cryptoxanthin and zeta-carotene predominate in the yellow papayas, lycopene is the most important in red varieties (Saint-Hilaire and Struebi, 1982). As the levels of β-carotene indicate, eating of 200–300 g from all varieties studied except Kapoho Solo, would satisfy more than 50% of the RDA of the vitamin for most persons. This would help to alleviate deficiency of the vitamin, whose symptoms have already been reported in Kenya, even from the papaya growing areas (Bohdal *et al.*, 1969).

Results of this study will assist the breeders in identifying the papayas appropriate for various uses, especially those suitable for desserts and salads. The results will also assist the nutritionists and dietitians in determining the appropriate quantities of papaya to incorporate in the dietaries for sufficient vitamin C and vitamin A equivalents.

REFERENCES

Barakat, M.Z., M.F.A. El-Wahab and M.M. El-Sadr (1955). Action of N-Bromosuccinimide on ascorbic acid. New titrimetric method for estimation of vitamin C. *Anal. Chem.* **27**, 536-540.

Berk, Z. (1976). *Braverman's introduction to biochemistry of foods.* Elsevier Scientific publishing Company, Amsterdam, Oxford, New York.

Bohdal, M., W.E. Gibbs and W.K. Simons (1969). Nutritional survey and campaign against malnutrition in Kenya. Report of WHO/FAO/UNICEF-assisted project. Ministry of Health, Kenya.

Candlish, J.K., L. Gourley and H.P. Lee (1987). Dietary fibre and starch in some Southeast Asian Fruits. *J. Food Composition and Analysis* **1**, 81-89.

Duckworth, R.B. (1966). *Fruit and vegetables.* Pergamon Press, Oxford, London, Edinburgh, New York, Toronto, Sydney, Paris, Braunschweig.

Harvey, T.C. and S.C.M. Kwok (1975). Importance of enzyme inactivation prior to extraction of sugars from papaya. *J. Food Sci.* **40**, 770-771.

Harvey, T.C. Jr., K.L. Hibbard, T. Goo and E.K. Akamine (1979). Sugar composition of papayas during fruit development. *Hort. Science* **14**(2), 140-141.

HCDA. (1987). Annual Report. Horticultural Crops Development Authority. Nairobi, Kenya.

IFEIP. (1986). International Federation of [illegible]

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POST-FLOOD NUTRITIONAL ANTHROPOMETRY OF CHILDREN IN MATLAB, BANGLADESH

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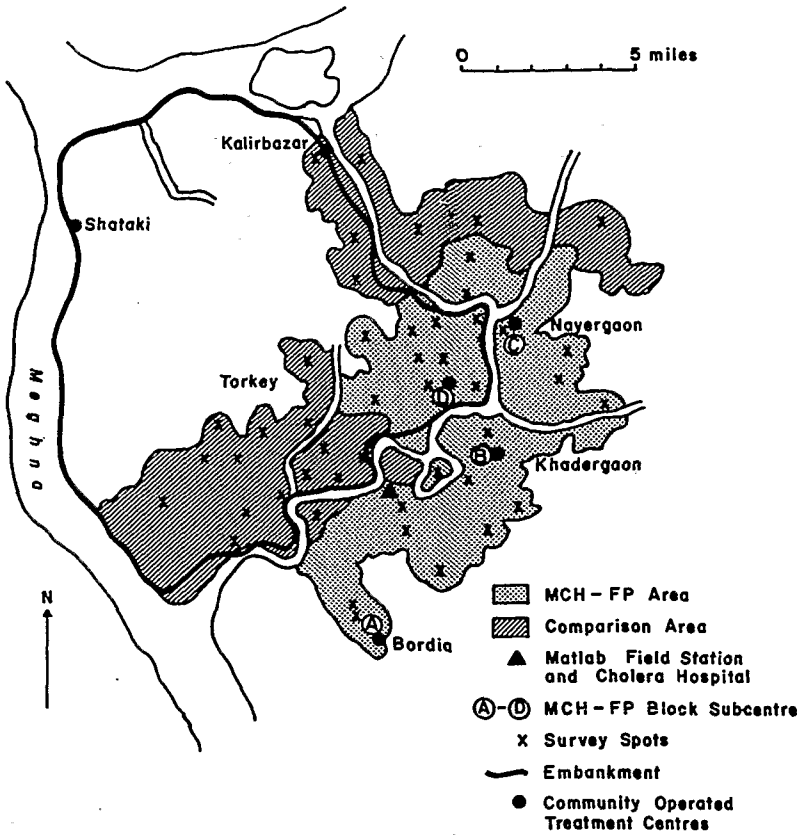
The Matlab area was severely affected by the floods of 1988 in Bangladesh. To assess the impact of flooding in Matlab the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) performed post-flood surveys. Six-hundred households were surveyed. In addition, length, weight, and mid-upper arm circumference were measured in children aged 6–35 months. Baseline economic status appeared to be higher inside the Matlab embankment, where the average material damage was worse. Anthropometry of children from inside and outside the embankment did not differ significantly for degree of flood damage. There was also no difference in these indicators between October and December, when post-harvest improvement would normally occur. Analysis of indicators of household socio-economic status revealed landlessness and lack of maternal education as significantly associated with lower child anthropometry. Female children and those 12–36 months also had lower mean percent of median anthropometric indices.

