A case–control study of the impact of improved sanitation on diarrhoea morbidity in Lesotho

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A health impact evaluation of the Rural Sanitation Pilot Project in Mohale's Hoek district, Lesotho, was conducted from October 1987 to September 1988. A clinic-based case–control design was used to investigate the impact of improved sanitation on diarrhoea morbidity in young children. The results indicate that under-5-year-olds from households with a latrine may experience 24% fewer episodes of diarrhoea than such children from households without a latrine (odds ratio = 0.76; 95% confidence interval, 0.58–1.01). The impact of latrines on diarrhoea was greater in those households that used more water, practised better personal hygiene, and where the mothers had a higher level of education or worked outside the home. In common with studies conducted in Malawi, Philippines, and Sri Lanka, little evidence was found that the relationship between latrine ownership and diarrhoea was confounded by socio-economic status or environmental variables. For a sample of cases and controls, data on exposure status (presence or absence of a latrine) that were collected by interview at the clinics agreed closely with those obtained by observation during a home visit.

Introduction

The provision of a potable water supply and adequate excreta disposal facilities for all is the main objective of the International Water Supply and Sanitation Decade (1981–90). An important justification for the implementation of water supply and sanitation programmes is provided by the health benefits expected to accrue to recipient communities; measuring these anticipated health benefits remains, however, problematic. In 1975 an expert panel convened by the World Bank concluded that large-scale longitudinal studies were probably the only means of assessing the health benefits of water and sanitation projects and recommended that, "given the very high cost, limited possibility of success and restricted application of results", such studies should not be undertaken.[a] While two subsequent reviews of studies of the health impact of water and sanitation interventions revealed that a positive impact on diarrhoea and other water-related diseases had been reported in many instances (*1*, *2*), it has been pointed out that many of these studies suffered from serious methodological flaws (*3*).

In 1983, meetings were held at which methodologies for evaluating the health impact of water and sanitation programmes were discussed; subsequently, the case–control method was advanced as a relatively quick, inexpensive, and reliable alternative to longitudinal designs.[b]

Also in 1983, the government of Lesotho initiated the Rural Sanitation Pilot Project (RSPP) with support from the United Nations Children's Fund (UNICEF), the United Nations Development Programme (UNDP), and the World Bank. Additional financial assistance was provided by the United States Agency for International Development (USAID). The aim of the RSPP was to develop a decentralized strategy for rural sanitation that could be integrated with existing rural water supply and primary health care programmes and would lead to a sustainable improvement in the health status of the low income rural population. The project concentrated on promoting and constructing ventilated improved pit (VIP) latrines and on health education directed at improving standards of personal and domestic hygiene practices, with the objective of developing self-sufficiency within rural communities.

The RSPP ended in December 1986 and the National Rural Sanitation Programme (NRSP) was launched. In early 1987, at the request of the Lesotho

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[a] **World Bank.** *Measurement of the health benefits of investments in water supply. Report of an Expert Panel, 1976.* (Public Utilities Department Report No. PUN 20).

[b] **Briscoe, J. et al.** *Measuring the impact of water supply and sanitation facilities on diarrhoea morbidity: prospects for case–control methods.* Unpublished document WHO/CWS/85.3.

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Ministry of Health, the feasibility of evaluating the health impact of the RSPP was investigated (R.G. Feachem, unpublished report, 1987). Such an evaluation was determined to be feasible, and diarrhoea morbidity and nutritional status were identified as the most appropriate health impact indicators (outcome variables) for the study, applying the criteria of validity, reliability, responsiveness, and public health importance proposed by Briscoe et al. (*4*). A case–control study was designed to evaluate the impact of improved sanitation on diarrhoea morbidity. In addition, the possibility of studying the nutritional status of children as a second outcome measure was investigated (*5*). Here, we present an analysis of the association between latrine ownership and diarrhoea morbidity among children under 5 years of age.

