Epidemiol. Infect. (1990), **104**, 253–259
Printed in Great Britain

Environmental sanitation, food and water contamination and diarrhoea in rural Bangladesh

F. J. HENRY[1,*], S. R. A. HUTTLY[2], Y. PATWARY[1] AND K. M. A. AZIZ[1]

[1] *International Centre for Diarrhoeal Disease Research, Bangladesh*
[2] *Department of Epidemiology and Population Sciences, London School of Hygiene and Tropical Medicine*

(*Accepted 31 October 1989*)

SUMMARY

This study examined the role of food and water contamination in a health impact evaluation of a water and sanitation intervention project. Although lower diarrhoea rates were found in the improved area no consistent difference in food and water contamination was observed between areas. Furthermore, no relationship was found between contamination and diarrhoea in either area, even after controlling for the nutritional status of children. These results imply that other vehicles of transmission might be more important than food and water in diarrhoeal transmission. The focus of interventions should therefore be on changing behaviours to improve overall hygiene.

INTRODUCTION

The failure of several water and sanitation projects to demonstrate an impact on child health has been partly attributed to the application of poor methodological techniques [1]. Thus, recently, attention has been focused on alternative evaluation methods and in particular on the case-control method [2].

While these new efforts which aim to demonstrate an impact are desirable they fall short of describing how and why changes in morbidity are or are not observed. Most water and sanitation projects are not designed to include intermediate variables which can explain why the results were achieved. Many investigators assume that with improved water and sanitation there is a concomitant reduction in contamination of the vehicles of diarrhoea transmission.

Contaminated food and water are often regarded as important vehicles of diarrhoea transmission [3, 4]. However, studies have not been able to demonstrate this relationship. Most of the evidence has been based on the observation that (*a*) diarrhoea peaks in the age group in which contaminated supplementary foods are introduced [3–6] and (*b*) food and water contamination is high in the season when diarrhoea incidence is also high [3, 4, 7]. A direct relationship between contamination level and diarrhoea experienced by a child has rarely been observed

* Address for correspondence and reprints: Dr Fitzroy Henry, HIID, 1 Eliot Street, Cambridge, MA 02138, USA.

[8]. Therefore, the relative contributions of foods, water and other pathways in the causation of diarrhoea are not known.

The present study examines the relationship between contamination of these transmission vehicles and childhood diarrhoea in rural Bangladesh where a water and sanitation intervention project was in progress. This setting therefore provided a unique opportunity to study the effect of improved hygienic facilities on the contamination of weaning foods and household drinking water and in turn on diarrhoeal disease.

METHODS AND MATERIALS

This study was conducted as part of the health impact evaluation of a water and sanitation intervention [9] based in Mirzapur – a rural area of Bangladesh located about 60 km north of the capital Dhaka – details are provided elsewhere [9, 10]. In brief, handpumps were installed in late 1984 in an intervention area (about 820 households and 5000 people). Latrine construction and hygiene education were started in early 1985. A similar community (about 750 households and 4600 people) located about 5 km away served as a control area where no intervention was made but some handpumps were already installed. Each handpump served approximately 30 and 110 persons in the intervention and control areas respectively.

A systematic sample of children from each area aged 6–18 months in February 1985 were studied – 44 from the intervention area and 48 from the control area. Data on diarrhoeal morbidity, based on weekly recall, were available from the surveillance carried out as part of the overall health impact evaluation. Similarly, weights and heights were measured on average every 3 months from October 1984 to December 1987. For this study the anthropometric measurements done in April 1985 were used. Diarrhoea was defined as three or more loose motions in 24 h and an episode was considered complete when two diarrhoea-free days had elapsed. Health workers visited the homes of the study children on two consecutive days each month during the period February–July 1985. On each occasion a sample of the household's drinking water and the child's food (just prior to eating) were collected and stored in sterile jars, packed in cold-boxes. Faecal coliform testing was conducted at ICDDR,B's laboratory within 4 h of collection. Standard methods were used to test the food and water samples [11, 12]. A total of 897 food samples and 896 water samples were collected and analysed in this study.

Children were grouped into high and low contamination categories according to the number of faecal coliforms found in the water and foods they consumed. For water, the average contamination of all the samples collected for each child was used. For foods, because every child consumed a variety of foods each having different levels of contamination, it was necessary to use scores to classify foods. The median contamination level for each food type was used to divide each food sampled into high or low and given scores of 2 and 1. An average score was then derived for each child according to the foods consumed. For both water and food, the median of these averaged contamination values was then used to divide the children into high and low contamination groups.

Rainfall data were obtained from the meteorological department of the Peoples' Republic of Bangladesh.