FIGURE 1 Map of Survey area



ment of diarrhea for villagers in the area, and a Maternal/Child Health and Family Planning (MCH/FP) Health Services project with community health worker outreach to a population of 100,000. ICDDR, B maintains a Demographic Surveillance System (DSS) of the population covered by the MCH/FP program and for an additional 100,000 living in a neighboring comparison area where the only official health services are provided by the government. These activities are described more fully elsewhere (Bhatia *et al.*, 1980; Ruzicka and Chowdhury, 1978).

During the flood, relief was provided through health workers including basic curative care, distribution of water purification tablets and ORS packets. High-risk individuals were targeted for relief through the establishment of twelve temporary therapeutic feeding centers for malnourished children, and pregnant and breast-feeding women.

In addition, a series of post-flood assessments of household and child anthropometric status were performed to assist in targeting of both ICDDR, B post-flood

interventions and government relief. This paper describes and discusses the findings of these assessments, carried out in October and December 1988, and March 1989.

METHODS

Sample

Two samples were chosen for assessment, one from inside and one from outside the embankment, the two areas having unequal patterns of flooding. The sample areas are approximately at sea level, with the land inside the embankment being slightly lower than outside (Figure 1). Roughly half of each sample was from within the MCH/FP area and half from the Comparison area.

Each of the two samples contained 30 clusters, of 10 households each. The sampling frames consisted of all DSS households inside and outside the embankment numbered consecutively by location. Clusters were chosen by a random sampling method with the household, defined by one common cooking pot, as the sampling unit. Of these 600 households, those with children between 6–35 months were surveyed for follow-up in December and March.

Data Collection

Ten interview teams each surveyed an average of 10 households per day for six consecutive days. Teams were composed of one female community health worker, personally acquainted with the families surveyed, one experienced interviewer, trained in measurement of weight, length, and mid-upper arm circumference (MUAC), and one male porter.

The initial survey consisted of interview on household effects of the flood and anthropometry of children aged 6–35 months, assumed to be most at risk of malnutrition (Brown *et al.*, 1982). Most interviews were conducted with the wife of the household head (47%), the household head (34%), or the son or daughter-in-law (15%). Questionnaire included information about: occupation of the household head, ownership of land, paddy seed, animals, and stores of rice; house damage; water levels, animal and crop loss; relief received, and household actions taken in response to the flood. The extent of crop loss was estimated by the respondents and confirmed through observations of the interviewers. Anthropometric measurements were taken on the 311 children, aged 6–35 months, who were present in the house on the date of interview.