Methods

Study site and population

The study was performed in Mohale's Hoek district, the site of the RSPP. The district is located in the south of Lesotho, occupies an area of 3530 km^2, and is divided into seven constituencies. At the 1986 census it had a population of about 165 000 (Bureau of Statistics, Government of Lesotho, unpublished report, 1987), 84% of whom live in rural areas.

By August 1987, just prior to the evaluation, a total of 1374 VIP latrines had been constructed in the district through the programme. These latrines, however, represent only a small proportion of the total number currently in use in the district, since many households have constructed their own. How much of this construction has been a result of the promotional and health education work performed by project staff in the district is, however, not clear.

Study design

Cases and controls were recruited at four health facilities chosen in order to achieve the required rate of recruitment and for ease of accessibility. Two of these facilities (Mohale's Hoek Hospital and a private clinic) were in Mohale's Hoek town, while the other two were 30 km north-east (Mpharane Health Centre) and 35 km south (Holy Cross Health Centre) of the town. Recruitment took place from Monday to Saturday at the hospital and private clinic, and on Mondays and Wednesdays at Mpharane and Holy Cross. All children brought to the health facilities on these days and who were eligible for inclusion were recruited into the study.

Cases were children less than 5 years of age who presented to the participating health facilities with diarrhoea (as defined by the mother, with a minimum requirement of three or more loose or watery stools in the previous 24 hours). Controls were children in the same age range who reported with either respiratory infections or trauma, but without diarrhoea. In order to be eligible for inclusion in the study, children also had to meet the following selection criteria: they must be accompanied by a parent or guardian who had been responsible for the child for the previous 3 months: they must be living in a household within Mohale's Hoek district: they must not be suffering from a congenital abnormality or chronic illness; and the accompanying adult must consent to his or her child's inclusion in the study. Re-recruitment of children as cases or controls was permitted, provided the recruitments were separated by a period of at least 2 weeks.

After the child had been examined by a trained nurse, the parent or guardian was interviewed in the clinic using a structured questionnaire. Information on the child, the episode of illness, the family's access to water supply and sanitation facilities, household hygiene practices, and a wide variety of potential confounding variables was collected.

In addition, a random sample of cases and controls was visited at their homes and the parent or guardian who had been interviewed at the clinic was re-interviewed. The water and sanitation facilities available to the family and the general household conditions were also observed.

Statistical methods

All questionnaires were first checked and coded and the data were then double-entered on a microcomputer installed in Mohale's Hoek and later in Maseru. The data were analysed in Maseru using the SPSS/PC$^+$, NCHS, and EGRET software packages. Statistical techniques used in the analysis included Student's t-tests and χ^2 tests for general associations and for trends. After controlling for potentially confounding variables, estimates of the odds ratio for the association between diarrhoea morbidity and latrine ownership were calculated using the method described by Mantel & Haenszel (*6*). The 95% confidence intervals (CI) for these estimates are test-based (*7*). Evidence of effect modification was investigated using the method reported by Breslow & Day (*8*). In addition, logistic regression analyses (*8*) were performed to model the association between diarrhoea morbidity and latrine ownership, while controlling simultaneously for several confounding variables.

Results

Characteristics of cases and controls

Between 8 December 1987 and 6 June 1988, a total of 806 cases of diarrhoea and 814 controls were recruited at the four health facilities that participated in the study. Three of the cases and four controls were later excluded from the study when it was determined that these children had been recruited on a prior occasion during the previous 2 weeks. The remaining 803 cases and 810 controls included 83 children who were recruited into the study on two or more occasions (at least 2 weeks apart). Among these children, 81 were recruited twice and two were recruited on three occasions. A total of 24 children were included twice as cases and 22 twice as controls, while 19 children who were first recruited as cases were later recruited as controls, and 16 children included initially as controls were later recruited as cases. One child was recruited as a case and then twice as a control, and one child was recruited three times as a control.

