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FROM DIARRHOEA IN CHILDREN

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## PREFACE

The International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) is an autonomous, international, philanthropic and non-profit centre for research, education and training as well as clinical service. The Centre is derived from the Cholera Research Laboratory (CRL). The activities of the institution are to undertake and promote study, research and dissemination of knowledge in diarrhoeal diseases and directly related subjects of nutrition and fertility with a view to develop improved methods of health care and for the prevention and control of diarrhoeal diseases and improvement of public health programmes with special relevance to developing countries. ICDDR,B issues two types of papers: scientific reports and working papers which demonstrate the type of research activity currently in progress at ICDDR,B. The views expressed in these papers are those of authors and do not necessarily represent views of International Centre for Diarrhoeal Disease Research, Bangladesh. They should not be quoted without the permission of the authors.

ABSTRACT

Review of the available data suggests that anorexia during diarrhoea accounts for a 30% reduction of food intake. We studied the intake of food in 63 children below five years, 29 of whom had cholera, 15 rotavirus, 13 ETEC, and six shigella. The study showed a 30-40% reduction in food intake during the acute stage of diarrhoea. The intake of calories in the acute stage was 74.8 K.cal, 68.5 K.cal, 70.6 K.cal, and 70.0 K.cal per kg per day respectively for cholera, rotavirus, ETEC and shigella. In cholera and shigella the intake improved up to the level recommended by FAO/WHO within four or five days of the onset. But in rotavirus and ETEC diarrhoea it took as long as eight weeks for the intake to come up to the same level. The intake of food increased steadily without a simultaneous increase in the stool volume. This study suggests that the recommended level of food should be offered during diarrhoea of any aetiology, as a substantial amount of food can be consumed even in the acute stage of diarrhoea.

## INTRODUCTION

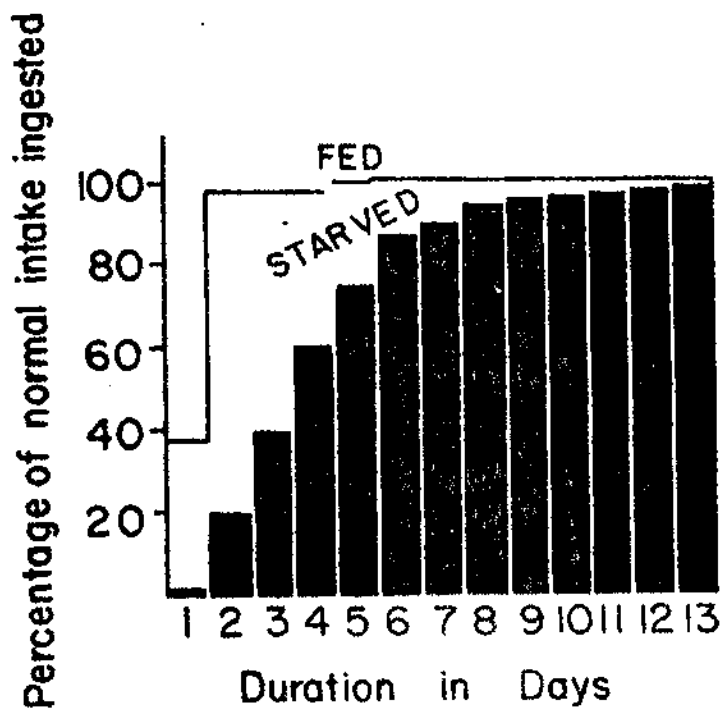
The results of published work suggest that the "nutritional status" of a child is as much the product of infection as of dietary intake (1, 2). A study by Mata and his co-workers (3) showed that the nutritional status of children in rural Guatemala was more related to infections than to the availability of food. The same may be true for many other developing countries. That the nutritional consequences of diarrhoea cause protein-energy malnutrition and growth retardation has been established (4, 5). Several factors are involved in this process. Important among them are partial anorexia or loss of appetite, cultural taboos or maternal behaviour during diarrhoea resulting in withholding of food as a measure to control diarrhoea, and increased catabolic process, compounding direct loss due to malabsorption.

The purpose of this presentation is to review the available data on the intake of food during diarrhoea, the impact of diarrhoea on the growth of children and to present our research on the intake of food both during acute stage of diarrhoeas of different aetiology and after recovery. Withdrawal or modification of food with the hope of reducing the volume of stool and duration of diarrhoea, is a widespread practice. Our predecessors placed their reliance on the appearance, volume and number of stools as the criteria for success of treatment. This point of view was challenged in 1924 by Park (6) who maintained that the child rather than the stools should be taken as the criterion for evaluating therapy. This was scientifically examined for the first time by Chung and co-workers as early as 1948. He studied two groups of infants with diarrhoea. In the first group those younger than six months were fed 100-120 K.cal per kg of body weight per day, while those older than six months were given 80 K.cal per kilogram. The other group was starved for the first 48 hours followed by oral feeding of 20 K.cal per kilogram per day which was increased at the rate of 20 K.cal per kilogram daily (Fig. 1). The mean intake of the fed group was 40.6 K.cal more during the first week than the starved group. The duration of diarrhoea in the fed group was not significantly different from the starved group, but the weight gain was higher in the fed group compared to the starved group as shown in Fig. 2. Chung further observed that higher stool volume in the fed group was associated with higher absorption of nutrients.