Table 1. *Prevalence of diarrhoea in children 6–23 months in areas with and without water and sanitation improvement*

Month (1985)	Intervention: No. of children	Intervention: % with 1 or more episodes	Control: No. of children	Control: % with 1 or more episodes
February	30	40·0	24	37·5
March	36	52·7	43	53·5
April	39	28·2	42	52·4
May	41	19·5	42	28·6
June	36	22·2	43	37·2
July	27	37·0	29	37·9

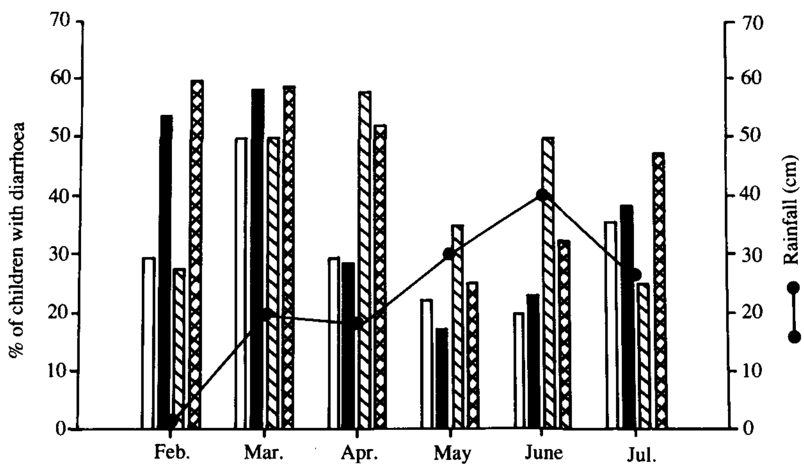

Fig. 1. Relationship between diarrhoea and water contamination in rural Bangladesh, 1985. □, Low contamination (intervention); ■, high contamination (intervention); ▧, low contamination (control); ⊠, high contamination (control).

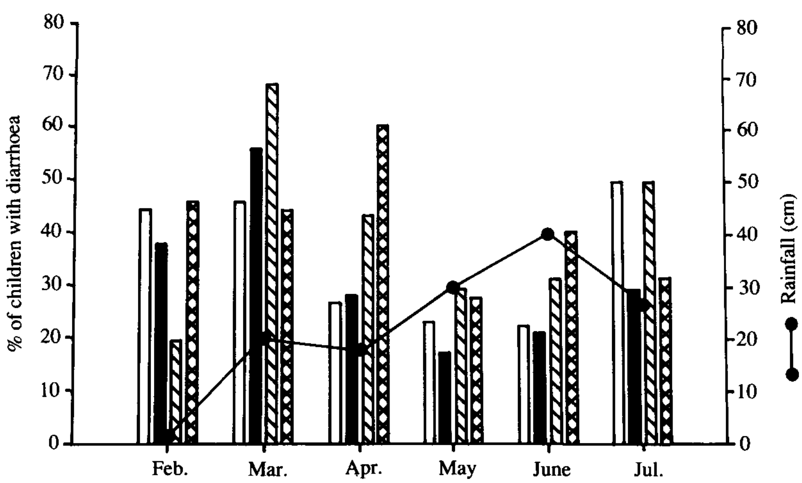

Fig. 2. Relationship between diarrhoea and food contamination in rural Bangladesh, 1985. □, Low contamination (intervention); ■, high contamination (intervention); ▧, low contamination (control); ⊠, high contamination (control).

https://doi.org/10.1017/S0950268800059422 Published online by Cambridge University Press

Table 2. *Nutritional status, water contamination and diarrhoea in rural Bangladeshi children* 6–23 months old (1985)*

Nutritional status (April 1985)	Contamination†	No.	Mean diarrhoea attacks Feb.–July		Mean diarrhoea attacks Jan.–Dec.	
Height for age (% NCHS)						
< 90	Low	19	2·4	2·4	3·5	3·7
	High	20	2·4		3·9	
> = 90	Low	12	2·1	2·2	3·5	3·8
	High	15	2·3		4·1	
Weight for height (% NCHS)						
< 85	Low	12	2·2	2·3	3·2	3·7
	High	15	2·4		4·1	
> = 85	Low	18	2·1	2·2	3·5	3·7
	High	20	2·4		3·9	

* Only children measured in April 1985.
† See text for classification.

Table 3. *Nutritional status, food contamination and diarrhoea in rural Bangladeshi children* 6–23 months old (1985)*

Nutritional status (April 1985)	Contamination†	No.	Mean diarrhoea attacks Feb.–July		Mean diarrhoea attacks Jan.–Dec.	
Height for age (% NCHS)						
< 90	Low	23	2·7	2·4	4·3	3·7
	High	16	1·9		2·8	
> = 90	Low	16	2·2	2·2	4·0	3·9
	High	15	2·2		3·8	
Weight for height (% NCHS)						
< 85	Low	13	2·4	2·3	3·8	3·7
	High	14	2·2		3·6	
> = 85	Low	25	2·4	2·2	4·3	3·8
	High	14	1·9		2·9	

* Only children measured in April 1985.
† See text for classification.

