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30 Malnutrition and gastroenteritis in The Gambia

M. G. M. ROWLAND AND J. P. K. MCCOLLUM

*Dunn Nutrition Unit, University of Cambridge and Medical Research Council,
Milton Road, Cambridge, U.K. and Keneba, The Gambia, and the
Institute of Child Health and Hospital for Sick Children, Great Ormond Street, London***Summary**

There is a strong association between failure to thrive and diarrhoeal disease in young Gambian children.

The high prevalence of diarrhoeal disease seen is not due to frequent attacks of "acute infantile diarrhoea" of viral origin. The picture of protracted diarrhoea is almost certainly due to colonization of the upper bowel and the high prevalence demonstrated to be at least partly due to the environment to which the children are exposed, particularly in terms of food and water hygiene.

Until this cycle of upper bowel colonization and protracted diarrhoea is broken, a diet-based nutrition programme cannot be expected to function effectively.

Introduction

A number of salient points emerge from the analysis of the pattern of infection in Keneba (COLE & PARKIN, 1977). There is a very high prevalence of diarrhoeal disease in our survey population. Between the ages of seven and 13 months the children, on average, have diarrhoeal symptoms for six days in each month, with a peak occurring at nine months of age. Diarrhoeal illness contributes almost exclusively the non-dietary element in failure to grow. The extent of this contribution is such that an intervention programme intended to improve the nutritional status of these children could be expected to achieve only limited success if it is based on dietary measures alone.

One may speculate that radical improvements in water supply, sanitation and personal hygiene could be expected to reduce the amount of diarrhoeal disease occurring (WATT *et al.*, 1953; HOLLISTER *et al.*, 1955; MORLEY, 1973). Such an approach, however, holds out little hope of early alleviation of the problems facing an isolated rural community such as Keneba.

Our overall aim is to try to determine some simple specific measures that can be introduced at rural village level to reduce the contribution of diarrhoeal disease to growth failure. Clearly, before this can be achieved a better understanding is required of what has hitherto been referred to as diarrhoeal disease.

Fortunately, in our survey community the term *dian joo* (Mandinka: *Konobayo lit: the belly runs*) is in almost all cases used quite accurately. Dysentery, much less often used, has a more variable meaning and further clarification is always sought. Our diagnosis, then, is in the first instance largely based on the mother's history.

Specific investigations have been pursued along three main channels. Firstly we have looked at possible sources and routes of transmission using water and food bacteriology studies. Secondly we have tried to identify a causal agent using stool microbiology. Thirdly we have sought, by way of upper bowel studies, a possible mechanism to

explain the association between frequent diarrhoea and failure to thrive.

Water bacteriology

The village is served by six wells between 10 and 25 years old, three having been built by the Area Council and the other three by the villagers themselves. These vary between 45 and 60ft in depth and a small part of the top section of the shaft only may be lined by cement.

Water is hauled by hand from these wells using buckets, often improvised from old inner tubes, on ropes. It is then transferred to a larger container, such as a tin bath, and carried back to the compound. There the water storage pots are replenished. These unglazed earthenware pots, which vary in size from 25 to 70 litres, may be stored in the kitchen or out in the yard areas. Different pots are kept for washing and for cooking and drinking purposes. They are usually covered and may occasionally be cleaned out, although this practice is far from routine. Water is obtained from them by dipping in with a small container, often a tin can which lies around to hand.

Samples were taken from each well on two occasions and from each of a 50% sample of water storage pots used by survey children on one occasion. The bacteriological methods used were standard to the U.K. (DHSS, 1969). Four types of examinations were made. Colony counts ranged from 2.6×10^2 to 4.0×10^8 per ml. Faecal coliforms almost always exceeded 1,600 per 100 ml of water with a range from 60 to 18,000 per 100 ml. Total coliform counts were even higher. In England it is recommended that supplies should be condemned where this figure exceeds 10 coliforms per 100 ml. Examination of unconcentrated 50 ml aliquots of water for specific pathogens yielded salmonellae from one well and from two water pots not filled from the affected well. In a different situation, concentration techniques would be used and it is likely that contamination with salmonella is more widespread than we have shown.

In summary, all Keneba well water shows marked evidence of faecal contamination and there is further evidence to suggest subsequent additional contamination in some of the water pots.

Food bacteriology

A small pilot study has also been initiated into the bacteriology of some of the commoner foodstuffs eaten by our survey children.