Like other infections, diarrhoea affects the nutritional status and the growth of the child. The effect of diarrhoeal illness on the nutritional status and the growth of a child is shown in Fig. 3 as demonstrated by Cameron and Hofvander (7). Each arrow indicates one episode of diarrhoeal illness and the lower line indicates the impact on the growth of the child in comparison to the growth of a normal child which is indicated by the line at the top. As long as the child is taking breast milk, he gets enough protein, though not adequate calories, and the effect of diarrhoea is manifested by marasmus. During and after weaning, which is around the age of 2 years, the child is

Fig. 1

PERCENTAGE OF NORMAL INTAKE CONSUMED PER DAY IN STARVED GROUP AND FED GROUP



CHUNG A.W. ET AL. J. PED. 33: 14-22, 1948

Fig. 2  
WEIGHT CURVES SHOWING ALGEBRAIC SUM OF DAILY  
WEIGHT GAINS AND LOSSES IN TWO GROUPS OF CHILDREN  
CHUNG A.W. ET AL. J. PED. 33: 14-22, 1948

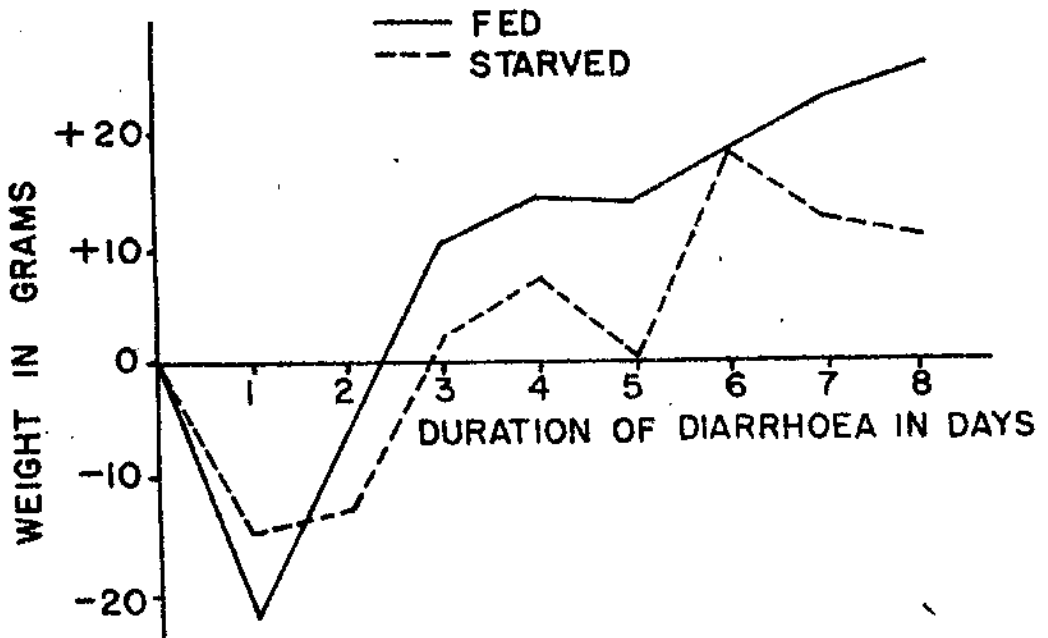
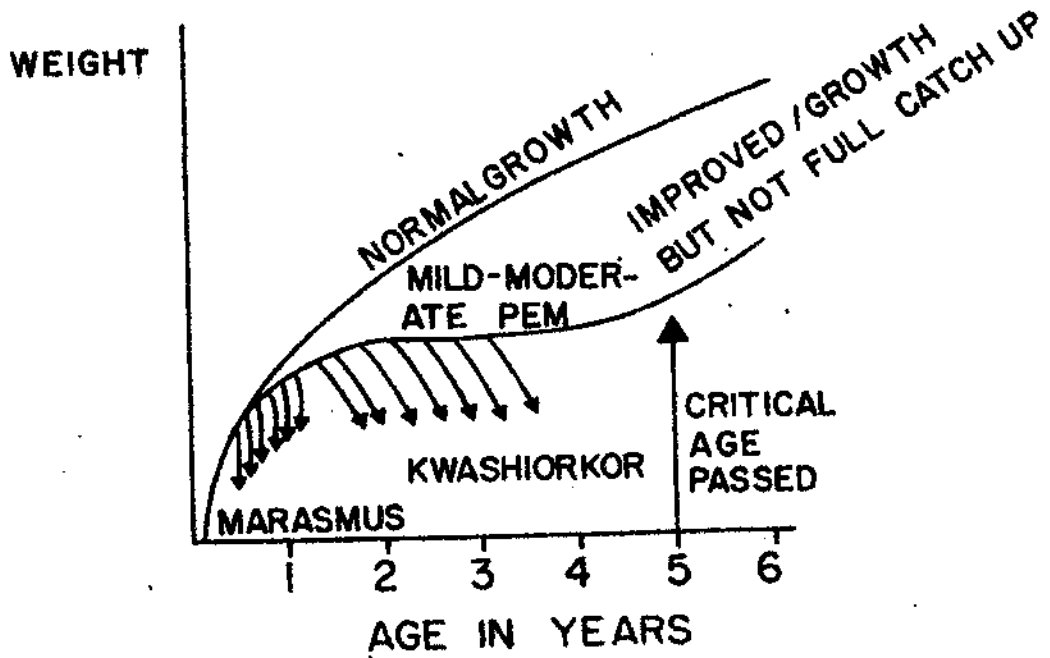


Fig. 3

EFFECT OF INFECTION AND PEM ON GROWTH  
CAMERON, M. ET AL.  
MANUAL ON INFANT FEEDING AND YOUNG CHILDREN.  
UN PROT. CAL. ADV. GROUP





deprived of the only source of protein, i.e. breast milk, and the effect of diarrhoeal episodes is manifested by kwashiorkor. If the child survives, at the age of five to six years there is some decrease in diarrhoeal illnesses and the child catches up growth but usually not up to the normal level.

