)*,	7·6	91·7	..
Bloody diarrhoea	336	6	11·3 (5·8–22·2)	11·5	98·9	10·5 (1·7–19·2)
Diarrhoea >7 days	1126	12	7·6 (4·4–13·1)	23·1	96·2	20·0 (8·1–31·9)

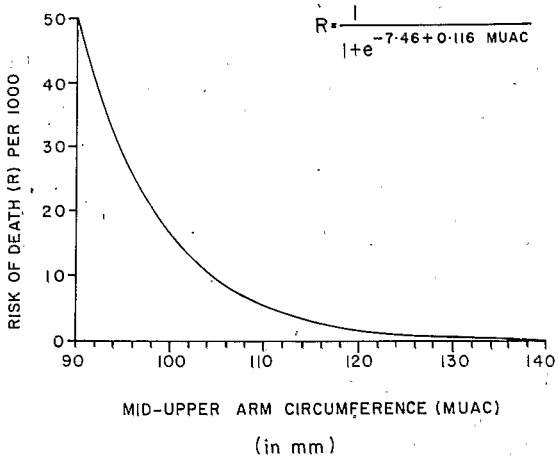
*Not significant; attributable risk not calculated. CI = confidence interval. ARI = acute respiratory tract infection.

Child-months were pooled for analysis: a child was regarded as a survivor if alive one month after interview and was entered as a new child-month for the next round. Standard statistical and epidemiological methods were used.[16,17] Relative risk was estimated by the incidence density ratios and confidence intervals were estimated by Miettinen's test.[17] Attributable risk, which represents an absolute measure of the risk of death to an individual, and its confidence interval were calculated by Walter's method.[18] Logistic models were used to describe the relation between MUAC and risk of death and to test the significance of other risk factors also present.[17]

RESULTS

Altogether 29 562 child-months (average 4927 children per month) were available for analysis. 52 children died from non-accidental causes within 1 month of interview. To assess the value of risk factors for the prediction of death, relative risk, sensitivity, specificity, and attributable risk were calculated.[2] A MUAC of 110 mm or less and the presence of oedema, bloody diarrhoea, and acute respiratory infection were associated with a high relative risk and specificity, but watery diarrhoea was not (table I). The association between MUAC and risk of death was well described by a univariate logistic model,[17] shown in the figure (Hosmer-Lemeshow statistic[19] $C^*_{10} = 11{\cdot}56$, 8 DF; $p = 0{\cdot}172$).

In many children, several risk factors were present concurrently. To establish to what extent these were independently associated with risk of death, a multivariate logistic model was developed with 1-month survival as the dependent variable and the risk factors as predictors. MUAC, acute respiratory infection, oedema (all $p < 0{\cdot}001$), no breast-feeding, bloody diarrhoea, and chronic diarrhoea (all $p < 0{\cdot}01$) were associated with risk of death, but age and sex were not once the other risk factors were controlled for. There was a significant interaction between breast-feeding and MUAC ($p < 0{\cdot}005$): changes in MUAC had less effect on the risk of death in breastfed than in non-breastfed children. The data also showed that breast-feeding was associated with a lower risk of death only in children with MUAC less than 110 mm: above 110 mm, there was a slight excess of deaths in breastfed children.



Risk of death for arm circumference values, described by a logistic model.

For intervention purposes, children are usually placed in two categories on the basis of MUAC values. To establish how this grouping would affect the assessment of risk of death, a second model was developed with MUAC entered as a dichotomous variable (1, MUAC of 110 mm or less; 0, MUAC of over 110 mm). In the absence of a specified intervention, the choice of cut-off point is arbitrary;[20] 110 mm was chosen because it was the limit below which the association between breast-feeding and improved survival appeared. This model was tested with the likelihood ratio and proved to fit the data well (χ^2 test, $p = 0{\cdot}36$). Regression coefficients did not change by much from the first model, with the exception of MUAC and breast-feeding which were affected by the categorisation of MUAC.†

This second logistic model was used to test the effect of risk factors being combined on the identification of children at high risk of death. All two-by-two combinations of the independent variables were entered in the model to estimate their relative risk, sensitivity, specificity, and attributable risk, with the assumption that the prevalence and clustering of risk factors was the same as in the survey. Low MUAC and absence of breast-feeding were considered as one variable. All combinations with a specificity higher than 95% and an attributable risk higher than 35% included a MUAC of 110 mm or less and absence of breast-feeding and are shown in table II. An increase in the number of risk factors tended to reduce specificity but raised sensitivity and attributable risk, as shown by the association between MUAC of 110 mm or less and the absence of breast-feeding, and/or oedema, and/or acute respiratory infection, and/or bloody diarrhoea (table II).