The diet of the population is cereal based, the nature of the cereal being to some extent determined by season and availability. Commonest are rice, millet, finger millet, sorghum and maize. Groundnuts and green leaves are commonly added. The initial weaning food, often introduced around the age of four months, is usually a

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very thin watery gruel based on one of the cereals. As the child grows older, food is usually presented in a more concentrated form, with more things added.

Although there is a tendency for adults to observe three meal-times per day, feeding of small children is particularly haphazard, never more so than during the rains, when considerable time and effort is diverted towards farming activities. At such times small children and infants may be left in the compounds in the care of young "nursemaids" with a supply of porridge or gruel for the next eight to nine hours, and food from the evening meal is sometimes stored overnight.

The bacteriological results indicate that freshly cooked food is generally of acceptable quality. However, after 30 minutes, *Bacillus cereus* which was present in two-thirds of the samples reaches unacceptable levels (10^3 to 10^7 organisms per g of food) which are known to be associated with gastro-intestinal symptoms (THATCHER & CLARK, 1973).

Evidence of coliform contamination is also found after periods in excess of 30 minutes, unacceptable levels being detected in one-third of the samples, presumably introduced after cooking.

From the description of the feeding habits it can be seen that children in the age group under discussion will be consuming food with significant levels of bacterial contamination for much of the time.

Stool bacteriology

During the 1975 rainy season from August to October, that is covering the period of peak prevalence of diarrhoea in our survey population, Dr. T. H. J. Matthews from the Clinical Research Centre, Harrow, carried out a stool bacteriology survey in Keneba. He took as his subjects Keneba survey children aged between six months and three years with an immediate history of diarrhoea of not more than four days duration. Specimens were also obtained from the same population when the children were not suffering from diarrhoea, but attended the clinic either with other ailments or, at our request, for routine examination. The results are summarized in Tables I and II.

The over-all isolation rate of bacterial pathogens of 5% is low by any standards (SEN, 1962; BACK & BROOKS, 1962; CHAN & LUCAS, 1964).

Table I - Stool bacteriology— isolation rates

	Numbers of specimens	Bacterial pathogens
Total	497	25 (5.0%)
Diarrhoea	356	20 (5.6%)
Routine	141	5 (3.5%)

Table II - Stool pathogens isolated

	Numbers	% of total +ve
Total	25	100
Pathogenic <i>E. coli</i> *	16	64
<i>Salmonella</i>	5	20
<i>Shigella</i>	4	16

*The five positive routine stool specimens all yielded path. *E. coli*.

Table III - Virus isolations in 27 selected Keneba children

	Tissue culture	Electron microscopy
Adeno virus	4	
Enterovirus	25	
Corona virus		5
Other virus-like particles		5
Rota virus		0
Total	29	10

Stool virology

During this period samples of stools in which no bacterial pathogens were demonstrated were sent for tissue culture and electron microscopy at Dr. Tyrrell's Unit at the Clinical Research Centre, Harrow. A total of 177 specimens were submitted, of which 138 (78%) were from patients with diarrhoea.

Table III indicates the results on the first 27 specimens examined. No specimen contained rotavirus. The significance of the corona viruses isolated is open to speculation. Virtually all specimens contained enteroviruses on tissue culture, but as previous studies have shown no relationship with disease (SCRIMSHAW *et al.*, 1964), no attempt has been made to type these, at least for the present. Since the completion of this initial analysis many more faecal samples have been analysed, with the same result. The findings will be published in detail elsewhere.

These results contrast strikingly with the findings elsewhere of a strong association of a virus, variously termed duovirus, rotavirus, orbivirus and reo-virus-like agent with acute diarrhoeal illness in young children, a subject which has been well reviewed (Anon., Editorial, *Brit. med. J.*, 1975). This may reflect a true difference in the aetiology of diarrhoea in our rural survey population as compared with urban populations, often the subjects of other reports. It may also reflect the quite different nature of the protracted or recurrent diarrhoea which is the pattern seen in Keneba.

Upper bowel studies

In a further attempt to clarify the nature and effect of the diarrhoeal illness, during the rainy season this year one of us (J.P.K. McC.) carried out studies of small intestinal function by means of duodenal intubation.

A cohort of children was taken in Keneba between the ages of six and 20 months. All had a history of protracted diarrhoea. Of the cohort of 46, six cases (13%) were technical failures and the parents of three children (7%) withheld consent, giving a remainder of 37 (80%) successful intubations.

These children were brought fasting to the clinic, where they were sedated. A tube was passed via the mouth and having passed the pylorus of the stomach (as judged by the appearance of a bile stained aspirate with a high pH), the tube was advanced a further 20-25 cm, manipulating the patient to bring it to the duodeno-jejunal flexure.