Food intake is reduced in the acute phase of diarrhoea. This has been amply demonstrated by different workers. According to FAO/WHO in 1973 (8) the daily recommended allowance for energy and protein was fixed at 100 K.cal/kg and 1.25 gm/kg respectively per day. Using this standard, Mata and co-workers showed that Guatemalan village children take a diet deficient in calories but adequate in protein in normal condition as shown in Figs. 4 and 5. This intake was affected by different kinds of illnesses including diarrhoea as shown in Fig. 6. The cause of infection lies in non-nutritional factors. Malnourished children however tend to harbour infections for longer periods and often have more severe clinical manifestations of diseases (9-13). Gyr and co-workers demonstrated that protein-deficient patat monkeys suffer from more severe symptoms of cholera compared to normal ones (13).

Martotell and co-workers, in a longitudinal study in Guatemala (4) involving 477 pre-school children, attempted to measure the effect on food intake of illnesses such as respiratory infections, diarrhoea, and a group of selected common symptoms, while the children were in their home environment. The authors found that on an average the reduction of calorie and protein intake was 20% which is equivalent to 175 K.cal and 4.8 g protein per day (Fig. 7). It became apparent that the effect of diarrhoea on food intake was greater than the effect of respiratory infections.

Recently, at the International Centre for Diarrhoeal Disease Research, Bangladesh, studies were carried out to estimate the effect of diarrhoeal illness on food intake in the hospital and in the home. Hoyle, Yunus and Chen (14) studied the food intake in two groups of children with diarrhoea in a field hospital. The mothers of one group received intensive dietary education and the other group received routine hospital care. The authors compared the food intake of these two groups with that of a healthy group matched for age. The importance of this study lies in the fact that breast feeding was continued and intake from the breast milk was measured separately. The results are presented in Table I.

The total calorie intake among the children with diarrhoea was 75 K.cal/kg/day compared to 130 K.cal/kg/day in the healthy children. In other words, there was about 40% reduction in intake during diarrhoea. Most interestingly the calorie intake from breast milk did not decrease in the children with diarrhoea compared to the healthy children. In this study the intake of food was not studied in the same patients during a healthy period to compare with that in diarrhoea period. However it was concluded that the calorie intake from breast milk remains undisturbed even during diarrhoea.

Fig. 4  
ESTIMATES OF PERCENTAGE OF RECOMMENDED CALORIES  
CONSUMED BY A CHILD IN GUATEMALA  
MATA ET AL. AM J CLIN. NUTR. 30:1215, 1977

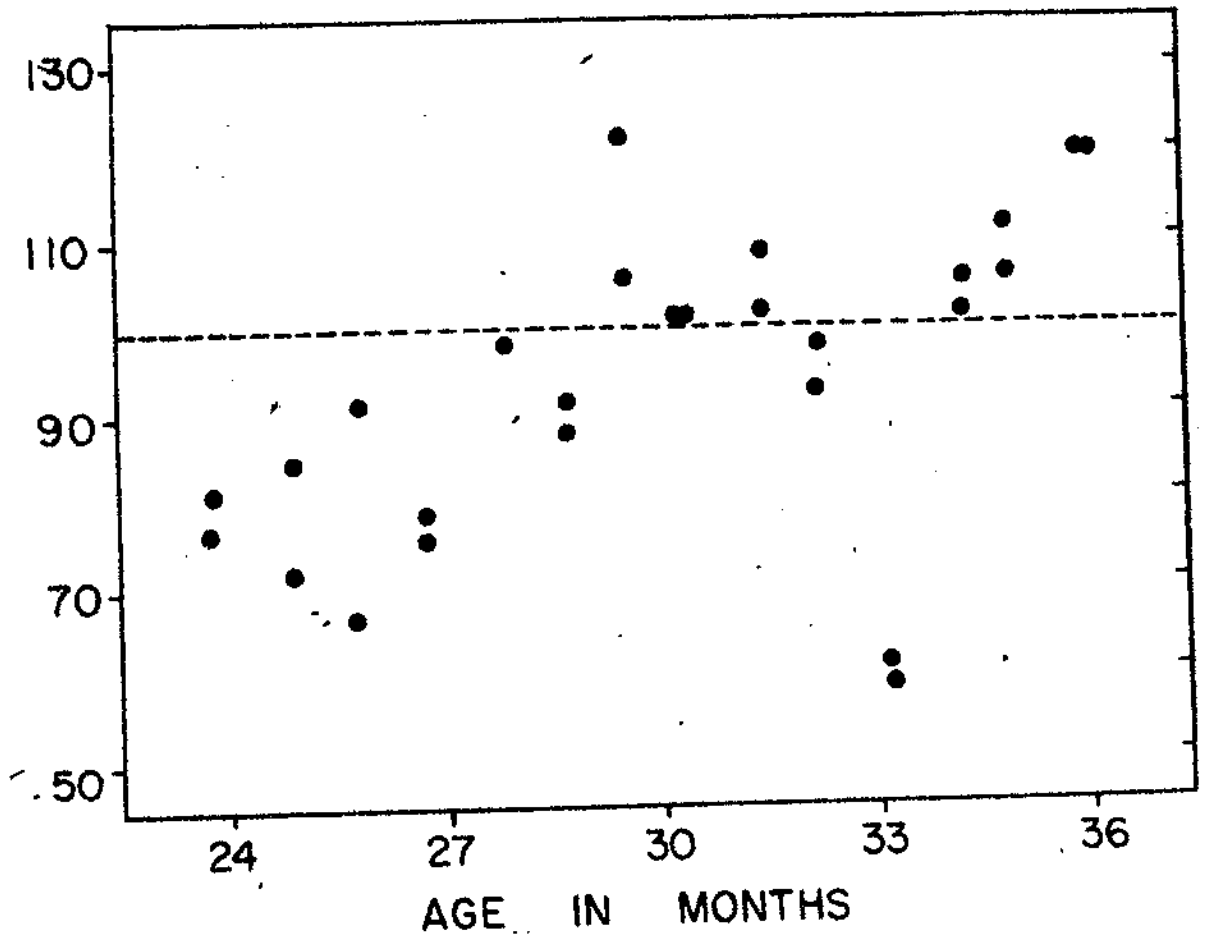


Fig. 5  
ESTIMATES OF PERCENTAGE OF RECOMMENDED ALLOWANCE OF  
PROTEIN CONSUMED BY A CHILD IN GUATEMALA  
MATA ET AL. AM. J. CLIN NUTR. 30, 1215, 1977