Children were weighed with Salter scales calibrated daily. Length was measured with the child supine on a standardized lengthboard. Left MUAC was determined with insertion tapes (Zerfas, 1975). Weight-for-age (W/A), weight-for-length (W/L), and length-for-age (L/A) were calculated using anthropometric software from the Centers for Disease Control, Atlanta, GA, U.S.A. Exact birth dates were obtained from DSS. The nutritional indices were expressed as percent of median NCHS standards (WHO, 1986).

The follow-up survey in December was done on only the 273 households with children measured in the first round still aged 6–35 months, and included repeat anthropometry. A new questionnaire about socio-economic status (SES) was used during the second survey, including questions on: income, land ownership, and investments; parental education and employment; and further actions taken to survive the crisis. A third round of anthropometry on 187 of the original children

still 6–35 months old was performed in March, with enrolment of an additional 87 children in this age range from neighboring households.

Data Analysis

Household data The initial household data were analyzed by comparison of the samples from inside and outside the embankment for baseline economic status, damage or loss due to the flood, diarrhea prevalence, and household actions taken. Differences were tested by chi-square analysis.

Anthropometry. Child anthropometry and follow-up survey data were analyzed by comparing the difference in mean % of NCHS median weight-for-age, weight-for-length, and length-for-age using one-way analysis of variance or t-test between means when appropriate. This approach was chosen because analysis of mean percent of median seems more sensitive for detecting small changes in anthropometric status (WHO, 1986; Briend *et al.*, 1989). T-test between means was performed for variables analyzed as bivariate, including: gender, village location, borrowing of money, receipt of relief, and selling of possessions; and to compare anthropometric means between months. Monthly anthropometric means were also tested using analysis of variance with age as a covariate, both with and without the new children enrolled in March. One-way analysis of variance was used in analysis of all other variables. For variables exhibiting a difference by one-way analysis of variance, specific pairs of interest were identified using the Scheffe multiple comparison test (Armitage, 1971). Two-way analysis of variance was performed for adjustment of land ownership when comparing anthropometric means according to sale of possessions.

RESULTS

TABLE I
Household information, inside vs. outside embankment
Initial survey (n=600) — October 1988, Matlab

	Inside % (n=301)	Outside % (n=299)	Total % (n=600)
Occupation of main earning member prior to flood			
none	5	1	3
day laborer	7	8	8
ag. laborer	17	16	17
farm own land	22	13	18
other (non-agric.)	49	62	54
Land ownership (acres)*			
none	20	40	30
<0.5	28	19	23
0.5–1.5	30	20	25
>1.5	22	21	22
Paddy seed before the flood*			
none	46	70	58
those having seed	54	30	42
Cows and goats before flood*			
none	42	49	46
those having animals	58	51	54
Rice stores*			
<= 7 seers	52	61	57
> 7 seers	48	39	43

* $p < 0.05$ by chi-square analysis

occupations, (primarily fishing), but overall, there were fewer people working than before the floods. In addition, less than 60% of those currently without work could

TABLE II
Damage or loss and response to floods, inside vs. outside embankment
Initial survey (n=600) — October 1988, Matlab

	Inside % (n=301)	Outside % (n=299)	Total % (n=600)
House damage*			
no	39	66	52
yes	61	34	48
House flooding*			
below knee height	12	68	40
above knee height	88	32	60
Poultry loss*			
no	47	62	54
yes	53	38	46
Relief received			
no	54	60	57
yes	46	40	43
Valuables sold			
none	85	81	83
things sold	15	19	17
Borrowed money			
yes	31	32	31
no	69	68	68
Received help from relatives or others			
yes	86	90	88
no	14	10	12
Loss of crops (%)*			
(for those owning land)	(n=240)	(n=178)	(n=418)
100%	93	64	80
< 100% loss	7	37	20

* $p < 0.05$ by chi-square analysis

Changes in anthropometry. Analysis of anthropometric data was only performed on the 281 children who were present at both the first and second round. The children not measured on the second round were those absent from the house. None of the children died between rounds.

Mean % NCHS median W/A, W/L, and L/A, and mean MUAC were not significantly different between October and December by t-test, while both W/L and MUAC showed improvement in March (Table IV). When analysed by analysis of variance controlling for age, both with and without the new children enrolled in March, the results were not significantly different. Percentage of children below standard severity cut-offs also showed no significant change.