A total of 391 cases (49%) and 423 controls (52%) were female. The reported incidence of diarrhoea among the cases (Fig. 1) exhibited a peak among 6–11-month-olds. Table 1 shows the signs and symptoms associated with diarrhoea. Of 793 cases, 379 (47.8%) were diagnosed to be suffering from some degree of dehydration, as follows: 260 (68.6%) were mildly dehydrated, 104 (27.4%) were moderately dehydrated, and 15 (4.0%) were severely dehydrated. In addition, 29.8% of the children who were recruited as cases were also diagnosed to be suffering simultaneously from a respiratory infection, and 84% were reported to be passing bloody and/or mucoid stools.

Of the 810 controls, 793 were diagnosed to be suffering from acute respiratory infections, while 17 had suffered trauma.

Fig. 1. **Age distribution of 802 cases of diarrhoea, Mohale's Hoek district, Lesotho.**

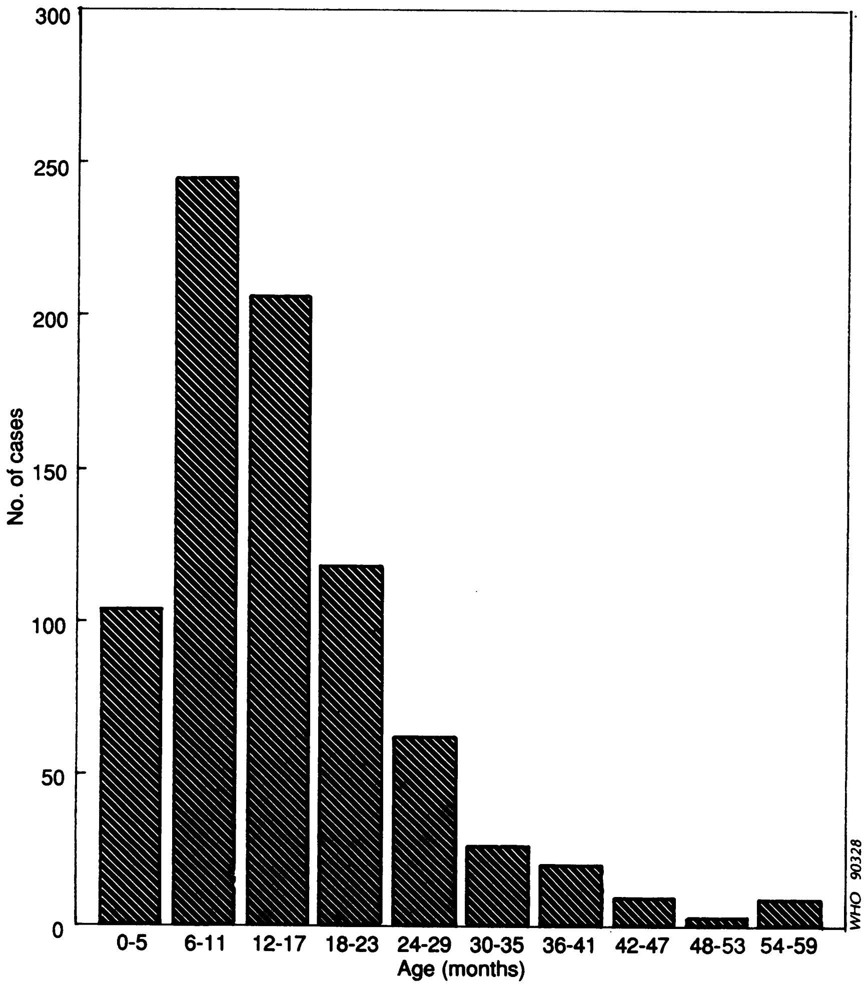

Table 1: **Summary of the signs and symptoms associated with 803 episodes of diarrhoea among children under 5 years of age, Mohale's Hoek district, Lesotho**

Signs and symptoms	No. of cases
Reported number of stools in past 24 hours	
3–5	506 (63.4)[a]
6–9	181 (22.7)
⩾10	112 (14.0)
Fever reported	
Yes	423 (52.8)
No	378 (47.2)
Blood/mucus reported in stool	
Yes	678 (84.4)
No	125 (15.6)
Dehydration status	
None	414 (52.2)
Mild	260 (32.8)
Moderate	104 (13.1)
Severe	15 (1.9)
Reported onset of episode	
Same/previous day	165 (20.7)
2–3 days ago	232 (29.1)
4–7 days ago	138 (17.3)
1 week ago	131 (16.4)
>1 week ago	132 (16.5)
Associated complaints	
None	511 (64.0)
Respiratory	238 (29.8)
Measles	9 (1.1)
Otitis media	14 (1.8)
Other	27 (3.5)

[a] Figures in parentheses are percentages.

