© International Epidemiological Association 1998 Printed in Great Britain International Journal of Epidemiology 1998,27 1090–1100

Hygiene behaviour in rural Nicaragua in relation to diarrhoea

Anna C Gorter,[a,b,c] Peter Sandiford,[c] Johanna Pauw,[a] Patricia Morales,[a] Rosa María Pérez[a] and Henk Alberts[a]

Background Childhood diarrhoea is a leading cause of morbidity and mortality in Nicaragua. Amongst the risk factors for its transmission are 'poor' hygiene practices. We investigated the effect of a large number of hygiene practices on diarrhoeal disease in children aged <2 years and validated the technique of direct observation of hygiene behaviour.

Methods A prospective follow-up study was carried out in a rural zone of Nicaragua. From the database of a previously conducted case-control study on water and sanitation 172 families were recruited, half of which had experienced a higher than expected rate of diarrhoea in their children and the other half a lower rate. Hygiene behaviour was observed over two mornings and diarrhoea incidence was recorded with a calendar, filled out by the mother, and collected every week for 5 months.

Results Of 46 'good' practices studied, 39 were associated with a lower risk of diarrhoea, five were unrelated and only for two a higher risk was observed. Washing of hands, domestic cleanliness (kitchen, living room, yard) and the use of a diaper/underclothes by the child had the strongest protective effect. Schooling (>3 years of primary school) and better economic position (possession of a radio) had a positive influence on general hygiene behaviour, education having a slightly stronger effect when a radio was present. Individual hygiene behaviour appeared to be highly variable in contrast with the consistent behaviour of the community as a whole. Feasible and appropriate indicators of hygiene behaviour were found to be domestic cleanliness and the use of a diaper or underclothes by the child.

Conclusion A consistent relationship between almost all hygiene practices and diarrhoea was detected, more schooling producing better hygiene behaviour. The high variability of hygiene behaviour at the individual level requires repeated observations (at least two) before and after the hygiene education in the event one wants to measure the impact of the campaign on the individual.

Keywords Diarrhoea, hygiene behaviour, observation

Accepted 7 January 1998

Childhood diarrhoea is a leading cause of morbidity and mortality in developing countries.[1] As such it has stimulated much research that is aimed at understanding its aetiology and evaluating preventive and therapeutic strategies. The Diarrhoeal Diseases Control Programme of the World Health Organization has selected several areas which merit special consideration:[2] improvements in water availability and sanitation; improved nutrition, especially the promotion of breastfeeding and better weaning practices; good personal and domestic hygiene; immunization against measles and rotavirus; and oral rehydration therapy (ORT).

Over the last decade several epidemiological studies examined hygiene practices as risk factors for childhood diarrhoea.[3–13] Some of these practices identified as risk factors have subsequently been used as targets for behaviour modification through health education campaigns.[14–19] While hand washing has been the subject of many studies,[7,9,16,18,20–27] other specific behaviours have received less attention.[13,28]

Several investigations have used observation data, but little work has been performed to confirm their validity and repeatability.[28] Two studies, one in Burkina Faso[29] and one in

[a] Fundación de Desarrollo Social y Económico del Area Rural (DESEAR), Villa Carlos Fonseca, Nicaragua.

[b] Instituto Centroamericano de la Salud (ICAS), Managua, Nicaragua

[c] Institute for Health Sector Development, 27 Old Street, London EC1V 9HL, UK.

Reprint requests to Anna Gorter, Apartado Postal 2691, Managua, Nicaragua.

Bangladesh[30] compared responses from KAP (knowledge, attitudes, practices) questionnaires with observation data and found that results could be very different. Desirable practices were reported but not observed more times than they were observed but not reported. The studies claimed that data from direct observation are more valid than from questionnaires. However, repeated observations of a small sample of households in one of the studies[29] revealed a high variability of hygiene behaviour. The authors suggested that studies should be undertaken to assess this variability, and validity and repeatability of direct observation versus KAP questionnaires for measuring hygiene practice.

In this paper we present a study of the influence of hygiene practices on the incidence of diarrhoea in children aged <2 years, the relationship with maternal education and socio-economic position and the repeatability of direct observation of these practices. The study was carried out as part of an integrated programme of diarrhoea research in an area of rural Nicaragua. The initial investigation was a case-control study examining risk factors for diarrhoea. It was found that reduced availability of water and low maternal education were related to increased rates of diarrhoea.[31] Other studies examined the determinants of water quality and domestic water use.[32,33] Subsequent work documented lay beliefs regarding the causes, treatment and prevention of diarrhoea, mothers' responses to diarrhoea, their willingness to use ORT[34] and possible explanations for Nicaragua's decline in infant mortality over the past 20 years.[35] Results from this programme, e.g. the demonstration that poor availability of water was associated with a higher risk of diarrhoea, have informed and encouraged the development of prevention programmes such as production of rope pumps for water and sanitation programmes[36–39] and other health promotion activities.

