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Childhood diarrhoea in Sri Lanka: a case-control study of the impact of improved water sources

T. E. Mertens, M. A. Fernando[1], S. N. Cousens, B. R. Kirkwood, T. F. de C. Marshall, R. G. Feachem

Department of Epidemiology and Population Sciences, London School of Hygiene and Tropical Medicine, London, U.K.,
[1]Department of Community Medicine, Faculty of Medicine, University of Peradeniya, Peradeniya, Sri Lanka

Abstract

Between January 1987 and March 1988 a case-control study of the impact of improved water sources on childhood diarrhoea was conducted in Kurunegala District, Sri Lanka. Two thousand four hundred and fifty eight cases of diarrhoea were recruited at five of the hospitals in the district. Another 4140 children presenting at the same hospitals with complaints other than diarrhoea were recruited as controls. Data from the five hospitals suggest that children in households drawing their drinking water from handpumps suffer 46% fewer episodes of diarrhoea than children in families using unprotected traditional sources (95% c. i. 29–59%), while children in families using protected traditional wells suffer 35% fewer episodes than children in families using unprotected traditional sources (95% c. i. 27–41%). There were, however, substantial differences between the different hospitals. Among children recruited at one of the hospitals, the reduction in diarrhoea rates associated with the use of improved sources was estimated to be 93% compared with an average of 18% for the other four hospitals. In common with other case-control studies conducted in Malawi and the Philippines, little evidence of confounding of the association between diarrhoea and water supply was observed. Our results suggest that, in Sri Lanka, the use of improved water supplies, including protected traditional wells, rather than unprotected traditional sources may lead to a substantial reduction in diarrhoea morbidity among children under five years of age.

Introduction

The evidence accumulated over more than two decades indicates that the relationship between improved water supplies and improved health is complex (Esrey and Habicht, 1986). The search for evidence of a health impact resulting from improved water supplies has focussed on the incidence of childhood diarrhoea, growth faltering and mortality (Briscoe et al., 1986). Studies related to diarrhoea have suggested that both the quality and the quantity of water affect the transmission of enteric diseases. First, faecal contamination of drinking water is a potential transmission route for certain enteric diseases, especially those caused by bacterial infections

(Craun and McCabe, 1973). Second, the availability of water affects the quantity of water used for personal and domestic hygiene which is inversely related to the transmission of enteric diseases (White et al., 1972).

However, the assessment of the relative importance of quality versus quantity is complicated by their potentially wide variation over time and between different locations and by the multiplicity of transmission routes of enteric pathogens. Where water is scarce and the density of population low, the quantity of water used by a household is thought to play a major role in determining the incidence of diarrhoeal diseases. However, where water is relatively abundant and the population density higher, quality of water may be a more important risk factor for enteric infections.

In this paper we examine the impact of improved water supplies on diarrhoea morbidity as reported to health facilities in the district of Kurunegala, Sri Lanka. First, we compare children presenting at selected health facilities for diarrhoea (cases) with children suffering from other diseases at the time of recruitment (clinic controls). Second, we investigate the correlation between diarrhoeal rates among young children and indicators of faecal contamination in samples of drinking water used by the household. Finally, the relationship between the practice of boiling drinking water and diarrhoeal rates is examined.

Methods

Design

A case-control study was conducted in the district of Kurunegala, situated mainly in the dry zone of Sri Lanka and was based in five health facilities, and their catchment areas as described by Mertens et al. (1990a).