Table 2: **Distribution of cases and controls with respect to selected demographic and socioeconomic indicators**

Indicator	No. of cases	No. of controls
Age group (months)		
0– 5	104 (13.0)[a]	272 (33.6)
6–11	245 (30.5)	170 (21.0)
12–23	324 (40.4)	217 (26.8)
24–59	129 (16.1)	151 (18.6)
Sex		
Male	410 (51.2)	384 (47.6)
Female	391 (48.8)	423 (52.4)
Area of residence		
Taung	95 (11.9)	68 (8.4)
Mpharane	126 (15.8)	126 (15.6)
Mohale's Hoek	465 (58.3)	494 (61.2)
Mekaling	77 (9.6)	91 (11.3)
Qaqatu	30 (3.8)	24 (3.0)
Thaba-Telle	5 (0.6)	4 (0.5)
Recruitment clinic		
Mohale's Hoek	263 (32.8)	388 (47.9)
Private clinic	439 (54.7)	301 (37.2)
Mpharane	72 (9.0)	94 (11.6)
Holy Cross	29 (3.6)	27 (3.3)
Maternal education		
None	19 (2.4)	19 (2.3)
Primary	576 (72.0)	540 (66.7)
Form 1–5+	205 (25.6)	250 (30.9)

[a] Figures in parentheses are percentages.

The distribution of cases and controls with respect to selected demographic and socioeconomic variables is shown in Table 2. Cases were, on average, older than controls ($P = 0.03$). More controls than cases were aged less than 6 months, and more cases than controls were aged 6–24 months. At the beginning of the study (the peak of the diarrhoea season), cases were recruited at a greater rate than controls; later, however, the rate of recruitment of cases fell and that of controls increased ($P = 0.0001$). There was no evidence of any difference in the distribution of cases and controls by area of residence ($P = 0.20$). Cases did, however, tend to live further away from the clinics than did controls ($P = 0.01$).

There was some evidence of an association between the father's occupation and the incidence of diarrhoea ($P = 0.08$); fathers of cases were slightly less likely to have a profession than those of controls. However, there was no strong evidence of an association between diarrhoea morbidity and mother's occupation ($P = 0.13$). Mothers of controls tended to have received more years of schooling than those of cases ($P = 0.03$).

The households of controls reported using more water ($P = 0.13$) from "better" sources ($P = 0.02$) than those of cases; they were also more likely to possess a latrine ($P = 0.009$).

Latrine ownership and usage

About 36% of cases and 43% of controls were reported to be living in households with a latrine. Slightly over 40% of these households possessed VIP latrines, 44% had ordinary pit latrines, and 13% had bucket latrines.

Latrine ownership was highly dependent on the constituency in which the family lived ($P < 0.001$). Levels of ownership were highest in Taung and Mohale's Hoek (>40% among both cases and controls), and lowest in Mekaling, Qaqatu, and Thaba-Telle (<30% among both cases and controls). The three last-mentioned areas were the furthest from Mohale's Hoek town, and were the most rural of the six constituencies included in the study. Latrine ownership was also closely related to the distance from the child's home to the recruiting health facility. Those families who lived closest to the health facility were most likely to own latrines; and the further a family lived from the health facility the less likely it was to possess a latrine ($P < 0.0001$).