RESULTS

During 1984, prior to the introduction of the improved water and sanitation facilities, diarrhoea rates for all children under 5 years in the intervention and control areas were similar. Table 1 shows the monthly diarrhoea rates for the sample of children in this contamination study. In February, March and July diarrhoea prevalence was similar in the two areas. However, from April to June the rates were less frequent in the intervention area than in the control area. Despite this difference in diarrhoea rates the contamination levels of food and water samples were previously shown to be high and similar in the two areas [10].

Figs. 1 and 2 illustrate, by area, monthly diarrhoea rates in children according to their contamination category. During the dry period of February children drinking highly contaminated water tended to have more diarrhoea in both the intervention and control areas (Fig. 1). However, this pattern did not persist during the rainy season. Fig. 2 shows no consistent relationship between food contamination and diarrhoea. Thus overall, for both water and food, no clear and consistent association was found between contamination and diarrhoea.

Diarrhoea attack rates were similar in malnourished and better nourished groups (Table 2). However, children ingesting highly contaminated water showed a trend of slightly more frequent diarrhoea attacks irrespective of nutritional status. A reversal of this trend was noted for foods (Table 3). The size of the samples was small and these differences were not statistically significant.

DISCUSSION

This water and sanitation intervention project had a significant impact on diarrhoeal morbidity in children under 5 years of age [9] and also in children aged 6–23 months (Table 1). There are several mechanisms through which this impact could have occurred and the present study examined two of these possibilities – food and water contamination. Like other studies [13] we were unable to demonstrate an association between contamination levels of weaning foods or drinking water and incidence rates of diarrhoea. Does this mean that food and water are not the dominant vehicles of diarrhoea transmission? There are several important points to consider in the interpretation of these results.

From the methodological point of view, the measures of food and water contamination for each child (taken from one meal on 2 days of each month) are necessarily a proxy for the levels to which that child is normally exposed. Daily measurements from all meals were not feasible in this study. The high levels of contamination found and the high diarrhoea attack rates, in both the intervention and control areas, make an association between the two difficult to demonstrate [14]. Nevertheless, our results do not support the possibility that improvements in food and water quality were the reason for the observed difference in diarrhoea rates.

The extent to which diarrhoea transmission occurs through waterborne as opposed to other routes is unclear [15]. There are multiple causes and transmission routes for diarrhoeal diseases and some aetiology-specific diarrhoeas are more influenced by water and sanitation than others. For cholera, the importance of a non-waterborne mode of transmission is stressed [16, 17]. For shigellosis, person-to-person contact seems to be the dominant route [17, 18]. Studies which attempted to identify potential sources of enterotoxigenic *Escherichia coli* within the home have shown that mothers' and children's hands were important vehicles of risk for the transmission of diarrhoea disease. Food and drinking water appeared to be less important [19]. There is growing support for the theory that water quantity is more important than quality in reducing diarrhoea transmission [20–22] and the results from the final analysis of this project also support this concept [9].

Of major concern is not only why children get disease but why others remain relatively free of symptoms despite the ingestion of high loads of contaminated food and water. It is suggested that children escape disease successfully because of the adequacy of their host defence mechanisms which can be reflected in the nutritional status of the individual. In this study we showed that the number of diarrhoea attacks was not related to contamination even when the child's nutritional status was considered. However, other studies on contamination have indicated that nutritional status may be important in influencing the development, duration and severity of the disease [23, 24].

The coincidence of weaning and diarrhoea is often regarded as cause and effect, but children do not only start getting supplementary foods at the time when diarrhoea peaks, they also start crawling on the dirty floor, using unclean utensils, fingers, and other household items which are often put into the mouth. Weaning foods are therefore one of several possible vehicles which may be culpable. Clearly the need is to reduce the overall level of household faecal contamination through changes in hygienic behaviour.

The direct relationship observed between hand contamination and diarrhoea [22] may explain why handwashing is an effective intervention for the reduction of diarrhoeal disease [18, 25–27]. It is recognized that a cleaner water supply is a necessary but not sufficient condition for reducing diarrhoea. The identification of patterns of behaviour (e.g. handwashing) relating to contamination might therefore give better insights into effective intervention strategies than specific vehicles of contamination.