Cases were recruited from children below five years of age reporting with diarrhoea to one of four hospitals or a peripheral clinic. Diarrhoea was defined as three or more loose or watery stools in the previous 24 hours, or as stools with blood or mucus. A concurrent design was used with clinic-controls selected at the same time as the cases, usually the same day, from those still at risk of diarrhoea (Miettinen, 1976; Rodrigues and Kirkwood, 1990). Immediately after recruitment of a case a child suffering from a control disease, frequency matched for age with the cases, was chosen from children satisfying the eligibility criteria. Multiple recruitment of the same child as case and/or control was possible with the caveat that a child could not be recruited into the study again until after a period of three weeks. This was to ensure that a child was not recruited twice for the same episode of illness. Control diseases were acute conditions thought to be unrelated to water supply or sanitation facilities and included respiratory tract infections, malaria, fever of unknown origin and otitis. The basis

Table 1 Comparison of cases with clinic controls with respect to type of drinking water source, using clinic data

	Unimproved source	Protected shallow well	Piped	Handpump	Total
Total	1837	4058	287	281	6463
% cases	44.0	34.0	33.8	29.9	36.7
Relative rate	1.0	0.65	0.65	0.54	
95% C.I.*		0.59, 0.73	0.50, 0.84	0.41, 0.71	

*C.I.: confidence interval

for selection of the control diseases was that children suffering from these diseases and reporting to hospital would have been recruited as cases had they suffered an episode of diarrhoea (Rothman, 1986). Children were not eligible, if they had congenital or hereditary abnormalities, were suffering from chronic debilitating diseases, if their residence was outside the district, if their mother had died, or if they were a twin. 0.8% of children were excluded on this basis. Most of these criteria were applied because it was expected that children with such attributes had a background likely to be associated with one of the exposures of interest (Schlesselman, 1982). A ratio of approximately 1:2 was maintained between cases and controls in each age group, except in Ambampola and Kurunegala where the ratio of cases to controls was approximately 1:1.

Hospital examination and interview

Medical professionals examined all the children. Before proceeding with the interview the consent of the mother or accompanying adult was always sought. This was obtained in more than 98% of instances. A structured questionnaire was used to collect information on the episode of illness, access to, and type of water supply, sanitation facilities used, indicators of socio economic status and child feeding practices.

Home visits

In the five areas a random subsample (56%) of clinic cases and controls were visited at their homes, and the mother or guardian asked further questions concerning a wide variety of potential confounding variables and short observation schemes relating to water supply, sanitation and hygiene practices, were carried out.

Some misclassification with respect to the choice of water sources occurred between the clinic and the home interviews. Validity checks revealed that the differences in the classification between clinic and home interviews were probably the result of changes in practice between the two interviews rather than inaccurate response at the clinic (Mertens et al., 1990 a). On this basis, data collected during the clinic and the household visits were combined for further stratified analysis of the effect of water supply on diarrhoeal morbidity, using the water source data collected at the hospital.

Statistical methods

In case-control studies following a concurrent design the cross-product estimates the relative rate of disease among exposed and unexposed rather than the odds ratio (Rodrigues and Kirkwood, 1990). We defined as "exposed", households taking water from improved supplies and as "unexposed" households taking water from an unprotected source. Relative rates less than one, therefore, correspond to reduced rates of reported diarrhoea among the children of households using improved water sources. Crude and adjusted estimates of the relative rates of the associations between putative risk factors and diarrhoea morbidity were calculated according to the method of Mantel and Haenszel (1959). Confidence intervals quoted for these estimates are test-based (Miettinen, 1976). Homogeneity of the relative rate across strata was tested according to the method of Breslow and Day (1980). The analysis of the data were performed using the software package SAS. Logistic and conditional logistic regression ana-

lyses, which enable the effects of several different risk factors to be modelled simultaneously, were performed using the software package EGRET.

A large sample size was chosen in order to detect effects due to exposures which are not very prevalent in the community and to investigate possible interaction effects (Smith and Day, 1984).

Results

Study groups

The following analyses and results are based on 6598 children recruited in five hospitals and satisfying all inclusion criteria. 2458 cases of diarrrhoea and 4140 clinic controls were enrolled in the hospitals, a case/control ratio of 1:1.7. A total of 3694 (56%) follow-up home visits were completed. Of these, 1415 were households of cases and 2279 households of controls.