Latrine owners tended to be better off than non-owners, and were more likely to use improved water sources ($P < 0.0001$) and larger quantities of water ($P < 0.0001$). They were also more likely to report good hygiene practices than non-owners (daily bathing ($P < 0.0001$); handwashing before feeding the child ($P < 0.0001$), before eating ($P = 0.003$), and after defecation ($P < 0.0001$)).

Reported usage of latrines by latrine-owning adults was 99%; however, the use of latrines for the disposal of children's stools was less common. Among both the case and control groups, 50% of latrine owners reported that they disposed of the child's stools in the latrine; 48% away from the household; and 2% did not report taking any particular steps to dispose of the stools.

Association between diarrhoea morbidity and latrine ownership

Cases were less likely than controls to come from latrine-owning households (Table 3), and this association between disease status and latrine ownership was statistically significant ($P < 0.01$). The crude estimate of the odds ratio obtained from these data is 0.76 (95% CI, 0.62–0.93). Initially, evidence of confounding was sought by carrying out stratified analyses of the data and by comparing the Mantel-Haenszel estimate of the odds ratio thus obtained with that from the crude analysis. The estimate of the odds ratio remained remarkably stable (0.70–0.82) when a wide variety of potentially confounding variables were controlled individually. The results for some of the potential confounders that were examined are shown in Table 4.

Although little evidence of confounding was detected, some evidence of effect modification was found using Breslow & Day's test for homogeneity (*8*). The association between latrine ownership and diarrhoea morbidity appeared to be modified by all of the following: handwashing by the mother after defecation, quantity of water used (number of litres per capita per day), maternal occupation, and maternal education level (Table 4). In general, the impact of latrine ownership on diarrhoea appeared to be greater in households where mothers reported handwashing after defecation and the use of larger quantities of water, and for families in which the mother had a higher level of education and where she undertook paid employment outside the home.

In order to control several confounding variables simultaneously and to search for further evidence of effect modification, logistic regression analyses were undertaken. Those variables expected, *a priori*, to be confounders (age, clinic of recruitment, month of recruitment, area of residence, and distance from home to clinic) and those that altered the estimate of the odds ratio for the association between diarrhoea morbidity and latrine ownership by 0.03 or more (father's occupation, number of rooms in the house, possession of a stove, mother's education level, father's education level, source of water, quantity of water, water storage practices, bathing and handwashing before feeding the child) were included in the logistic regression model. The estimated odds ratio (0.76) obtained from this model is the same as that obtained using the crude analysis (Table 3). However, the 95% CI around the estimate of the odds ratio was wider (0.58, 1.01; $P = 0.057$) and includes the null value (1.0). To test for effect modification, we included the main effects (where necessary) and interaction terms for handwashing after defecation, mother's occupation, and quantity of water used in the basic logistic regression model described above. Inclusion of terms for handwashing after defecation and its interaction with latrine ownership improved the model somewhat ($\chi^2 = 3.1$,1 degree of freedom, $P = 0.08$). Although the interaction was not significant at the 5% level, the results were consistent with the hypothesis that latrine ownership or handwashing after defecation alone has little or no effect on the incidence of diarrhoea (odds ratios = 1.28 and 0.98, respectively), while a combination of both these factors may lead to a substantial reducation in its incidence (odds ratio = 0.70).

Terms representing interactions between latrine ownership and maternal occupation ($\chi^2 = 9.8$,1 degree of freedom, $P = 0.002$) and between latrine ownership and quantity of water ($\chi^2 = 8.53$, 2 degrees of freedom, $P = 0.01$) were statistically significant. The reduction in diarrhoea morbidity associated with latrine ownership appeared to be greatest in households where the mother worked outside the home, and in those where relatively large quantites of water were used.

Table 3: **Distribution of latrine ownership in the households of cases of diarrhoea and controls**[a]

Latrine ownership	No. of cases	No. of controls
Yes	292 (36)[b]	347 (43)
No	511 (64)	463 (57)
Total	803 (100)	810 (100)

[a] Odds ratio = 0.76; 95% CI = 0.62, 0.93; $\chi^2 = 6.80$, $P = 0.009$.