After 30 minutes a test meal was given, being a modification of the "Lundh meal" used in adults. This meal of chicken, glucose and corn oil was introduced via a separate naso gastric tube and post-prandial juice collected for a total of two hours. This technique is currently in routine use at the Hospital for Sick Children,

Great Ormond Street. The following components of the aspirate were examined, aerobic and anaerobic bacteriology, parasites and total and individual bile salt concentrations.

Bacteriology

Aerobic and anaerobic bacteriological studies have so far been carried out on 25 of the patients. A few of these studies were carried out in Keneba, but most samples were returned to London, frozen at -70° in glycerol transport medium. The total count in healthy children is usually considered to be not greater than 10⁷ organisms per ml (GRACEY & STONE, 1972; TOMKINS *et al.*, 1975). In 19 of the 25 patients (76%) the total bacterial count was 10⁴ per ml of juice or greater and therefore clearly abnormal (Fig. 1).

In addition the spectrum of organisms found was clearly abnormal. In 14 (56%) of the patients significant numbers of *Klebsiella* were found, in six (24%) *Pseudomonas*, in 14 (56%) *E. coli*, and in four (10%) *Bacteroides*. One patient had *Salmonella paratyphi B* in the duodenal juice. The gram-negative organisms have been kept and will be assayed for their ability to produce toxins.

Parasites

The only parasite detected was *Giardia lamblia*. This was observed in specimens of juice from six (16%) of the 37 cases. None of these was under the age of a year. Looking only at the group over the age of a year gives an isolation rate of 22%—this merits further study.

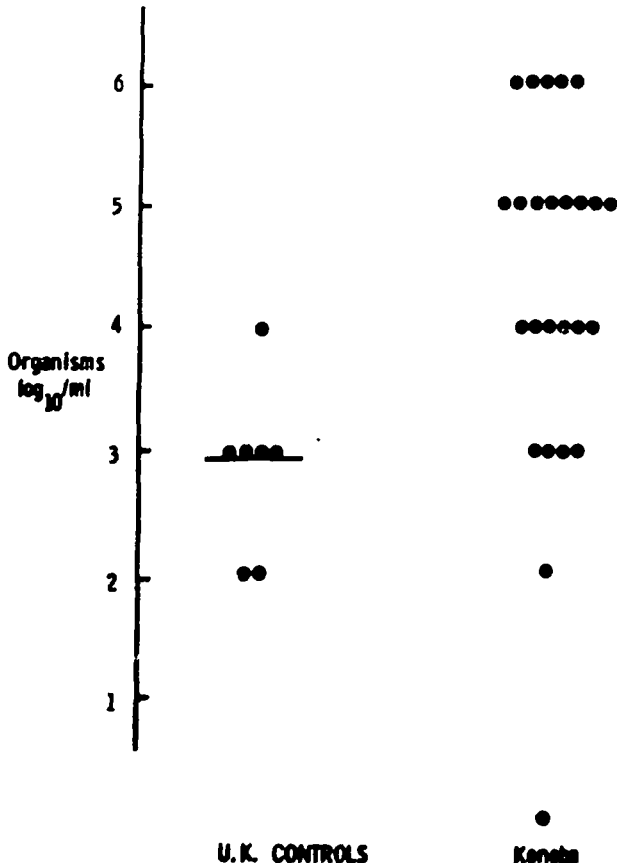


Fig. 1. Total bacterial counts in jejunal aspirates from 25 children in Keneba, The Gambia; controls are from data collected in the U.K.

Bile salts

Bile salts are synthesized in the liver, stored in the gall bladder and discharged into the small intestine during a meal. There they play a key role in many of the digestive processes, coming together above a certain concentration to form micelles which solubilize dietary lipid ready for absorption.

There are three main bile salts, namely, cholic acid, chenodeoxycholic acid and deoxycholic acid. Their molecular structure (Fig. 2) differs in the number and position of the hydroxyl groups on the characteristic steroid nucleus. Cholic acid has three hydroxyl groups (a trihydroxy bile salt), the others having two (dihydroxy bile salts).

Normally these bile salts are conjugated to one or other of the two amino-acids glycine and taurine. Unconjugates may be found in the presence of bacterial colonization of the gut, as may disturbances in the total and individual bile salt concentrations.