Crude analysis

A comparison of cases with clinic controls, using data collected at the hospital, with regard to the type of water source used by the household is presented in Table 1. The relative rate (RR) associated with using piped supplies and protected wells instead of unimproved sources is 0.65. This suggests that children using piped supplies and protected shallow wells may suffer up to 35% less diarrhoea than children using unimproved sources. The reduction in diarrhoea morbidity may be as large as 46% among children from households using handpumps.

As Table 1 shows, over the period of the study the vast majority of the population drew their drinking water from traditional sources: either protected shallow wells or unprotected sources. Since very few children came from families using piped supplies or handpumps children have been classified as using improved (piped, handpump, protected well) or unimproved sources (unprotected wells and surface water) in the following analyses.

Variation of the effect between areas

The relative rate of diarrhoea among users of improved sources versus users of unimproved sources varied widely between the five different areas (Table 2). The data from Wariyapola hospital showed a reduction in diarrhoea of more than 90% associated with the use of an improved source whilst data from Kurunegala, Maho and Nikaweritiya showed smaller reductions of between 11 and 20%. In Ambampola there was no evidence of an association between diarrhoea and type of source and the confidence interval was wide, probably due to the small sample size.

Table 2   Relative rates of the association between improved water sources and diarrhoea rates for each catchment area, using clinic data

Catchment areas	Cases		Clinic controls		R.R.	95%C.I.
	n	% Improved source	n	% Improved source		
Wariyapola	222	36.0	599	88.7	0.07	0.05, 0.10
Maho	679	69.8	1228	72.2	0.89	0.72, 1.11
Nikaweritiya	815	66.8	1556	71.6	0.80	0.66, 0.96
Kurunegala	519	73.2	618	77.4	0.80	0.60, 1.06
Ambampola	135	61.5	92	60.9	1.03	3.10, 0.34
Overall	2370	65.9	4093	74.9	0.65	0.58, 0.72
Overall excluding Wariyapola	2151	69.0	3526	72.5	0.84	0.75, 0.95

RR. = Relative Rate; C. I = Confidence interval

Table 3   Examination of confounding in the comparison of cases with clinic controls, using combined clinic and home data

Variables controlled for	5 areas		4 areas excluding Wariyapola	
	R.R.	test for homo-geneity	R.R.	test for homo-geneity
None	0.65		0.82	
Catchment area	0.66	p < 0.001	0.81	p = 0.98
Age	0.65	p = 0.42	0.81	p = 0.39
Income	0.65	p = 0.81	0.81	p = 0.93
Number of pregnancies	0.66	p = 0.93	0.83	p = 0.69
Mother's age	0.65	p = 0.84	0.82	p = 0.52
Distance from home to hospital	0.66	p = 0.35	0.83	p = 0.18
Time of return trip to water source	0.58	p = 0.49	0.82	p = 0.04
Mother's education	0.64	p = 0.24	0.81	p = 0.15
Father's education	0.66	p = 0.16	0.83	p = 0.20
Father's occupation	0.64	p = 0.68	0.81	p = 0.55
Religion	0.64	p = 0.01	0.80	p = 0.03
Season	0.66	p = 0.13	0.82	p = 0.78
Feeding mode	0.60	p = 0.45	0.82	p = 0.24
Boiling water	0.65	p = 0.48	0.82	p = 0.37
Use of latrine	0.66	p = 0.31	0.84	p = 0.06
Disposal of child's stools	0.64	p = 0.64	0.82	p = 0.85
Water quantity per capita	0.65	p = 0.51	0.82	p = 0.57
Use of different source for drinking and other purposes	0.66	p = 0.73	0.83	p = 0.5
Type of floor of house	0.64	p = 0.09	0.81	p = 0.04

R.R = Relative Rate

Since the association between diarrhoea morbidity and type of source appeared to differ substantially between the Wariyapola area and the other study areas a separate analysis was conducted for the four areas excluding Wariyapola. This analysis found smaller reductions in diarrhoea morbidity associated with the use of improved water supplies. The crude relative rate was 0.84 (95 % confidence interval (CI) 0.75, 0.95) (Table 2) or, when using combined clinic and household data, RR = 0.82 (95% CI 0.69 to 0.98), suggesting a reduction of 18% in childhood diarrhoeal rates amongst users of improved water supplies (Table 3). For handpump users, however, the estimated reduction in diarrhoea rates compared with users of unimproved water sources was 27%.