[b] Figures in parentheses are percentages.

Table 4: **Selected results from the analysis of the association between latrine ownership and diarrhoea morbidity, after stratifying on potential confounders**

Stratified for:	Mantel-Haenszel odds ratio	95%, test-based CI	Two-sided P-value	Homogeneity (P)[a]
Not stratified	0.76	(0.62, 0.93)	0.008	–
Age	0.78	(0.63, 0.96)	0.02	<0.25
Sex	0.75	(0.62, 0.93)	0.007	<0.25
Clinic	0.75	(0.61, 0.93)	0.008	<0.25
Constituency	0.74	(0.60, 0.91)	0.005	>0.90
Month	0.79	(0.64, 0.97)	0.03	>0.90
Mother's occupation	0.75	(0.61, 0.93)	0.008	<0.01[b]
Mother's education	0.80	(0.65, 0.99)	0.04	<0.001[b]
Source of water	0.82	(0.66, 1.02)	0.08	>0.90
Quantity of water	0.79	(0.64, 0.98)	0.03	<0.03[b]
Handwashing after defecation	0.78	(0.63, 0.95)	0.02	<0.05[b]

[a] Calculated using Breslow & Day's test for homogeneity.

[b] $P < 0.05$ indicates some evidence of effect modification.

Discussion

The age distribution of the incidence of diarrhoea, which peaked for children aged 6–11 months, is consistent with other data from Lesotho (M. Toole & D. Hatch, unpublished report, 1987) and elsewhere in Africa and developing countries (*9*). The proportion of diarrhoea cases that presented with dehydration (47.8%) is in accord with outpatient data (47.5%) for Lesotho as a whole (*10*). Data from six district hospitals in Lesotho from February to June 1987 (M. Toole & D. Hatch, unpublished report, 1987) indicate that, among children aged less than 5 years who presented with diarrhoea and dehydration, 62% were mildly dehydrated, 35.3% were moderately dehydrated, and 2.7% were severely dehydrated. These levels are also in good broad agreement with those reported in the present study.

A more surprising finding concerns the 84% of cases in the present study that were reported by the accompanying adult to be passing bloody and/or mucoid stools. This is considerably higher than the 22% of cases found during a recent community-based study conducted in Lesotho (P.S. Yoder & K. Wilkins, unpublished report, 1988). It is likely, however, that the present clinic-based study recruited more severe cases of diarrhoea than the community study mentioned above. In addition, Yoder & Wilkins found that caretakers were more likely to seek treatment for the diarrhoea when the child's stools were bloody, and that caretakers were more likely to report blood or mucus in the child's stools when asked directly about its presence or absence. It seems probable that, in the present study, asking directly about the presence of blood or mucus in the child's stools led to a substantial number of false positive responses, perhaps because mothers were anxious to impress upon the attending nurse the seriousness of their child's condition.

The primary objective of this study was to evaluate the impact of improved sanitation facilities on the incidence of diarrhoea. While it might be hoped that improved sanitation will lead to a reduction in the incidence of infectious diarrhoeas, it seems unlikely that such improvements will have any impact on noninfectious diarrhoeas. The inclusion of children suffering from noninfectious diarrhoea as cases will therefore lead to an underestimation of the impact of improved sanitation on the incidence of infectious diarrhoeas,[c] while providing an unbiased estimate of the impact of improved sanitation on reported diarrhoeas of all etiologies. In the present study, a substantial proportion of children with diarrhoea (30%) were suffering simultaneously from a respiratory infection. The inclusion of such children as cases might have been expected to lead to an increase in the proportion of noninfectious diarrhoeas; however, a crude analysis of the data, excluding those children who were suffering from both diarrhoea and a respiratory infection, produced an estimated odds ratio for latrine ownership of 0.78. This suggests that the inclusion as cases of children with both conditions did not, in this setting, increase the proportion of noninfectious cases recruited.

[c] **Cousens, S.N. et al.** *Case–control studies of childhood diarrhoea: I. Minimizing bias.* Unpublished WHO document CDD/EDP/88.2.