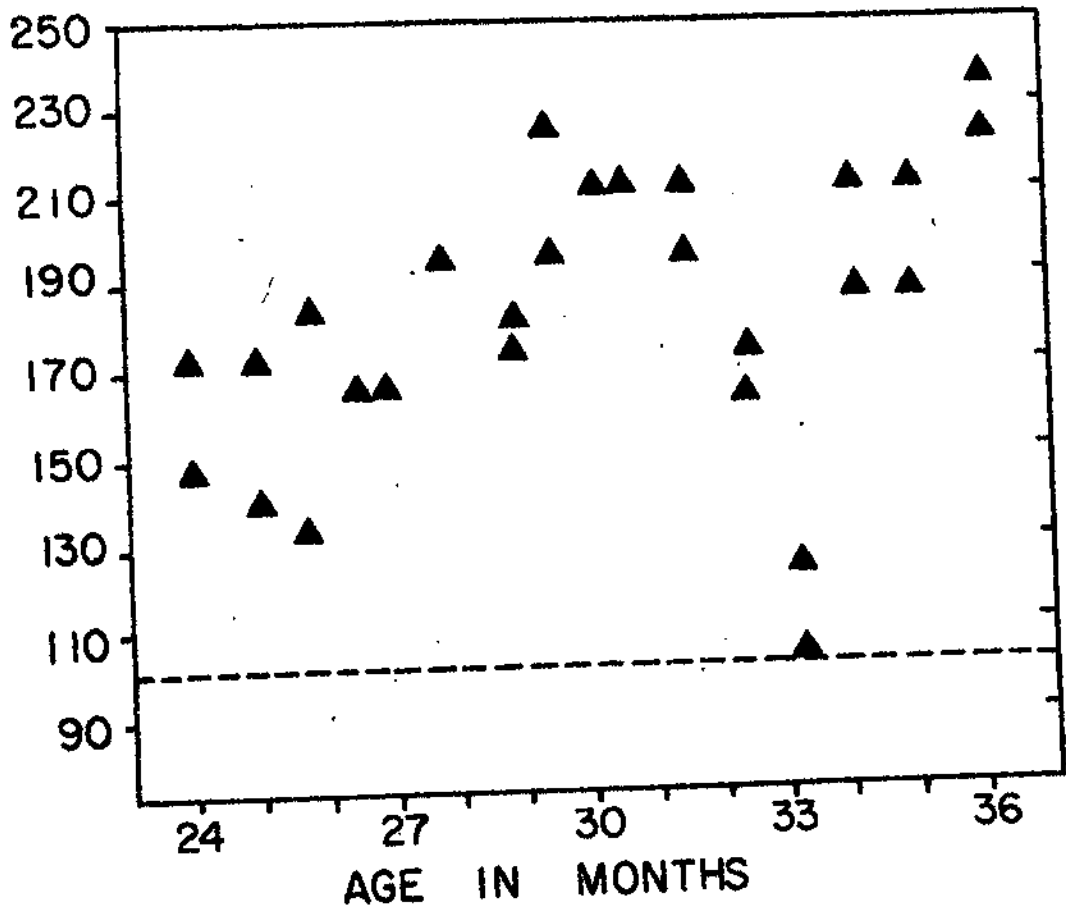


Fig. 6  
PERCENTAGE OF RECOMMENDED ALLOWANCE  
OF PROTEIN CONSUMED BY A CHILD IN GUATEMALA  
AND EFFECT OF DIARRHOEAL ILLNESS