Materials and Methods

The studies were conducted in Villa Carlos Fonseca, a rural municipality on the Pacific coastal plains of Nicaragua, 40 km from the capital Managua. Within its area of 500 km^2 there are approximately 32 000 inhabitants living in 38 different communities. It is almost an entirely agricultural society.

This investigation of the effect of hygiene practices on diarrhoea incidence is a prospective follow-up study of families who had participated in the initial case-control study that examined the links between diarrhoea and environmental sanitation.[31] A total of 2458 illness episodes were recruited to that study; 1229 bouts of diarrhoea plus a control group of 1229 illnesses not directly related to water supply and sanitation. As it was possible for children to be recruited on more than one occasion, and for different children within one family to be recruited, a total of 1402 families were included in the study and this group became the sampling frame for the prospective follow-up study of hygiene practices.

Of these 1402 different families, 585 mothers of infants had presented a child to the health facilities on two or more occasions with a diarrhoeal episode or with an illness serving as a control. Since cases of diarrhoea had been matched to controls at the outset, there was initially a probability of exactly 50% that any given episode was one of diarrhoea. This was effectively still the case with the reduced group of 585 families (of 1641 episodes of illness, 824 or 50.24% were diarrhoea). The cumulative binomial probability was calculated of observing more cases of diarrhoea than of control diseases within a given family. Using these probabilities 397 families were selected as 'high risk' or 'low risk' for diarrhoea and of these 172 also had a child <2 years old at the start of the follow-up period. Thus a total of 88 'high risk' and 84 'low risk' mothers were selected.

Before data collection was commenced in January 1989, a pilot study was performed with 41 households selected at random from a local population register. Observations lasting 3–4 hours were made by study assistants. They used a data recording form that was made intentionally open-ended in order to gain some idea of the range of practices likely to be encountered. From the results and experience obtained in this initial study a structured observation recording form was designed and pretested. Information was recorded on food hygiene (including baby's bottle hygiene), personal hygiene around study child, domestic hygiene, water hygiene and safe faeces disposal, as well as details on social, economic and educational status of the families, availability of water, and presence of latrines. A variety of different starting times for the observations were tried in order to find the period when most of the relevant activities were occurring.

Eight female field workers were recruited with at least 2 years of secondary school and who could not be distinguished from the local women. All had experience in child care and had managed household activities. The field workers attended a week long training workshop and were then accompanied and supervised by the study assistants for about three observations, until the latter were satisfied with their work. During the study every fourth observation was overseen by one of the assistants. After each observation we reviewed the forms, checking in particular for inconsistencies and omissions, and discussing certain problems.

In each house, two periods of observations were carried out by the same field worker from about 8.30 am to 1 pm which is when most of the relevant domestic activities take place. The second observation was performed after 1 to 2 weeks and the observer had no access to the form of the first observation. Field workers were assigned randomly to a family and blind to the diarrhoeal history of them. The purpose of the visit (observation of hygiene practices) was not revealed. Permission was given by the mothers to observe their children.

All observations were performed during the dry season. The incidence of diarrhoea in children aged <2 years was measured for 5 months. We started one month after the observations and included the rainy season when diarrhoea incidence in Nicaragua is highest.[31] The mothers were asked to fill out a daily diarrhoea calendar, especially designed for illiterate women. If there was more than one child aged <2 years, a diarrhoea calendar was given for each child. A photo of the child was taken and attached to the calendar. This also served as an incentive for the mother to take part in the study. A field worker visited the home each week and collected the completed calendars, reviewing them with the mothers to verify the accuracy of the record.

Coding and data entry was performed. Statistical packages (Epi Info and Lotus) were used for data analysis. Following the recommendations of MacClure and Willett,[40] the repeatability of the dichotomous variables was measured using the unweighted Kappa score which takes into account the degree of

concordance to be expected by chance alone.[41] Negative Kappa scores indicate less concordance than would be expected by chance. Positive Kappa scores between 0 and 1 suggest better concordance than expected by chance, with Kappa scores of 1 representing perfect agreement between the repeated measurements. For dichotomous variables, as are all variables of the hygiene behaviour presented, it is generally accepted that values <0.40 imply poor repeatability, 0.40–0.75 good repeatability, and values >0.75 indicate excellent repeatability.[41] Kappa scores are known to be biased however, when prevalence is either very high or very low.[42,43] Differences in proportions were tested for statistical significance using the χ^2 statistic, and for trend using the Mantel-Haenszel extension to the χ^2 test.

Results

All 172 families could be observed. The observed children had a mean age of 13 months. The average household consisted of almost eight family members. Mothers had a mean age of 28 years and a mean education of 3 years (range 0–11), with 23% being illiterate. Half of the houses were connected to electricity, 46% had a radio, 39% a concrete or tiled floor (as opposed to earthen), and only 7% a television.