In Wariyapola, the estimated crude relative rate of the association between diarrhoea and type of source was 0.07 (95% CI: 0.05, 0.1), a huge reduction of diarrhoeal rates associated with the use of improved supplies. The differ-

ence between the predominant use of protected shallow wells among the controls and the large proportion of unimproved source users among the cases was almost entirely responsible for the observed association. Further analyses were performed to investigate why the results for Wariyapola suggested such a large effect. It was found that, within the group using unimproved sources, there was no significant difference between the distribution of cases and controls in the use of unprotected water holes, irrigation channels or "tanks". However, data on water contamination suggested that 100% of the samples taken from unprotected sources in Wariyapola were contaminated with faecal material during the four months of recruitment and that, amongst positive samples taken from protected shallow wells the average level of contamination was low in comparison to other areas and low in comparison to the average level of contamination in unprotected sources. Furthermore, a higher proportion of users of improved supplies claimed to boil water in Wariyapola than in the other catchment areas. The same was not true for the users of unimproved sources. In Wariyapola, boiling had the strongest effect on the average level of contamination of the stored water, suggesting that the information given by the mother was accurate.

In addition, the cases and controls who reported to Wariyapola hospital shared characteristics which made them different from the population reporting to other hospitals. A relatively large number (117/821, 14%) of households claimed that they were using piped supplies, suggesting that a large proportion of mothers reporting to the hospital lived in Wariyapola town. Also, a large majority (88%) of households in Wariyapola were in the middle monthly income group '250 to 500 Rupees'.

Analysis of confounding factors

Evidence of confounding was sought, initially by stratifying on each extraneous variable individually and examining the association between diarrhoea and water supply within the different strata. Table 3 presents estimates of the relative rate of diarrhoea according to type of source, after controlling a variety of potentially confounding variables. These results are based on data collected during both the hospital and home interviews. Results are given both including and excluding data from Wariyapola. The results obtained are remarkably consistent: in the five areas combined, the summary estimate of the relative rate varied between 0.58 and 0.66. In the four areas the summary estimate of the relative rate varied between 0.80 and 0.84.

Table 4   Differences in mean log₁₀ FC counts in source water samples, between clinic cases and clinic controls

a) By area, corrected for water source:-

	Maho	Nikaweritiya	Kurenegala	Wariyapola	Ambanpola
Mean	0.058	0.103	0.028	0.002	0.125
s. e.	0.070	0.134	0.076	0.141	0.126

b) By type source, corrected for area:-

	Piped supply	Handpump	Protected well	Unprotected source
Mean	0.186	0.175	0.065	0.027
s. e.	0.310	0.255	0.056	0.072

Averages of the differences between cases and controls classified by area and type of water source were calculated following the weighting procedure described by Armitage and Berry (1987, pp 259, 260).

In order to control several potential confounders simultaneously logistic regression analyses were carried out. The criteria for including a variable in logistic regression models were as follows. First, a basic model was constructed, including all variables expected to be confounders on an a-priori basis. These were age, season of recruitment, area of recruitment and time needed to reach the hospital. Then, those variables which showed some confounding effect of the association between water source and diarrhoea in the stratified analysis were added to the model in order of importance (e. g. time of return trip to water source followed by feeding mode). If the inclusion of a variable did not alter the summary estimate of the relative rate obtained from the preceding model by more than 0.02, the variable was dropped and the following one introduced (Kleinbaum et al., 1982). A model including age, period of recruitment, distance from home to hospital, hospital of recruitment, time of return trip to water source, latrine use and method of child's excreta disposal led to an estimate of the relative rate of 0.65 (95 % CI: 0.58, 0.74). Logistic regression analyses of the data of four areas did not modify substantially the crude estimate of the relative rate for these four areas nor did it remove the statistical significance of the association.