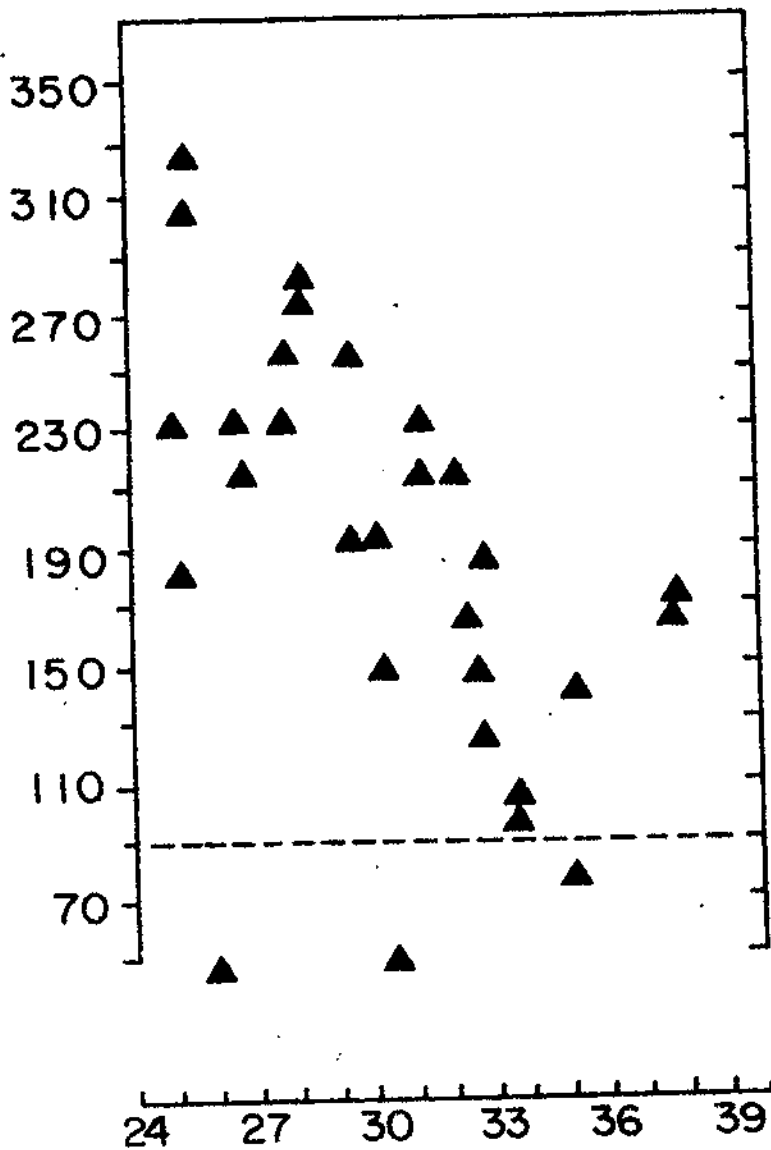


Fig. 7

COMPARISON OF HOME DIETARY ENERGY INTAKE FOR CHILDREN  
WITH OR WITHOUT SELECTED COMMON SYMPTOMS  
AM. J. CLIN. NUTR. 33 : 345, 1980

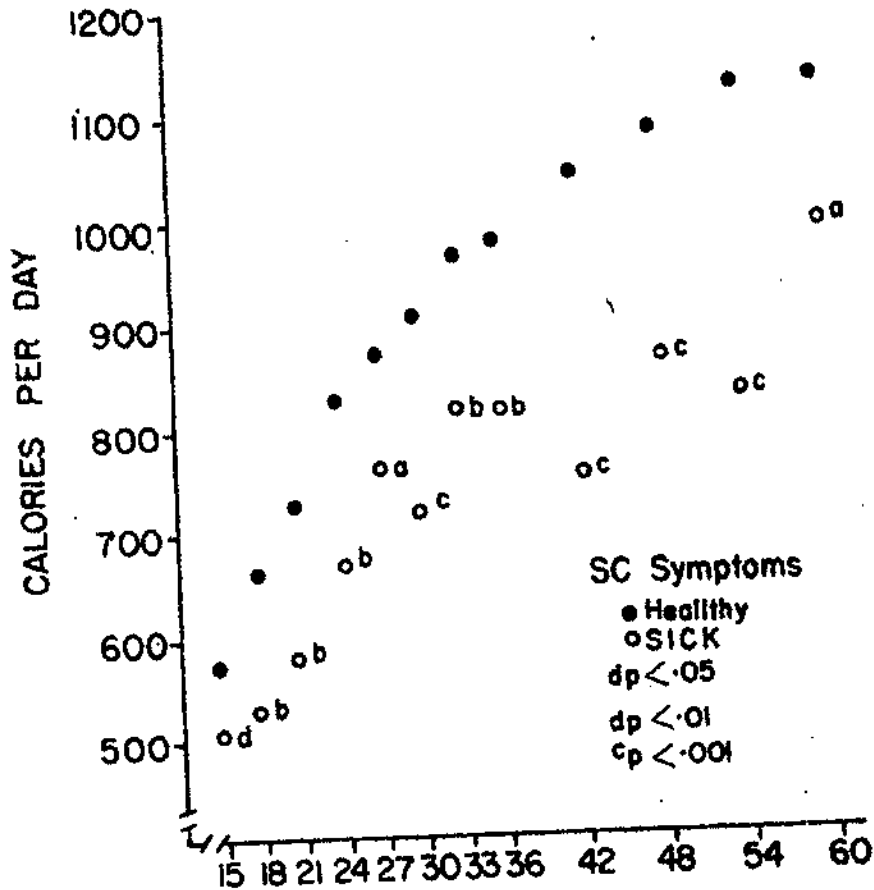


TABLE I--TOTAL CALORIE INTAKE (K.CAL/KG/24 HR) FROM BREAST MILK, ORAL FLUIDS,  
AND WEANLING FOODS AMONG CHILDREN WITH DIARRHOEA AND HEALTHY  
CONTROLS (MEAN  $\pm$  SEM)

Source of Calories	Healthy Controls (11)*	Children with Diarrhoea (15)*
Breast Milk	53.6 $\pm$ 6.7	46.9 $\pm$ 5.5
Oral Fluids		10.1 $\pm$ 2.0
Weanling Foods	86.3 $\pm$ 21.1	33.3 $\pm$ 8.8
Total Calories	129.9 $\pm$ 16.8	75.0 $\pm$ 8.3

Hoyle *et al.* Am J Clin Nutr. 33, 2365, 1980

\* Figures in parentheses indicate the number of subjects studied.

In another study carried out in a rural area in the southern part of Bangladesh (15), which involved 65 children between the age of 13 months to 60 months, the children's intake during both healthy periods as well as during diarrhoeal episodes in their homes was measured. The authors demonstrated that the intake of both calories and protein was reduced by 70% from normal levels, although environmental conditions remained unchanged. The severe reduction of intake of calories and protein in this study may be due to withdrawal of food in a home environment, which may be minimised in a hospital setting.

#### Intake of Food in Acute Stage of Diarrhoea and After Recovery:

In the present study, intake of nutrients was measured among children below 5 years of age during acute diarrhoea due to *V. cholerae*, enterotoxigenic *E. coli*, rotavirus and shigella. Measurements were taken at the acute diarrhoeal stage and at two and eight weeks after recovery. The objectives of the study are as follows:

1. To make a quantitative estimate of the nutrient intake in acute diarrhoea in children due to different aetiology and to compare it with that after recovery.
2. To study the pattern of intake of nutrients in the acute and convalescent stages of diarrhoea and after recovery.
3. To study the impact of food intake on stool volume in diarrhoea.