Misclassification of exposure status will also lead to a biased estimate of the odds ratio.[c] Clearly, a child's exposure to improved sanitation will be assessed most accurately by a visit to his or her home; a clinic-based study is, however, much simpler to conduct if exposure data can be reliably collected. In the present study, exposure data were collected at the clinic and, for a subsample of the 102 cases and 81 controls, also during follow-up visits at home. Analysis of these data revealed that the level of misclassification was relatively low (about 3%) for data collected at the clinic (Table 5). Case–control studies of water supplies in Malawi (B.A. Young & J. Briscoe, unpublished report, 1986) and Nicaragua (P. Sandiford, unpublished report, 1988) have reported differences in the classification of water sources between clinic and household data for 5–11% of children. These comparatively high rates of misclassification may arise because, from time to time, some families change their water sources. Also, for the classification of exposure, it should be noted that we related diarrhoea to latrine ownership. A proportion of these latrines will not have been optimally used; and the association between diarrhoea and the optimal use of latrines will therefore be greater than that observed simply between diarrhoea and latrine ownership.

Controls should be representative of the population from which cases are drawn. The controls used in the present study were almost exclusively children with respiratory infections. By choosing such children, we hoped to select controls who, had they suffered an episode of diarrhoea of appropriate severity during the course of the study, would have been recruited as cases, and the converse. There was some evidence that cases lived further from the clinics than controls: 54% of cases lived more than 10 km from the recruiting clinic, compared with only 45% of controls. This suggests that reporting practices in Lesotho may differ somewhat for diarrhoea and respiratory infections. Distance from the child's home to the clinic was taken into account in the analysis.

Table 5: **Comparison of latrine ownership status observed during home visits with responses obtained during clinic interviews**

	Observation (household):		
Clinic interview:	Latrine	No latrine	Total[a]
Latrine	86	3	89
No latrine	3	91	94

[a] False positive rate = 3/89 = 3.4%; false negative rate = 3/94 = 3.2% (both rates at the clinic, assuming the household data to be correct).

In addition to the problems of misclassification and selection bias, the estimate of the odds ratio will be biased by any failure to control effectively for confounding. It is never possible to be certain that confounding has been completely controlled in observational studies. Strenuous efforts were made in the study to ensure that any confounding which occurred was controlled. For this purpose, stratified analyses were performed for more than 30 potentially confounding variables, but no strong confounding was detected. Indeed, the estimate obtained from the crude analysis of these data was the same as that obtained using a logistic regression analysis. Clinic-based studies of water supply and diarrhoea in both Malawi (*11*) and the Philippines (*12*) have also found little evidence of confounding. Briscoe et al. have suggested that it might be possible to develop a simple protocol for case–control studies of diarrhoea and water supply/sanitation interventions in which information on confounders would not be collected (*13*). The results of the present study offer some support to this for studies in which diarrhoea morbidity is the outcome of interest. More experience with the method is, however, required before simplified studies that do not record confounders can be conducted with confidence. For example, in a case–control study of diarrhoea mortality in Brazil, Victora et al. found a crude association between latrine ownership and risk of infant mortality from diarrhoea (*14*). This association disappeared when socioeconomic status and water supply were taken into account.

Our results have provided some evidence that improved sanitation can have a positive impact on diarrhoea morbidity in young children in rural Lesotho. A crude analysis of data obtained at selected health facilities indicated that latrine ownership may be associated with about a 24% reduction in the incidence of reported diarrhoea. More detailed analyses of the data are consistent with this finding. The estimate of the odds ratio calculated using a logistic regression analysis of the data was the same as the crude estimate, although the 95% CI (0.58, 1.01) includes the null value (no effect). On the other hand, a cross-sectional survey of *Giardia lamblia* infection among 267 children in Lesotho failed to find any evidence of an association between latrine ownership and risk of infection (*15*). However, only 11% of the children who were positive for *G. lamblia* were reported to have had diarrhoea in the 24 hours preceding the collection of the stool sample, and no attempt was made to examine the association between latrine ownership and the health status (diarrhoeal/not diarrhoeal) of the child. The results of the last-mentioned survey, which focused on infection (symptomatic or asymptomatic) with one particular enteropathogen, do not preclude the possibility that improved sanitation may substantially reduce the incidence of diarrhoea caused by a variety of etiological agents.

