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Bacterial contamination of weaning foods and drinking water in rural Bangladesh

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SUMMARY

The aim of this study was to determine what weaning foods and food preparation practices expose children to a high risk of diarrhoeal disease through exposure to a contaminated diet. Bacterial contamination of 897 food and 896 drinking water samples was assessed in a water and sanitation intervention project.

The geometric mean of faecal coliforms per g or ml was $7{\cdot}5 \times 10^3$ in left-over rice, $1{\cdot}4 \times 10^2$ in other types of boiled rice, $2{\cdot}5 \times 10^2$ in milk, 4·8 in household drinking water, and 3·5 in bread. Multiplication of faecal coliforms occurred when there was a delay of more than 4 h between preparation and consumption of food. All samples were more contaminated in the rainy than in the dry season. Strategies to reduce contamination should therefore focus on 'wet' foods, early consumption after preparation, and re-heating of left-over foods. Understanding the reasons for the faulty practices is also essential to the formulation of effective measures.

INTRODUCTION

Infant feeding is recognized as a principal factor in the high childhood mortality and morbidity rates in less developed countries (1). These high rates occur when infants are given fluids or foods to supplement or replace breast-feeding. The danger is that once the weaning process is initiated, usually in unhygienic circumstances, even breast-fed infants suffer high rates of diarrhoeal morbidity, well termed 'weanling diarrhoea' (2). These morbidity and mortality rates are often similar to those of artificially fed infants (1–4).

Recent studies in Bangladesh have shown that breast-feeding considerably reduces the risk of dying (5). Although over 60% of these children breast-feed into their third year of life (6) the infant and child mortality rates in Bangladesh are among the highest in the world (7). In an attempt to identify effective measures which might reduce these high rates this study examines the weaning foods and food preparation practices which contribute to heavy bacterial contamination.

METHODS

This study was part of the health evaluation of a water and sanitation intervention project conducted in Mirzapur – a rural area of Bangladesh located about 60 km north of the capital Dhaka. Two areas were studied for the evaluation – the intervention area (2 villages, approximately 820 households and 5000 people) and the comparison area (3 villages, approximately 750 households and 4600 people) separated by a distance of about 5 km. Handpumps (approx. 1 per 30 persons) were installed in late 1984 in the intervention area. Latrine construction took place over the following 18 months (1985 to mid-1986) and a hygiene education programme commenced in early 1985. In the comparison area, previously installed hand pumps each served approximately 110 persons and installation facilities were poor. A tubewell is a closed well and water is obtained by suction with a hand pump. A ring well is an open well from which water is obtained by a bucket and rope. The majority of the people were Muslims (77%); 49% of adult males and 78% of females were illiterate. Most men were involved in agricultural activity or daily waged labour, while women worked mainly in the home.

This contamination study was conducted from February to July 1985 in both the intervention and comparison areas. All households with children aged 6–18 months in February 1985 were considered eligible for this study. There were 116 such households in the intervention area and 123 in the comparison area. These households were listed serially and the second and fourth in every group of five consecutive households were selected. In households where more than one child of the appropriate age was available only the youngest was selected. Thus 44 children (19 boys) were followed up monthly from the intervention area and 48 (21 boys) from the control area.

During the period of study health workers visited the homes of all cohort children on two consecutive days each month. Mothers were interviewed on aspects of food type, preparation, storage, time of cooking and consumption. On each occasion, a sample of the household's drinking water and the child's food were taken between 9 a.m. and 12 noon – a period when most children ate. Health workers recorded the noon temperature on the day of sampling from March to July. Foods were collected just before they were to be eaten. Small portions (5–10 g) of food and water samples were collected in sterilized jars and put in a cold box containing a frozen coolant and then transported to the International Centre for Diarrhoeal Disease Research laboratory to be tested within 4 h of collection. Samples were not obtained when children were absent or not eating during the time of collection. A total of 897 food samples and 896 water samples were collected and analysed. All samples were tested for the presence of faecal coliforms. Food samples were blended and serially diluted before testing. Milks and water were examined as presented. Standard methods were used for testing water (8) and food (9). In brief, faecal coliforms were counted on M-FC agar which was incubated at 44 °C for 24 h. Information on daily rainfall was collected for the study area from the Government Meteorology Department.

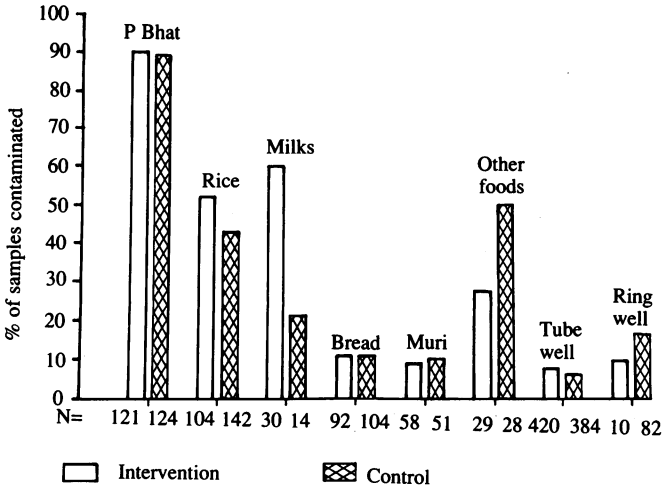

Fig. 1. Contamination of weaning foods and household drinking water in rural Bangladesh.