Effect modifiers

Relative rates were also tested for homogeneity across the different strata of each confounding variable (Breslow and Day, 1980). Using data from all five areas, there was evidence of variation in the relative rate between hospital catchment area (P < 0.001) and different religious groups (P = 0.01) (Table 3). As discussed above, the variation in the estimated relative rate between different catchment areas was particularly strong. There was also some indication that the benefit obtained from using improved water sources may be modified by socioeconomic status: using an improved water supply was associated with a 16% reduction of diarrhoea rates among families living in better housing conditions as indicated by the presence of a cement floor compared with a reduction of 40% among children living in households with mud floors. When Wariyapola was excluded no evidence remained of association between improved supplies among households with cement floors, but among those with mud floor the relative rate was 0.75. Interestingly, the interaction effect associated with areas of recruitment, and observed in the data from all five catchment areas disappeared when data from Wariyapola were excluded, suggesting that the data from Wariyapola con-

tributed largely to this modifying effect. However, another set of interactions appeared in the analysis of four areas. The time taken for the return trip to the drinking water sources appeared to modify the association between diarrhoea and type of drinking water source: people who took more than six minutes for the return trip gained greater benefit from using improved sources. In addition, among those households where adults and/or children used a latrine, the estimate of the relative rate of diarrhoea associated with type of drinking water source was around one, suggesting that latrine users gained little benefit from using improved supplies. In contrast, among those who did not own a latrine the relative rate was 0.73.

Relationship between water quality and diarrhoea

Bacteriological analyses of the drinking water used by the study population were performed in 1987 and showed that, all year round, unimproved sources were substantially more contaminated than improved supplies and that the level of faecal pollution of the traditional sources used by the population followed a seasonal pattern similar to that of reported childhood diarrhoea (Mertens et al., 1990 b). We now examine the association between disease status and faecal coliform count in the water samples, firstly in source water samples and secondly in stored water samples.

The crude relative rate of diarrhoea associated with the finding of no organisms or any organisms in the water sample was 0.8. This suggests that water sampled from the homes of diarrhoeal children was more polluted than water used by households of controls. This association was not statistically significant (p > 0.2). Correcting for area or water source, or both provided no further evidence of any association.

Cases and controls were also compared with respect to mean faecal coliform (FC) count (on a logarithmic scale) in water samples where organisms were found. The mean count was 0.135 higher (s. e. = 0.057) among cases than controls. Although the association is statistically significant (p = 0.02) it does not take account of other factors. After taking account of area, the mean difference was reduced to 0.075 (s. e. = 0.042) and the association was marginally non significant (p = 0.08). Table 4 shows the mean differences by area corrected for source, and by source corrected for area. These differences were all positive in the direction of an association

between diarrhoea and FC count though, none was statistically significant. The overall mean difference, allowing for both source and area was 0.0553 (s. e. = 0.0429). There is therefore limited evidence of a direct link between FC count in the water samples and disease status.

Given the association between FC count and disease status, an estimate of the logistic regression coefficient indicates the magnitude of the contribution of FC count to the risk of diarrhoea. With correction for area only, the estimate was 0.18, with 95% confidence limits –0.03 and 0.38. With correction for area and source, the estimate was 0.14, with limits –0.08 and 0.36 implying that an increase in FC count by a factor of ten may be associated with an increased risk of diarrhoea between none at all and a factor of 1.4. Because of the probably weak correlation between FC count and the challenge experienced earlier by a child these figures are likely to be underestimates.

There was no evidence of an association between FC counts in *stored* water and the disease status of the children.