These aspects have been examined in the duodenal juice of the patients, using the 3 hydroxysteroid dehydrogenase assay and separation by thin layer chromatography. The results are summarized in Figs. 3-5. One half of the Keneba survey population specimens fall below the critical micellar concentration of 2 mM per l (Fig. 3). The mean total bile salt concentration in a group of U.K. controls was 7 mM per l. The ratio of glycine:taurine conjugates is usually three; half of the Keneba survey children were clearly abnormal, with values in excess of six (Fig. 4). This is identical to the pattern seen in ileal resections and in this situation is likely to be due to malabsorption of the taurine conjugates. Normally dihydroxy bile salts account for 60% of the total bile salts present. Four-fifths of the Keneba series had a dihydroxy bile salt concentration of less than 50% of the total (Fig. 5).

Thus well over half of the survey cohort showed significant disturbances of bile salt metabolism, likely to be due

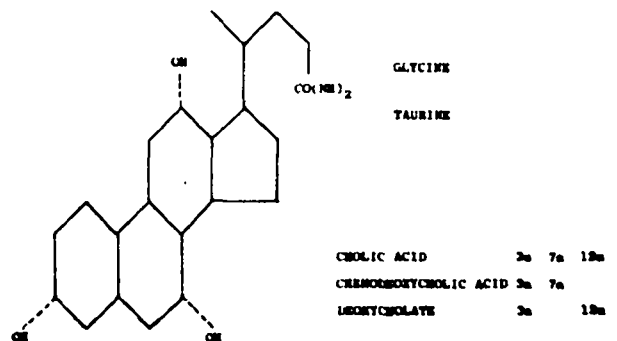


Fig. 2. Basic structure of the three main bile salts in jejunal aspirates.

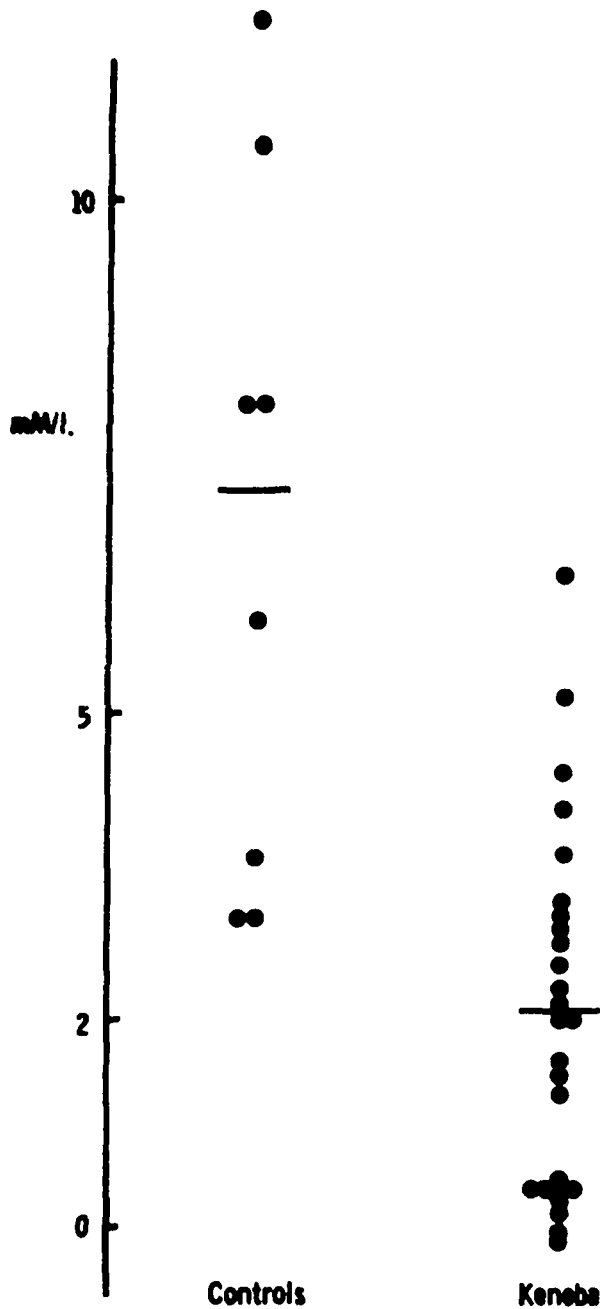


Fig. 3. Total bile salt concentration in jejunal aspirates from 25 children in Keneba, The Gambia; controls are from data collected in the U.K.