FOODS AND FEEDING PATTERN

Breast-feeding remains the main part of the diet for children below 18 months (6). The next most important foods at this age are boiled rice, fresh and powder milks i.e. 'wet foods'. Other foods such as fish, lentil (dal), potato and bread are not eaten in large quantities until after 2 years of age in this area of Bangladesh (6). Milk is often used fresh but is sometimes boiled and left for a few hours. *Panta bhat* is boiled rice to which water is added and stored for long periods, usually overnight. Salt, onion and chilli are also added before consumption. *Muri* is raw rice mixed with salt water and then fried in a container with hot sand. *Muri* and bread have a small water content and are considered here as 'dry foods'.

Most of the rice dishes were prepared in large quantities to allow several servings. Meals were usually prepared in open kitchens close to the house and fuelled by cow-dung or wood. Food was commonly cooked in metal pots and stored mainly on tables or the floor. Samples were considered as 'contaminated' when coliforms exceeded 10^3 c.f.u./g. This division is largely arbitrary but is used here merely as a basis for comparison.

RESULTS

Figure 1 shows the proportion of samples classified as contaminated for each type of food or water, according to area. Most of the variation in contamination occurred between the types of food and water consumed rather than between the intervention and comparison areas. The results were combined for the two areas in the remaining analyses.

The geometric mean of faecal coliforms per g or ml was $7{\cdot}5 \times 10^3$ in left-over rice, $1{\cdot}4 \times 10^2$ in other types of boiled rice, $2{\cdot}5 \times 10^2$ in milk, 3·5 in bread, biscuits and cakes (Table 1). In general, 'wet' foods such as *panta bhat*, rice and milk were more contaminated than 'dry' foods such as *muri* and bread. The mean contamination of household water collected from ring wells ($2{\cdot}3 \times 10^1$) was higher than that from tube wells (3·3).

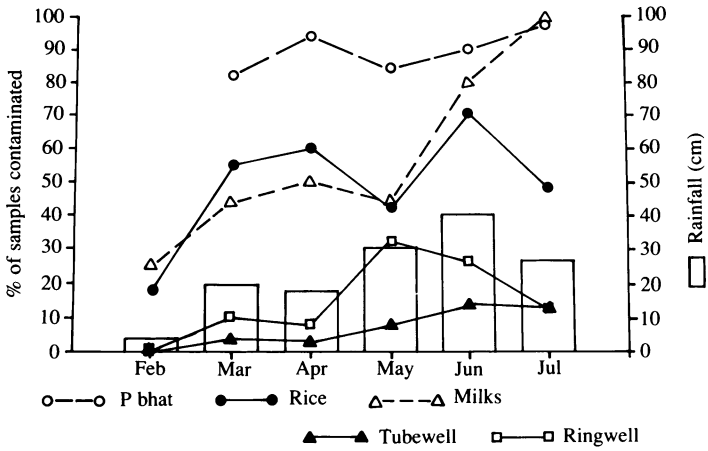

Fig. 2. Monthly variation in rainfall and contamination of food and water in rural Bangladesh.

During the rainy season a larger proportion of food and water samples were contaminated when compared to the dry season in February (Fig. 2). However, *panta bhat* contamination remained consistently high. *Panta bhat* was inadvertently not studied in February. In general, water contamination increased with rainfall but ringwell water was more contaminated than tubewell water, particularly during the rainy season.

Mean contamination of foods increased with environmental temperature. However, this increase was primarily for wet foods. The dry foods showed no such increase (Table 1).

Apart from rice, 90% of the other foods are eaten within 4 h of preparation and most of the others (dry foods) were stored for more than 24 h. Thus an association between time since preparation and contamination level could not be examined for those foods. Thirty-six per cent of boiled rice foods and 90% of *panta bhat* were eaten more than 12 h after preparation (Table 2). Contamination of food was lowest within the first 4 h of preparation but increased thereafter. There was no difference in contamination between foods stored on the floor, bench or hanging from the roof. Also, no significant difference in contamination was found between foods kept covered and uncovered.

DISCUSSION

This study shows that wet foods, such as milk and rice (particularly *panta bhat*) which make up a large proportion of the child's non-breast milk diet in this 6–23 month age range, contribute most of the faecal bacteria ingested through diet. Contamination of drinking water was lower than that of foods but like other studies (10) it increased during the rainy season. It was observed that foods eaten after 4 h storage are more contaminated than those eaten earlier. For *panta bhat* a 10-fold increase in mean counts of faecal coliforms was observed between storage for 0–4 h and 16–23 h. The need to retain the liquid properties of the rice gruel appears to increase faecal contamination to high levels. In addition, the practice

Table 1. *Faecal coliform contamination of weaning foods in relation to temperature, March–July 1985*