Stratification of children by gender and age revealed significantly lower mean percent of NCHS median for females compared to males, and for those more than 12 months of age in contrast to the younger age group. There was no difference between the inside and outside samples (Table V).

TABLE III
Diarrhea reported in 6–35 month olds inside vs. outside embankment
Initial survey (n=311) — October 1988, Matlab*

	Inside % (n=162)	Outside % (n=149)	Total % (n=311)
Diarrhea prevalence (1 day)			
none	74	82	78
watery	22	17	20
dysentery	4	1	3
Diarrhea prevalence (past 2 weeks)			
none	57	60	59
watery	37	35	36
dysentery	6	5	5

* Differences not statistically significant by t-test at 0.05 level.

TABLE IV
Mean % of NCHS median weight-for-age, weight-for-length, length-for-age, and MUAC
October (n=281), December (n=264), and March (n=268).
1988–1989, Matlab

Nutritional Indicator	Mean	St. dev.
Weight-for-age (%)		
October	70.8	10.4
December	71.3	10.4
March	72.1	9.6
Weight-for-length (%)		
October	84.9	8.0
December	85.3	7.9
March*	86.9	8.8
Length-for-age (%)		
October	90.3	4.9
December	90.3	5.3
March	90.0	4.5
Mid-upper arm circumference (mm)		
October	131.2	11.6
December	132.2	11.5
March#	133.6	11.2

* significantly different from Oct and Dec ($p < 0.05$)
# significantly different from Oct ($p < 0.05$)

Presence of watery diarrhea was associated with lower means of anthropometric indices (Table VI).

SES indicators selected for analysis included income from earnings and investments, land ownership, rice stores, and parental education. The factors showing the most difference between categories were ownership of land and educational level of the mother of the child (Table VII).

TABLE V
Mean % of NCHS median weight-for-age, weight-for-length, and length-for-age, gender, and village location (n=281).
Initial survey, October 1988, Matlab

	N	Weight-for-age October Mean	Weight-for-length October Mean	Length-for-age October Mean
Age (mos)				
6–12	58	74.7*#	87.1*	93.7*#
13–24	112	69.3#	83.4*	89.7#
25–36	111	70.3*	85.4	89.0*
p		0.00	0.01	<0.001
Gender				
male	138	72.2	85.7	90.9
female	143	69.4	84.2	89.6
p		0.02+	0.12	0.02+
Embankment				
inside	150	70.5	84.6	90.3
outside	131	71.2	85.3	90.2
p		0.56	0.41	0.90

* and # Scheffe multiple comparison test significant at < 0.05 level between this pair of means.
+ ($p < 0.05$)

Level of stress, as indicated by the sale of possessions and borrowing of money, was not associated with differences in anthropometric status when these variables were tested alone. Yet, those who sold possessions tended to have more land and after adjusting for land ownership by two-way analysis of variance, sale of possessions was significantly associated with lower anthropometric means. In addition, children from households which had received food relief had lower means than those who did not receive relief.

DISCUSSION

There was no difference in the average anthropometric status in children inside versus outside the embankment after the floods. Factors unrelated to flooding were more significant in explaining observed differences in anthropometry.

The information collected by questionnaire in these surveys may be biased. It is difficult to assess socio-economic status even in the best of circumstances. One might assume that during periods of stress and crisis reporting of loss and needs are exaggerated, particularly if relief is expected to follow. Attempts were made to minimize such false reporting. The presence of health workers personally acquainted with families and unaware of the purpose of the survey, combined with observation of households by the team at the time of interview, helped to validate the information obtained.