Boiling of water and diarrhoea morbidity

Approximately 25% of mothers claimed that they boiled the water given to the child. Boiled water was usually kept to cool for several hours before consumption. In more than 50% of the households where water was claimed to be boiled the quality of the water was clearly improved (Mertens et al., 1990 b). However, crude and stratified analyses did not reveal any evidence of a direct link between diarrhoeal rates and the practice of boiling drinking water given to the child.

Discussion

This case-control study provides some evidence that improved water supplies may have a substantial positive impact on reported diarrhoea morbidity in young children in the district of Kurunegala, Sri Lanka. A crude analysis of the data collected at five health facilities indicates that the use of drinking water from handpumps, as opposed to unprotected sources, may be associated with a reduction in the incidence of reported diarrhoea of up to 46%. The comparison of cases and clinic controls also suggested that the reduction in diarrhoea associated with using protected shallow wells rather than unprotected sources was, on average, 19% in four areas and more than 90% in Wariyapola. These estimates did not change substantially and remained statistically significant after adjustment for confounding.

In Wariyapola, epidemiological and bacteriological evidence seem to indicate a large health benefit for families who use protected wells as opposed to families using unimproved sources. However, it seems unlikely that the characteristics of water quality in Wariyapola could wholly explain why diarrhoea rates were associated so strongly with water source in that area. Recruitment in Wariyapola hospital lasted for a shorter period (four months) than in three other hospitals and we do not, therefore, have any insight into the importance of seasonal variations. Possible explanations for the large association observed in Wariyapola might be the oc-

currence of a waterborne diarrhoea epidemic focussed in a particular section of the population of Wariyapola during the period of recruitment, or a cluster of households exposed to a particularly heavily polluted source in the same area.

The results from this evaluation in Sri Lanka come in addition to a body of evidence accumulated by studies in other parts of the world which have suggested that improved water supplies may substantially reduce mortality due to diarrhoea (Victora et al., 1988) or diarrhoeal rates (Esrey and Habicht, 1986). The authors of this latter review underlined, however, that in many of the previous studies it was impossible to disentangle whether water quality or increased water quantity was responsible for the differences observed between groups using improved and unimproved water supplies. There are four arguments from the findings reported in this series of papers, which appear to suggest that, in this setting, water quality plays an important role. First, the percentage of contaminated traditional sources and their mean level of contamination (with a slight delay) followed a marked seasonal pattern, rising before, and peaking during the north-east monsoon, at the same time as the incidence of reported diarrhoea appeared to increase to its second peak in 1987 (Mertens et al., 1990 b and 1990 a). Second, there was an association between the type of source used by a household and childhood diarrhoeal morbidity. Third, except for households using piped supplies, which used larger quantities than all the others, there was no significant association between the type of source and the domestic water consumption (Mertens et al., 1990 b). Fourth, there was some weak retrospective evidence of a positive association between the mean faecal coliform counts at the *source* and reported diarrhoeal incidence, indicating that waterborne transmission of diarrhoeal diseases may play an important role in this setting. That the evidence of such an association should be limited is not surprising, since the FC count from one sample, taken *after* the disease episode, can only be weakly correlated with the challenge experienced by the child.

Another study conducted in Lesotho also found that concentrations of faecal coliforms were higher in the wet season (Feachem et al., 1978). However, it was noted by the authors that diarrhoea peaked later in the wet season and that the increase in faecal pollution was only slight, suggesting that, in Lesotho, diarrhoeal diseases may not be primarily transmitted through a waterborne mechanism. There, the lack of data linking diarrhoea rates with the contamination of drinking water prevented any further investigation of the problem.

The absence of a direct association between the contamination of stored water or boiling of it and diarrhoea morbidity appears to support the intuitive theory that the public health significance of faecal pollution of stored water may be slight (Mertens et al., 1990 b; Feachem et al., 1978). This is also suggested by the differences in faecal contamination between improved and unimproved sources (Mertens et al., 1990 b). The seasonal pattern of contamination of the sources and the fact that transmission of waterborne diarrhoea at the source may be common imply that an important improvement of the water quality may be achieved by building headwalls and drainage aprons around the unprotected wells, to prevent run-off.