Stratified analysis of our data suggest that the quantity of water used per capita per day in a household, the practice of handwashing after defecation, and the education level and occupation of a child's mother may modify the impact of latrine ownership on the incidence of diarrhoea. These results concerning effect modification should be interpreted with caution, since a large number of tests were performed and it is therefore likely that some statistically significant findings may have arisen by chance alone; they are, however, consistent with the threshold theory proposed by Shuval et al., since the impact of latrine ownership appears to be greater among families who have higher socioeconomic status and better water-use and hygiene practices (*16*). In contrast, Esrey & Habicht found that latrine ownership in Malaysia had a greater impact on infant mortality among families with illiterate mothers than among those with mothers who were literate (*17*). These authors suggest that this may be because literate mothers without access to toilets nevertheless dispose of faeces in a relatively safe way, and thus derive less benefit from latrines than their illiterate counterparts. The apparent discrepancy between these findings and those from the present study may reflect the different settings of the two investigations, the different outcome measures used (diarrhoea morbidity versus infant mortality), or have arisen simply by chance. We therefore re-emphasize that our results concerning effect modification should be interpreted with caution.

Our findings are consistent with a review article which concluded that water supply and sanitation programmes can have substantial impacts on diarrhoea morbidity (*1*), and with recent case–control studies in Malawi (*11*), Philippines (*12*), and Sri Lanka (T.E. Mertens, unpublished report, 1988), all of which found evidence for positive health impacts of improvements in water supply and sanitation. They are also consistent with the view that it is important to integrate water supply, sanitation, and health education programmes if substantial health benefits to communities are to be achieved.

Further evidence of the benefits of improved sanitation on the health of young children is presented in a report (D.L. Daniels & S.N. Cousens, unpublished, 1988) that explores the association between latrine ownership and the nutritional status of children under 5 years of age.

Finally, the present study was conducted in less than one year at a cost of about US$ 80 000, which represents about 2% of the investment in the National Rural Sanitation Programme so far. It provides further evidence that the case–control method is a cost-effective approach to the problem of evaluating the health impact of water supply and sanitation interventions.

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Résumé

Effets de l'amélioration de l'assainissement sur la morbidité liée à la diarrhée au Lesotho: étude cas-témoins

Les effets sur la santé du projet pilote d'assainissement rural mis en œuvre dans le district de Mohale's Hoek, au Lesotho, d'octobre 1987 à septembre 1988 ont été évalués. Une enquête cas-témoins dans les dispensaires a été utilisée pour étudier les effets de l'amélioration de l'assainissement sur la morbidité liée à la diarrhée chez les jeunes enfants. Les résultats ont montré que le nombre des épisodes de diarrhée chez les moins de 5 ans vivant dans des foyers pourvus de latrines était de 24% inférieur au nombre des épisodes chez les moins de 5 ans vivant dans des foyers sans latrines (risque relatif = 0,76, intervalle de confiance à 95%, 0,58–1,01). Les latrines avaient d'autant plus d'effet sur la diarrhée que les foyers utilisaient davantage d'eau, observaient une meilleure hygiène personnelle et que les mères étaient plus instruites et occupaient un emploi à l'extérieur. Pas plus qu'au Malawi, aux Philippines et à Sri Lanka, on n'a pu prouver que le statut socio-économique et l'environnement étaient des facteurs confondants en ce qui concerne le lien entre la possession de latrines et la diarrhée. Pour un échantillon de cas et de témoins, les données sur l'exposition (présence ou absence de latrines) recueillies par les enquêteurs dans les dispen-

saires coïncidaient étroitement avec les données obtenues par observation lors d'une visite à domicile.

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