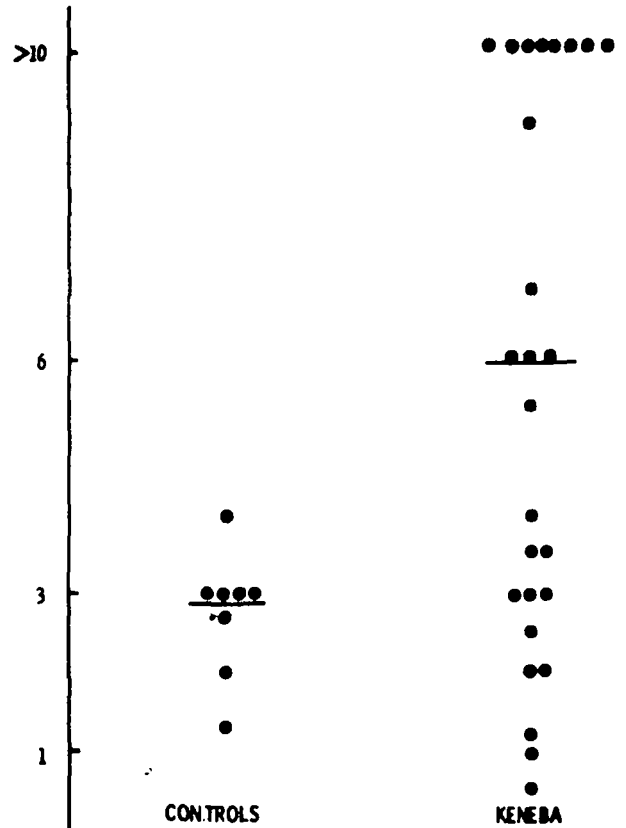


Fig. 4. Glycine:taurine ratio in the bile salt conjugates of children from Keneba, The Gambia; controls are from data collected in the U.K.

to malabsorption of bile salts. The importance between the diarrhoeal disease in Keneba and colonization of the upper gut seems established. The links between this clinical abnormality and the poor hygiene of the village food and water supplies is being investigated in more detail. It is hoped that suitable preventive interventions will be possible and the effectiveness of these will be quantified, their effectiveness being judged on how well they are able to minimize the poor growth performance demonstrated in the first paper of this symposium (WINTERBARD *et al.*, 1977).

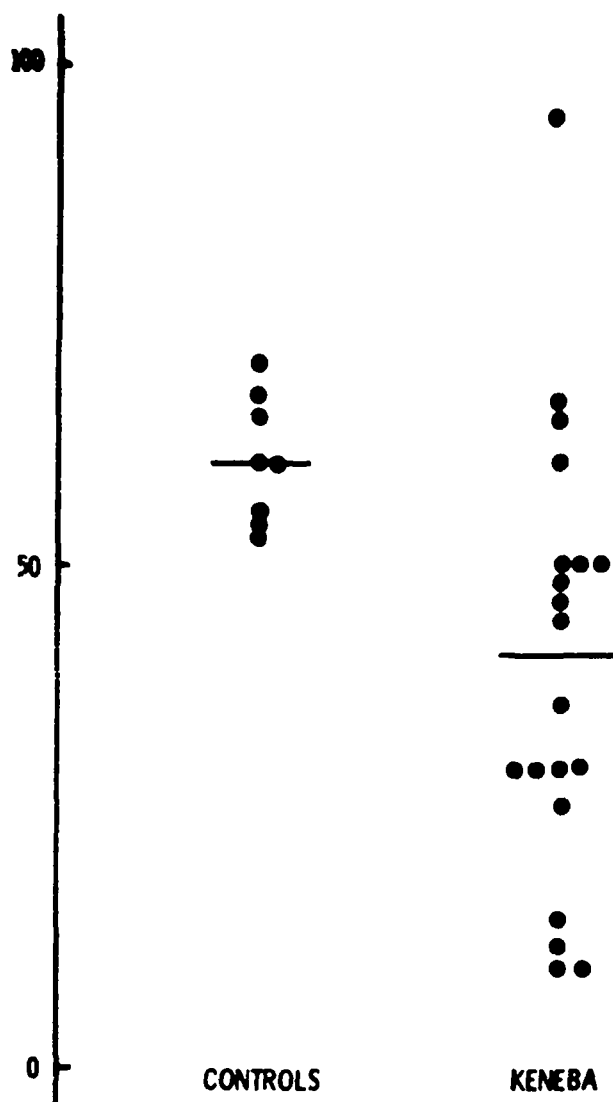


Fig. 5. The percentage of dihydroxy bile salts in Keneba, The Gambia; controls are from data collected in the U.K.

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