Food type and noon-time indoor temperature (°C)	No. of samples*	Geometric mean of faecal coliforms/g
Panta bhat (overnight rice)	245	$7{\cdot}5 \times 10^3$
< 28	44	$4{\cdot}6 \times 10^3$
28–29	88	$4{\cdot}3 \times 10^3$
> 29	113	$1{\cdot}4 \times 10^4$
Other rice (boiled)	185	$1{\cdot}4 \times 10^2$
< 28	41	$5{\cdot}4 \times 10^1$
28–29	77	$8{\cdot}1 \times 10^1$
> 29	67	$4{\cdot}9 \times 10^2$
Powder milk	11	$2{\cdot}3 \times 10^3$
< 28	2	$3{\cdot}1 \times 10^1$
28–29	5	$4{\cdot}0 \times 10^3$
> 29	4	$1{\cdot}0 \times 10^4$
Fresh milk	22	$1{\cdot}2 \times 10^2$
< 28	8	$4{\cdot}2 \times 10^1$
28–29	6	$4{\cdot}6 \times 10^1$
> 29	8	$7{\cdot}5 \times 10^2$
Muri (rice fried)	107	2·7
< 28	8	1·8
28–29	59	3·5
> 29	40	2·1
Bread	168	3·5
< 28	33	2·3
28–29	60	4·8
> 29	75	3·3
Other foods	54	$5{\cdot}0 \times 10^1$
< 28	15	$7{\cdot}4 \times 10^1$
28–29	24	$5{\cdot}6 \times 10^1$
> 29	15	$2{\cdot}9 \times 10^1$
All foods	792	$1{\cdot}2 \times 10^2$
< 28	151	$7{\cdot}7 \times 10^1$
28–29	319	$7{\cdot}9 \times 10^1$
> 29	322	$2{\cdot}0 \times 10^2$

* Temperatures were not taken in February and the corresponding samples were excluded.

Table 2. *Faecal coliform contamination of rice foods in relation to storage time*

	Panta bhat		Boiled rice	
Time since preparation (h)	*n**	Geometric mean per g	*n**	Geometric mean per g
0– 4	14	$3{\cdot}2 \times 10^3$	135	$2{\cdot}5 \times 10^1$
5–11	4	$5{\cdot}6 \times 10^3$	16	$2{\cdot}4 \times 10^2$
12–15	160	$7{\cdot}1 \times 10^3$	58	$4{\cdot}0 \times 10^2$
16–23	64	$1{\cdot}1 \times 10^4$	35	$8{\cdot}7 \times 10^1$

* Time since cooking could not be estimated for three *panta bhat* and two boiled rice samples

of adding salt to left-over rice causes considerable multiplication of *Vibrio cholerae* within 24 h (11). Strains of *V. cholerae* on cooked rice increases up to 10^5 organisms/g overnight (12). Similar results have been obtained in The Gambia where supplementary foods given to children were heavily contaminated with bacteria, particularly if they were allowed to stand after being prepared (13–14). In El Salvador 18% of foods were contaminated with *Escherichia coli*. Faecal contamination in the home was suggested as an important source of these organisms (15). Forty-four percent of dishes in rural Kenya were considered to be 'unsafe' (16). In Guatemala heavy contamination with coliforms was found in tortillas before and after cooking (17). These observations of highly contaminated water and weaning foods with the concomitant increased diarrhoea in infancy led to the view that it might be better to postpone supplementation (18). However, the specific cause and effect in this relationship is not clear because the bacterial contaminants in this studies are not exclusively diarrhoeagenic pathogens, and more importantly, food is not the only source of infection. In another study in rural Bangladesh which considered the presence of *E. coli*, the results showed a significant association between the frequency of isolation of *E. coli* in the weaning foods and of enterotoxigenic *E. coli* diarrhoea in the infants consuming them (19).

Bottle-feeding with infant formula food is increasing in rural Bangladesh. Currently, 5% of children below 2 years of age use this as the main feeding method (6). The dangers of bottle-feeding are well documented (1–4). The use of local foods for weaning is therefore correctly advocated, however, attempts must also be made to prevent faecal contamination of these foods.

Ideally, foods should be prepared hygienically and eaten at one sitting or stored safely until consumption. Boiling water and re-heating foods before consumption can also considerably reduce the risk of illness. These are recommendations which are easy to prescribe but difficult for a poor and busy mother to practice. The drawbacks and limitations of this approach of boiling drinking water has been documented (20, 21). In addition, the fuel cost for re-heating will have to compete for the limited resources available for other vital activities.

Where mothers are required to walk long hours, fetch water and firewood, sow and harvest rice, it is difficult to find time to cook foods often, prepare special weaning foods and to feed frequently. Experience from several countries shows that weaning programmes may fail because of landlessness (22) or maternal employment (23). Recommendations which require expenditure of money or time are usually ignored (22). There is usually a variety of good reasons for a mother's behaviour regarding child feeding. Hence, merely telling her about the hazards of contaminated weaning foods will do little to change behaviours.

Fortunately, there is now increased recognition that social, cultural, economic and environmental factors shape infant feeding patterns. Only with an understanding of the reasons for the practices which lead to the heavy contamination, as observed in this study, can dietary measures to reduce diarrhoea be effective.

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