#### METHODS AND PATIENTS

Sixty-three children below five years of age, of whom 29 had cholera, 15 had rotavirus infection, 13 ETEC diarrhoea and six diarrhoea due to shigella, were involved in this study. Patients with mild to moderate dehydration with short duration of diarrhoea and without any apparent complications were selected from the population of a diarrhoea treatment centre in Dacca, Bangladesh and included in a balance study. Clinical information about the study patients is presented in Table II. Cholera patients were comparatively older and also lost more fluid. The patients in the other groups were comparable in respect to age, body weight, dehydration status and purging rates. To correct dehydration and to maintain hydration, fluid was administered by intravenous route only. Following hydration, a charcoal marker was fed and immediately after that a familiar local diet was offered to the patients ad libitum. The composition of the diet is shown in Table III. The type of food was selected according to the choice of the children in a pre-study trial. Actual amount of food consumed was calculated by deducting the left over

TABLE II-- CLINICAL SUMMARY OF STUDY PATIENTS  
(MEAN  $\pm$  SEM)

Particulars	Cholera (29)*	Rotavirus (15)*	ETEC (13)*	Shigella (6)*
Age (months)	43.8 $\pm$ 2.75	17.2 $\pm$ 3.93	33.08 $\pm$ 3.16	33.0 $\pm$ 7.55
Body Weight (Kg)	9.6 $\pm$ .33	9.1 $\pm$ .59	9.8 $\pm$ .52	9.431 $\pm$ 0.68
HCT	35.4 $\pm$ 3.6	31.8 $\pm$ .90	32.8 $\pm$ .78	33.33 $\pm$ 2.03
SER. SPGR.	1.0273 $\pm$ .0006	1.0265 $\pm$ .0006	1.0265 $\pm$ .0005	1.0265 $\pm$ .0014
72 Hours Stool Vol. (mls/Kg/ 8 Hrs)	477 $\pm$ 63.01	142.3 $\pm$ 16.62	199 $\pm$ 22.80	246.66 $\pm$ 101.14
Total I.V. (Litre)	5.75 $\pm$ .83	1.155 $\pm$ .21	1.158 $\pm$ .27	1.982 $\pm$ 0.46

\* Figures in parentheses indicate number of subjects studied.



TABLE III--COMPOSITION OF THE STUDY DIET

Items of Food	K.cal/gm	Protein gm %
Boiled Rice	1.2	2.12
Curry*	1.34	7.56
Banana	1.24	1.81
Khichuri**	.94	2.57
Whole Milk	.77	2.37
Dessert/Halua***	1.47	2.7
Bread	3.01	8.06

\* Contained: Potato, Oil, Chicken, Pumpkin, Onion

\*\* Contained: Rice, Dal, Oil, Chicken, Potato

\*\*\* Contained: Milk, Egg, Semolina, Oil, Sugar

amount from the amount offered. Breast-feeding was continued and the amount consumed was determined by test weighing before and after feeding. The foods were offered at different times according to local customs, and special care was taken to keep the food habits of the children similar to the pre-diarrhoeal period.

After the appearance of the marker the intake study was carried out for 72 hours. Some patients from each aetiology were studied up to the seventh day of admission which included a convalescent period. The appearance of the first formed stool was taken as the end of the acute stage and the beginning of the convalescent stage of diarrhoea. Patients were discharged after clinical recovery and brought back at two and eight weeks after recovery. The intake-study was repeated during each period for 72 hours.

#### RESULTS

The mean intake of food in gm/kg/day is shown in Table IV. *Shigella* patients had the lowest intake in the acute stage compared to other aetiologies. In the recovery stage intake improved in all aetiologies but rotavirus patients showed minimum improvements.

The calorie intake in acute stage of diarrhoea, at two and eight weeks after recovery is shown in Table V. The mean calorie intake in the acute stage was around 70 K.cal/kg/day in all aetiological diarrhoea. But two weeks after recovery the calorie intake improved comparatively more in all aetiologies except in rotavirus which came up to the same level at about eight weeks after recovery.

The intake of fat, protein and calories together in different stages of diarrhoea is shown in Fig. 8 and the trend is the same as for calorie intake. The pattern of intake of calories showed a steady improvement day by day in cholera. It reached the FAO and WHO (8) recommended intake of 100 K.cal/kg/day on the fourth day in cholera and on fifth day in ETEC and rotavirus. This coincided with the appearance of the first formed stool in all groups. The cholera patients showed higher intake than the recommended allowance (120 K.cal/kg/day) on the seventh day and this remained the same after recovery. In ETEC patients calorie intake was highest (112 K.cal/kg/day) on the seventh day and did not change in the recovery stage. But rotavirus patients showed some differences. The highest calorie intake (115 K.cal/kg/day) was reached eight weeks after recovery.

Table VI shows the calorie balance in different stages of diarrhoea due to different aetiologies, that is, 62.6 K.cal, 44.7 K.cal, 60 K.cal and 63.6 K.cal for cholera, rotavirus, ETEC and shigella respectively. The

TABLE IV--INTAKE OF FOOD (GM/KG/DAY) IN ACUTE STAGE AND AFTER RECOVERY FROM DIARRHOEA (MEAN + SEM)

Aetiologies	Acute	Recovery	% Improved
Cholera	82 + 8.5	110.4 + 8.7	35
Rotavirus	87 + 10.4	102.7 + 11.1	18
ETEC	82.4 + 7.87	106 + 6.0	29
Shigella	73.2 + 10.9	114.3 + 8	56

TABLE V--INTAKE OF CALORIES IN ACUTE STAGE (A), 2 WEEKS (R<sub>1</sub>) AND 8 WEEKS (R<sub>2</sub>) AFTER RECOVERY (MEAN + SD)