As expected, material damage after the flood was worse for families living inside the embankment. At the same time, this sample also possessed more land, paddy seed, and large animals prior to the flood. Given that Matlab is predominantly an agriculturally based economy, one might argue that the baseline SES of those inside

TABLE VI
Mean % of NCHS median weight-for-age and weight-for-length for diarrhea today (Oct, Dec) and in past two weeks (Oct)
October and December 1988 surveys, Matlab

	N	Weight-for-age October Mean	Weight-for-age December Mean	Weight-for-length October Mean	Weight-for-length December Mean
Diarrhea today (October)					
no	214	71.7*	71.5	85.6*	85.4
yes-watery	56	66.7*	68.0	81.6*	84.4
yes-dysentery	7	69.4	70.0	86.0	88.5
p+		.01	.07	.003	.45
Diarrhea in past two weeks (Oct)					
no	162	72.7*	72.0*	86.3*	86.0
yes-watery	100	67.3*	68.5*	82.3*	83.9
yes-dysentery	15	69.4	72.4	84.9	86.7
p+		<.001	.02	.001	.13
Diarrhea today (December)					
no	218	71.2	71.5	85.6	86.0*
yes-watery	47	67.8	67.7	81.6	81.9*
yes-dysentery	12	70.5	68.2	83.7	84.3
p+		.11	.05	.01	.01

+ one-way analysis of variance
* Scheffe multiple comparison test significant at 0.05 level between these pairs of means

was better than outside. Such a difference in pre-existing SES might have rendered those inside somewhat more resistant to the potentially greater nutritional impact of the flood, in spite of the greater material damage they experienced. Indeed, many studies have emphasized the significance of various indicators of household status, including land ownership, maternal education, and family income, and their association with child nutritional status and mortality (Bhuiya, Zimicki, and D'Souza, 1986; Hassan and Ahmad, 1986; Bairagi, 1980, 1983; Razzaque, 1989).

The gender and age differences in anthropometric status have been documented (Bhuiya *et al.*, 1986; Briend, 1989). Preferential feeding of male children has been reported in Bangladesh (Chen, Huq, and D'Souza, 1981).

The prevalence of diarrhea was higher than previously reported (Briend *et al.*, 1987). This may have resulted from increased contamination of drinking water, seasonal variation in disease rates, and/or overreporting. The lower W/A and W/L indices in children with watery diarrhea may be due to dehydration.

While pre-flood anthropometry in these children is unknown, a mean W/A of 73.4% of NCHS median was documented in a separate random sample of 143 children (6–35 months) measured in Matlab in July 1988 (Henry, 1989). The 3.2% difference in W/A between these samples is not statistically significant but the sample sizes were insufficient to detect differences (Briend *et al.*, 1989). There was no detectable decline in anthropometric measures of the population studied, yet it is likely that in a normal year one would see improvement at this time of year due to harvests and increased job opportunities in November and December (Bairagi,

TABLE VII

Mean % of NCHS median weight-for-age and weight-for-length for selected socio-economic factors and indicators of stress and response to the flood (n=281) October and December 1988, Matlab

	N	Weight-for-age October Mean	Weight-for-age December Mean	Weight-for-length October Mean	Weight-for-length December Mean
Land owned					
none	106	69.5	69.5[a]	84.6	84.6[b]
< 0.5 acres	58	69.8	71.3	84.5	85.2
0.5–1.5 acres	79	71.5	71.0	84.4	84.3[a]
> 1.5 acres	36	74.6	76.8[a]	87.4	89.1[ab]
unknown	2				
p		0.06	0.01	0.23	0.02
Rice stores[c]					
0–1 seers	57	67.5	68.7	83.6	84.3
2–3 seers	98	71.3	71.1	85.5	85.2
4–9 seers	55	71.3	71.4	85.4	85.7
> = 10 seers	71	72.4	73.5	84.9	85.6
p		0.05	0.11	0.49	0.80
Mother's education					
< 1 yr	205	69.7[a]	70.2[a]	84.5	84.5
1–3 yrs	16	71.0	73.7	85.3	88.3
4–6 yrs	47	73.0	72.5	85.9	86.2
> 6 yrs	13	79.8[a]	79.2[a]	87.8	87.9
p		0.003	0.01	0.37	0.11
Money borrowed					
no	81	71.1	71.2	85.3	85.5
yes	199	70.7	71.3	84.8	85.1
unknown	1				
Food relief received					
yes	122	69.6	70.1	84.3	85.3
no	159	71.7	72.2	85.4	86.0
Possessions sold to buy food[d]					
no	213	71.4	71.7	85.4	85.4
yes	68	69.1	69.8	83.5	84.7