Some evidence of effect modification was detected. These results should, however, be interpreted with caution since a large number of tests were performed. In the analysis of the data excluding Wariyapola there was some evidence that the relative rate varied according to the use of latrine. The finding that latrine owners or users gained little benefit from using improved water supplies should be interpreted with caution since further analyses suggested that latrine ownership and/or use is not a risk factor for childhood diarrhoea in the district of Kurunegala. Rather, the safe disposal of child's stools was strongly associated with decrease in diarrhoea incidence (Mertens, unpublished data). Latrine ownership may be modifying the effect of the type of source by acting as a proxy for socio-economic status. There was also some indication in the analyses of both five and four areas that the benefit of improved water supplies may be greatest among the poorest section of the community as indicated by a mud floor in the household. There appeared to be little association between type of source and diarrhoea amongst children living in households where there was cement floor. Furthermore, in Wariyapola where some evidence of a large impact of improved sources was observed, the majority of the study population was in the middle income group. While these socio-economic indicators are quite crude, it is interesting to relate these findings to the threshold-saturation theory proposed by Shuval et al. (1981). The authors of this model suggested that at the lower end of the socio-economic spectrum there is a threshold below which investments in water supplies and sanitation facilities would result in little improvement in health, while a saturation in health improvement occurs for the wealthier people, so that for them also, improvements in water supplies and sanitation bestow little health benefit. Thus, according to this model the health benefit is greatest for those in the middle socio-economic range. The results outlined here suggest that, at the upper end of the socio-economic scale in this population saturation may have occured. From a public health perspective it has been suggested that it is necessary to implement more than one intervention in order to be able to detect a health impact among the most deprived subgroups of a population (Esrey et al., 1985). The improvement of sanitation facilities and health education, along with improved water supplies, are thought to carry synergistic benefits (Gordon et al., 1964) and can be combined interventions to be targeted at the poorest sections of the community. It is worth noting that we found no evidence that level of education of the mother modified the effect of the type of source used by the household. This is in contrast to another study of environmental sanitation and mortality trend in Sri Lanka where mortality rates were lower among literate mothers (Meegama, 1980). Esrey and Habicht (1986) argue that the findings reported by Meegama can be explained by the fact that in households of illiterate mothers the exposure to diarrhoeal pathogens will be multiple, thereby making the impact of sanitation facilities marginal at best.

Two recently published clinic-based case-control studies have provided some evidence that the provision of combined interventions may lead to reduced reported diarrhoeal rates in areas of Africa and Asia although, the results were not statistically significant and a careful analysis of interactions was impossible due to the relatively small sample size of these studies (Baltazar et al., 1988; Young and Briscoe, 1987).

In a methodological evaluation of these two case-control studies Briscoe et al. (1988) underlined the absence of confounding effects observed in the analysis of the association between environmental sanitation and diarrhoea. This is corroborated by the comparison of children recruited at the clinics in our study with regard to water sources but is not true for the study of other risk factors, such as the use of small water quantity or the inadequate disposal of child's faeces (Mertens, unpublished data). The same authors conclude that it may be possible to devise a simplified protocol for clinic-based case-control studies to assess the impact of environmental sanitation if no data on confounding variables should be collected. Our experience reinforces this suggestion for the impact evaluation of water supplies but not for the study of the relationship between diarrhoea and hygiene practices or other sanitary improvements.

The results from this study suggest that the diversion of the population in Kurunegala district who attend government facilities and use unimproved water sources or surface water, to improved sources (protected shallow wells, handpumps, piped supplies), is likely to bring about a substantial reduction in childhood diarrhoea morbidity in that section of the community.

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Dr. T. E. Mertens

Department of Epidemiology and Population Sciences
London School of Hygiene and Tropical Medicine
Keppel Street, London WC1 E7HT, U.K.