Aetiologies	A	R <sub>1</sub>	R <sub>2</sub>
Cholera	74.9 + 36.20	111.1 + 35.4	109.59 + 31.7
Rotavirus	68.5 + 22.6	87.2 + 26.2	115.0 + 20.2
ETEC	70.7 + 37.9	90.97 + 28.4	114.9 + 19.0
Shigella	70.0 + 28.2	100.5 + 27.8	109.3 + 18.8

Fig. 8  
INTAKE OF MACRO NUTRIENTS IN DIFFERENT  
STAGES OF DIARRHOEA

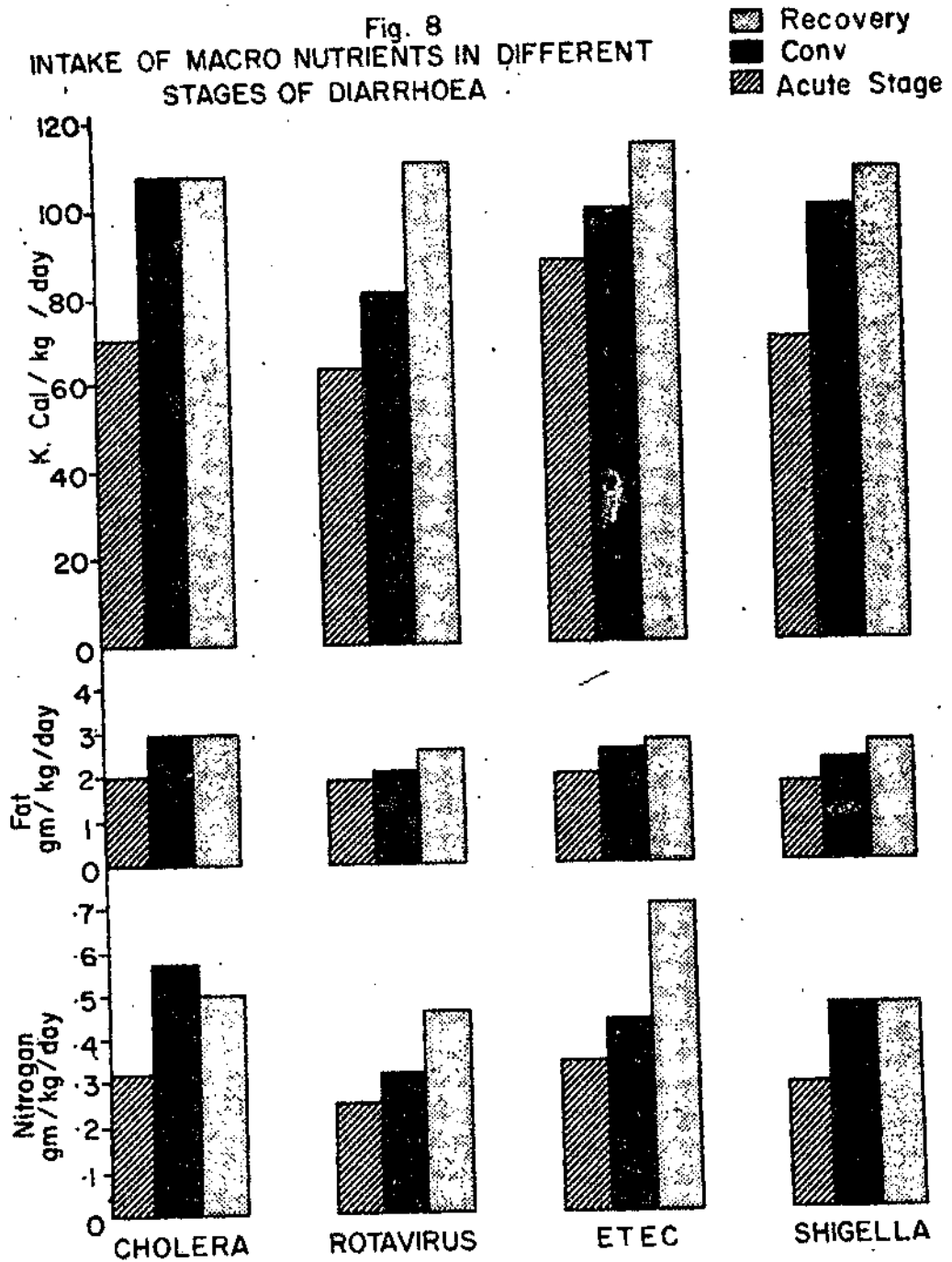


TABLE VI--CALORIE BALANCE IN DIFFERENT STAGES OF DIARRHOEA IN ACUTE STAGE (A),  
2 WEEKS (R<sub>1</sub>) AND 8 WEEKS (R<sub>2</sub>) AFTER RECOVERY (MEAN ± SD)

Aetiologies	A	R <sub>1</sub>	R <sub>2</sub>
Cholera	62.6 ± 35.0	99.1 ± 35.5	92.7 ± 47
Rotavirus	44.7 ± 22.6	76.9 ± 25.7	95.2 ± 23.2
ETEC	60 ± 32.1	76.3 ± 29.3	109.0 ± 9.1
Shigella	63.6 ± 23.0	80.9 ± 25.4	98.7 ± 14.4

calorie balance in the acute stage of rotavirus is comparatively less and two weeks after recovery a substantial calorie balance was achieved in all groups.