†Details available from A. B. on request.

TABLE II—SENSITIVITY, SPECIFICITY, RELATIVE RISK, AND ATTRIBUTABLE RISK OF MUAC ⩽110 mm IN THE ABSENCE OF BREAST-FEEDING AND COMBINED WITH OEDEMA, ARI, AND BLOODY DIARRHOEA.

—	Sensitivity (%)	Specificity (%)	Relative risk	Attributable risk (%)
MUAC ⩽110 mm with no breast-feeding	38·4	98·1	30·4	37·2
MUAC ⩽110 mm with no breast-feeding and/or oedema	42·3	97·9	32·5	41·0
MUAC ⩽110 mm with no breast-feeding and/or bloody diarrhoea	41·5	97·0	22·7	39·7
MUAC ⩽110 mm with no breast-feeding and/or ARI	47·9	96·3	23·7	45·9
MUAC ⩽110 mm with no breast-feeding and/or oedema and/or bloody diarrhoea and/or ARI	53·2	95·2	22·0	50·8

DISCUSSION

By measurement of MUAC alone, 56% of children who would die within a month could be identified with 94% specificity and an attributable risk of 53%. Specificity rose to 98% when absence of breast-feeding was taken into account, but sensitivity then fell to 38% and attributable risk to 37%. When selected illnesses were also considered a specificity of 95% and sensitivity of 53% was achieved, still with an attributable risk over 50%. This is considerably higher accuracy than has been reported so far.[3-6] In a previous report of the same population in Bangladesh, weight-for-age gave only 25% sensitivity with 96% specificity for the prediction of death in the ensuing 2 years,[4] and in the Punjab it had an even lower sensitivity (16%) with 95% specificity for a 2-month prediction.[3] In Papua New Guinea[5] with weight and height data, and in Zaïre[6] with MUAC, prediction was even less accurate for risk periods of 2 years and 100 days, respectively.

Previous studies have already suggested MUAC is better than other anthropometric indices for screening and identification of children, particularly younger ones,[21] at high risk of death.[4,6,7,13-15,21] We have substantially improved specificity and sensitivity by shortening to one month the period during which risk of death is considered. Catch-up growth in severely malnourished children who do not die within one month of measurement and the serious food shortage in this community may have contributed to the accuracy of our short-term assessment of risk of death.[22]

Attributable risk can indicate the maximum reduction in overall child mortality expected after removal of risk factors.[23] Our results suggest that a substantial improvement in child survival could be achieved by a simple screening procedure, provided it were backed up by rapid intervention. However, cultural practices, such as discrimination against girls, might reduce the effectiveness of such intervention;[24] in this community girls have a poorer nutritional status than boys, resulting in a higher risk of death.

To make any impression on childhood mortality in this community deaths due to severe malnutrition must be prevented. However, even with the degree of sensitivity achieved here, treatment of only the very severely malnourished would still leave many less severe cases at risk of death. A more effective strategy would be to improve the nutritional status of all children. However, the multifactorial origins of malnutrition make this notoriously difficult to do without major improvements in socioeconomic circumstances.[25] The treatment and rehabilitation of severely malnourished children is likely to remain a necessity in underprivileged communities.

Breast-feeding was associated with lower mortality even in the third year of life, but only in severely malnourished children. The data suggested a slightly higher risk of death associated with breast-feeding in better-nourished children, probably because the children who had been breastfed for longer came from poorer, less educated families with a higher mortality.[26] This is discussed in detail elsewhere.[27]

The lack of association between watery diarrhoea and risk of death probably reflects the widespread distribution and use of oral rehydration solution in the home,[28] as well as ready access to treatment facilities. This finding does not mean that oral rehydration in general would not prevent deaths, but rather that in this community little improvement in mortality would be expected from greater use of oral rehydration.