REFERENCES

1. Blum D, Feachem RG. Measuring the impact of water supply and sanitation investments on diarrhoeal diseases: problems of methodology. Int J Epidemiol 1983; **12**: 357–65.
2. Briscoe J, Feachem RG, Rahaman MM. Measuring the impact of water supply and sanitation facilities on diarrhoea morbidity: prospects for case-control methods. WHO document, WHO/CWS/85.3, Geneva 1985.
3. Barrell RAE, Rowland MGM. Infant foods as a potential source of diarrhoeal illness in rural West Africa. Trans R Soc Trop Med Hyg 1979; **73**: 85–90.
4. Guerrant RL, Kirchhoff LV, Sheilds DS, et al. Prospective study of diarrhoea illnesses in Northeastern Brazil: patterns of disease, nutritional impact, etiologies and risk factors. J Inf Dis 1983; **148**: 986–97.
5. Mata LJ, Kronmal RA, Garcia B, Butler W, Urrutia JJ, Murillo S. Breastfeeding, weaning and the diarrhoea syndrome in a Guatemalan Indian village. In: CIBA Foundation **42**, Elsevier, 1976.
6. Rowland MGM, Barrell RAE, Whitehead RG. Bacterial contamination of traditional Gambian weaning foods. Lancet 1978; i: 136–8.
7. Blum D, Huttly SRA, Okoro J, Akujobi CI, Kirkwood BR, Feachem RG. The bacteriological quality of traditional water sources in northeastern Imo State, Nigeria. Epidemiol Infect 1987; **99**: 429–37.
8. Black RE, Brown KH, Becker, S, Alim ARMA, Merson MH. Contamination of weaning foods and transmission of enterotoxigenic *Escherichia coli* diarrhoea in children in rural Bangladesh. Trans R Soc Trop Med Hyg 1982; **76**: 259–64.
9. Aziz KMA, Hoque BA, Huttly SRA, et al. Mirzapur Handpump Project. Final report, Dhaka: World Bank & International Centre for Diarrhoeal Disease Research, Bangladesh. 1989.
10. Henry FJ, Patwary Y, Huttly SRA, Aziz KMA. Bacterial contamination of weaning foods and drinking water in rural Bangladesh. Epidemiol Infect 1990; **104**: 79–85.

11. APHA. Standard methods for the examination of water and waste-water. Washington: American Public Health Association, American Water Works Association and Water Pollution Control Federation, 1981.
12. Thatcher FS, Clark DS. Micro-organisms in foods, vol. 1, Their significance and methods of enumeration. Canada: University of Toronto Press. 1968.
13. Lloyd-Evans N, Pickering HA, Goh SGJ, Rowland MCM. Food and water hygiene and diarrhoea in young Gambian children: a limited case control study. Trans R Soc Trop Med Hyg 1984; **78**: 209–11.
14. Rothman KJ, Poole CA. Strengthening programme for weak associations. Int J Epidemiol 1988; **17** (4) suppl: 955–9.
15. Feachem RG. Environmental and behavioural approaches to diarrhoeal disease control. In: Holme T, Holmgren J, Merson MH, Molby R eds. Acute enteric infections in children. New prospects for treatment and prevention. Amsterdam: Elsevier/North Holland Biomedical, 1981: 289–94.
16. Feachem RG. Environmental aspects of cholera epidemiology III. Transmission and control. Trop Dis Bull 1982; **79**: 1–47.
17. Feachem RG, Bradley DJ, Garelick H, Mara DD. Sanitation and disease. Health aspects of excreta and wastewater management. Chichester: John Wiley & Sons, 1983.
18. Khan MU. Interruption of shigellosis by handwashing. Trans R Soc Trop Med Hyg 1982; **76**: 164–8.
19. Echeverria P, Taylor D, Seriwatana J, et al. Potential sources of enerotoxigenic *Eschericha coli* in homes of children with diarrhoea in Thailand. Bull WHO 1987; **65**: 207–15.
20. Cairncross S. The benefits of water supply. In: Pickford J ed. Developing world water, II. London: Grosvenor Press, 1987.
21. Huttly SRA, Blum D, Kirkwood BR et al. Imo State (Nigeria) drinking water supply and sanitation. Project II: Impact on dracunculiasis, diarrhoea and nutritional status. In press.
22. Henry FJ, Rahim Z. Transmission of diarrhoea in two crowded areas with different sanitary facilities in Dhaka, Bangladesh. J Trop Med Hyg. In press.
23. Martinez C, Chavez A. XI Congresso Internacional de Nutricao. Rio de Janeiro. Abstracts, p. 275.
24. Hibbert JM, Golden HMN. What is the weanling's dilemma? Dietary faecal bacterial ingestion of normal children in Jamaica. J Trop Paediatr 1981; **27**: 255–8.
25. Black RE, Dykes AC, Anderson KE, et al. Handwashing to prevent diarrhoea in day-care centres. Am J Epidemiol 1981; **113**: 445–51.
26. Feachem RG. Interventions for the control of diarrhoeal diseases among young children: promotion of personal and domestic hygiene. Bull WHO 1984; **62**: 467–76.
27. Sircar BK, Sengupta PG, Mondal SK, et al. Effect of handwashing on the incidence of diarrhoea in a Calcutta slum. J Dia Dis Res 1987; **5**: 122–4.