[a] and [b] Scheffe multiple comparison test significant at < 0.05 level for this pair of means tested after one-way analysis of variance showed significance

[c] in "seers"; 1 seer = 0.9 kg

[d] Mean W/A and W/L in October different between groups at 0.05 level on two-way analysis of variance controlling for land ownership.

both the food crisis and the period of severe unemployment was relatively short, and the price of rice on the market was fairly well controlled. Given the limited amounts of relief that were distributed, it is difficult to conclude that relief itself, (i.e. food distribution), was sufficient to prevent significant decline in nutritional status.

Children most at risk of malnutrition following the flood were those which are most at risk during normal times, i.e. the children of the poor. These children were not necessarily from those families most affected by the flood. The official recommendation of targeting relief following a crisis to families which are landless and destitute should be emphasized and ensured.

REFERENCES

Armitage, P. (1971). *Statistical Methods in Medical Research.* Blackwell Scientific Publications, Oxford.

Bairagi, R. (1980). Is income the only constraint on child nutrition in rural Bangladesh? *Bull. WHO* **58** (5), 767-772.

Bairagi, R. (1983). Dynamics of child nutrition in rural Bangladesh. *Ecol. Food Nutr.* **13**, 173–178.

Bhatia, S., W.H. Mosley, A.S.G. Faruque and J. Chakraborty (1980). The Matlab family planning and health services project. *Stud. Fam. Plann.* **11**, 202-212.

Bhuiya, A., B. Wojtyniak, S. D'Souza and S. Zimicki (1986). Socio-economic determinants of child nutritional status: boys versus girls. *Food Nutr. Bull.* **8** (3), 3-7.

Bhuiya, A., S. Zimicki and S. D'Souza (1986). Socioeconomic differentials in child nutrition and morbidity in a rural area of Bangladesh. *J. Trop. Pediatr.* **32**, 17-23.

Briend, A., K.H.Z. Hasan, K.M.A. Aziz, *et al.* (1989). Measuring change in nutritional status: a comparison of the different nutritional indices and of the sample sizes required. *Eur. J. Clin. Nutr.*, in press.

Briend, A., B. Wojtyniak and M.G.M. Rowland (1987). Arm circumference and other factors in children at high risk of death in rural Bangladesh. *Lancet* **2**, 725-728.

Brown, K.H., R.E. Black, S. Becker and A. Hoque (1982). Patterns of physical growth in a longitudinal study of young children in rural Bangladesh. *Am. J. Clin. Nutr.* **36**, 294-302.

Chen, L.C., E. Huq and S. D'Souza (1981). Sex bias in the family allocation of food and health care in rural Bangladesh. *Pop. and Dev. Rev.* **7** (1), 55-70.

Hassan, N. and K. Ahmad (1986). Household distribution of energy intake and its relationship to socio-economic and anthropometric variables. *Food Nutr. Bull.* **8** (4), 3-6.

Henry, F.J. (1989). A multi-regional nutritional surveillance system in Bangladesh. Summary Report #3. ICCDR,B, Dhaka.

Razzaque, A. (1989). Sociodemographic differentials in mortality during the 1974-75 famine in a rural area of Bangladesh. *J. Biosoc. Sci.* **21**, 13-22.

Ruzicka, L.T. and A.K. Chowdhury (1978). Demographic surveillance system — Matlab. Methods and procedures. Dhaka: *ICDDR,B Scientific Report* **1** (9).

WHO Working Group (1986). Use and interpretation of anthropometric indicators of nutritonal status. *Bull. WHO* **64**, 929-941.

Zerfas, A.J. (1975). The insertion tape: a new circumference tape for use in nutritional assessment. *Am. J. Clin. Nutr.* **28**, 782-787.

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