Growth monitoring by monthly weighing is often recommended to detect early faltering ("invisible malnutrition").[29,30] This approach, however, requires accurate measurement, recording, and interpretation of the growth pattern of individual children and must also be followed by appropriate interventions.[31] In poor communities where severe malnutrition is rife, it may indeed be an expensive luxury.[32] Children with a MUAC of less than 110 mm are obviously malnourished and growth charts are not needed to identify them. In communities where severe childhood malnutrition still occurs, screening and referral of selected high-risk children may be one of the more effective strategies for the prevention of death.

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Preventive Medicine

EXPERIENCE WITH HEPATITIS B VACCINATION IN NURSES IN A HOSPITAL FOR THE MENTALLY HANDICAPPED

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Summary The extent of HBV infection in the staff of a large hospital for the mentally handicapped was investigated. Nurses with direct patient contact were identified as a particular risk group and hepatitis B vaccination was offered to them. Of the 500 who received a full course of vaccination 96% had detectable antibodies 9 months after starting vaccination. High titres (over 1000 IU/l) were found in 59·4%. Females responded better than males and the response was age-dependent. In only 2 of 20 non-responders did lasting immunity develop with a fourth dose of vaccine. Antibody titre decreased rapidly in all vaccinees followed up. In vaccinees with an initial titre above 100 IU/l the decrease in titre could be reversed by a booster dose. Those with a titre below 100 IU/l had a variable response to the booster dose and lasting immunity developed in only a few. A recall system was started that predicts when a booster dose will be required to maintain a protective level of antibody. Servicing such a vaccination programme is not easy.

INTRODUCTION

INFECTION with hepatitis B virus (HBV) is a significant occupational risk for health care staff which increases with the degree of exposure to contaminated blood and other fluids. Reduction of risk depends mainly on high standards of clinical hygiene and laboratory practice, supported by the administration of prophylactic hepatitis B immunoglobulin when incidents such as needlestick injuries involve the blood of known or suspected carriers. Health care groups are at greater risk than the general population.[1,2] The availability of hepatitis B vaccine provides a further means of protection which is safe and effective,[3,4] but the cost has tended to restrict its use to those staff considered to be most at risk. Despite the vaccine's proven efficacy and the known occupational risk, its perception as a vaccine prepared from material from groups at risk of hepatitis B and possibly AIDS has led some health care workers to be wary of vaccination. This study outlines a hospital hepatitis B immunisation programme in which these concerns were recognised and in which specific risk appraisal linked with education led to a high level of participation.

Patients in hospitals for the mentally handicapped are at risk of HBV infection.[5] Once HBV infection is introduced into such an environment spread can be rapid as extra opportunities for transmission are available to the virus (biting and scratching). Staff attending such patients are also at risk of infection, particularly those caring for aggressive patients. The usefulness of a vaccine in such a situation was first demonstrated by Krugman et al[6] using a crude inactivated vaccine.

Lennox Castle Hospital is a large hospital for the mentally handicapped in Glasgow with a staff of 1150 and 1000 patients. Since tests for hepatitis B surface antigen (HBsAg) were introduced in the West of Scotland in the early 1970s, a few acute HBV infections have been diagnosed in patients almost every year. In the 10 years before this study 10 members of staff became infected with HBV and 2 nurses infected their spouses. During normal investigation of illness in patients 22 long-term carriers of HBV were identified. In response to anxiety expressed by the staff and their trades union representatives, a project was set up to investigate the extent of HBV infection among the staff, to identify groups at risk, and to offer them hepatitis B vaccination. We report the results of the initial survey for HBV infection, the risk groups identified, and the response of 500 adults to the hepatitis B vaccine.

SUBJECTS AND METHODS

Lennox Castle Hospital is a completely self-contained unit situated 14 miles from Glasgow, with 15 doctors, 654 nurses, and 338 ancillaries.

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