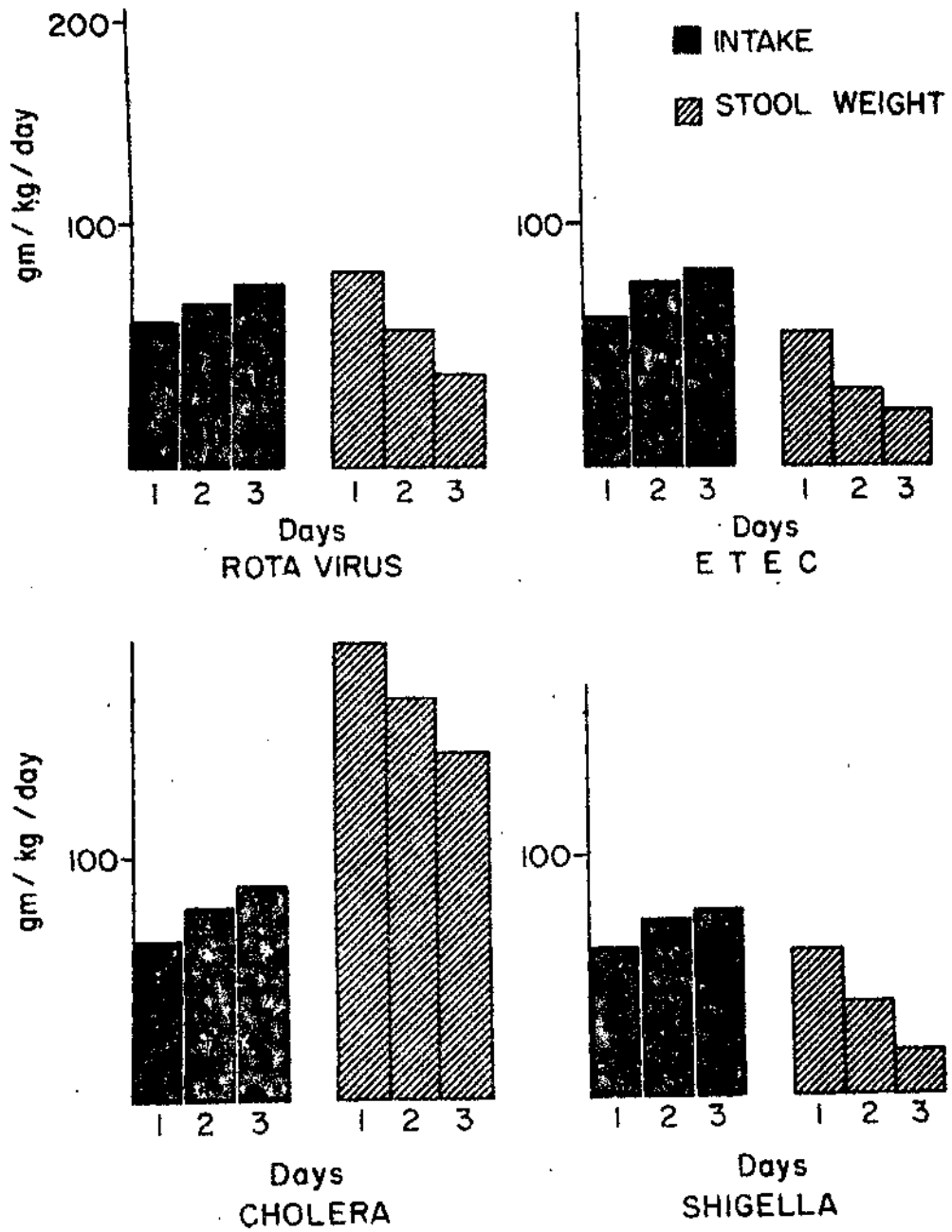
For ethical reasons the study could not be designed properly to answer the question of impact of food on stool volume. It was felt that a group of study children would have to be starved to see what impact this would have on stool volume. However, an attempt was made to measure the effect of food intake on the stool volume for a 72 hour period in each aetiology as is illustrated in Fig. 9. The mean intake of food in each 24 hour study period is shown beside the mean stool volume in the same 24 hour study period. In each aetiology food intake steadily increased and the stool volume decreased.

#### DISCUSSION

A review of the relevant literature has shown that diarrhoea, like many other illnesses, affects the nutritional status and growth of children. This is even more disastrous if the diarrhoea is recurrent. Withholding food may or may not reduce the duration and volume of diarrhoea, or change the character of the stool. But Park's observation is noteworthy in that the child is more important than the stool. Chung, almost two decades later, showed that although stool volume may increase in some cases because of food intake, even then the increase is associated with higher nutrient absorption and does not prolong diarrhoea.

The virtues of breast milk have been studied in detail, but the study of Hoyle *et al.* (14) shows that the anorexia of diarrhoea mainly affects supplementary food while the intake of breast milk remains unchanged. Thus it provides a

Fig.9  
RELATION BETWEEN FOOD INTAKE AND STOOL WEIGHT



unique source of calories and very much-needed protein. Anorexia frequently accompanies diarrhoeal illnesses, and even educating mothers in dietetics may not alter this. However, when it is offered to children suffering from diarrhoea of different aetiologies, there is a substantial intake of food and calories. The pathophysiology of the specific diarrhoea is related to the amount of food consumed. In non-invasive diarrhoeas like cholera, calorie intake returns to the recommended amount by the fourth day, and during the convalescent and recovery stages the intake exceeds even the recommended allowance. Rotavirus patients on the other hand take a longer period to return to the same level. This may be due to the pathology of rotavirus disease, selectively affecting the villous epithelial cells (16).

Despite anorexia there was substantial calorie balance even in the acute stage of diarrhoea when food was offered. If food had not been offered, this amount of calorie, which is necessary for normal metabolic activities and catabolic processes during diarrhoea, would have been obtained by burning body fat and available protein. This penalty of starvation pushes children further into a negative balance.

Based on information already available and on the information from our own study, the following conclusions can justifiably be drawn.

- \* There is about 30% reduction in food intake in diarrhoea of all aetiologies.
- \* Feeding, including breast feeding should be encouraged even in the acute phase of diarrhoea of any aetiology.
- \* There is no apparent deleterious effect from food intake on the volume or duration of diarrhoea, but it needs further study.

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