Diarrhoeal incidence data were collected from all families on whom observations were made, in 85% of cases for the full 5 months, in a further 6% between 4 and 5 months, 2% between 3 and 4 months and in 7% for <3 months. The most important reason for leaving the incidence study prematurely was moving out of the study zone, furthermore two mothers were unwilling to continue filling out the diarrhoea calendar and two children died. Extensive analysis of the incidence data has been presented elsewhere.[44]

In 54 of the 172 families, no diarrhoea was reported in the entire study period. These 54 mothers were compared with the 118 where at least one child had experienced one or more episodes of diarrhoea. An episode of diarrhoea was defined as four or more watery motions within a 24-h period. Mean age of children in the 'diarrhoea' group was 12 months; almost the same as that of children in the 'diarrhoea-free' group which was 13 months. Their breastfeeding and weaning profile at onset of study was exactly the same for both groups: 7% were never breastfed, 53% were being breastfed at the time the study began, and 40% had been weaned.

There was no difference in the duration of follow-up between families in the 'diarrhoea' group and those in the 'diarrhoea-free' group. Thus, the analysis of the relationship between diarrhoea with hygiene practice could be carried out using the full sample size of mothers, independently of how long they participated in the incidence study. Nevertheless, to see whether the different follow-up durations would influence the results, an analysis of the whole sample was compared with one excluding the 12 families who participated for <3 months. Only slight differences were seen. The analyses presented here are with all participating mothers.

Table 1 presents the Kappa score for each hygiene practice and hygiene facility that could be observed twice. Since not all behaviours occurred during the visit, not every practice could be observed both times. Therefore the effective sample size varies for each hygiene practice studied. The Table also shows the percentage of mothers who performed the different 'good' hygiene practices during the first observation and the percentage who did this during the second one. The denominator is thus the number of mothers who could be observed twice on this particular hygiene practice.

Table 2 compares the frequency of 'good' practice between families in whom an episode of diarrhoea was recorded and those in whom no diarrhoea occurred. Significant differences were detected for washing hands before preparing food, and having a clean kitchen floor. Several other practices were of borderline statistical significance. Of the 46 'good' practices studied only two went in the opposite direction (neither of which were statistically significant), five were unrelated and for 39 the association was in the expected direction. Of these 46 'good' practices, 18 were consistently performed by more than half of the families which stayed 'diarrhoea-free' and 14 by more than half of them who had presented diarrhoea. In all categories hygiene behaviour was poor with the exception of water hygiene and safe faeces disposal. Hands were only consistently washed before preparing food and on none of the other occasions such as before eating and picking up the child.

Table 3 presents the proportion of 'diarrhoea-free' families among those in whom 'good' practice was observed twice, once and not at all. Mothers of the three groups together form the effective sample size. In order to limit the amount of data, we show only those hygiene behaviours which were most closely related to diarrhoea in Table 2. In general, the

Table 1 Kappa score and frequency of 'good' hygiene behaviour

'Good' hygiene practices	Families observed 2×	Observations		Kappa
		First[a]	Second[b]	
Food hygiene				
Hands washed before preparing food	113	79%	74%	0.47*
Hands washed when contaminated during cooking	87	33%	32%	0.66*
Fruit washed before eating	41	27%	22%	0.34
All food in covered pans or no food left	171	64%	64%	0.12
Utensils covered	171	8%	9%	0.66*
Hands of mother washed before eating	50	24%	28%	0.38
Hands of child washed before eating a meal	47	13%	11%	0.28
Hands of child washed before eating a snack	53	23%	11%	0.22
Child is assisted when eating	39	62%	56%	0.58*

Table 1 Continued

'Good' hygiene practices	Families observed 2×	Observations		Kappa
		First[a]	Second[b]	
Baby's bottle hygiene				
Hands washed before preparing baby's bottle	85	54%	59%	0.43*
Hands washed before giving bottle or breast feeding	103	25%	30%	0.35
Hands of child washed before drinking bottle	90	26%	28%	0.09
Bottle given by adult (against child holds bottle)	93	44%	40%	0.06
Bottle used is clean	84	96%	98%	–0.03
Bottle covered	91	67%	66%	0.43*
Personal hygiene around the child				
Hands washed before picking up child	153	16%	11%	0.24
Child taken care by own mother not by caretaker	170	81%	82%	0.59*
Clean appropriate place for child to stay	163	31%	26%	0.70*
Mother/caretaker attends the child all the time	164	42%	40%	0.58*
Domestic hygiene				
Table was cleaned within half hour after eating, cooking	138	62%	57%	0.31
Utensils cleaned within half hour after being used	142	45%	42%	0.31
Kitchen floor clean at onset of the observation	171	29%	29%	0.43*
Living room floor clean at onset of the observation	170	32%	34%	0.29
Barrier against animals in the house	171	4%	3%	0.48*
Chase dogs out of the house when they enter	95	11%	13%	0.18
Chase pigs out of the house when they enter	54	26%	30%	0.45*
Chase chickens out of the house when they enter	116	10%	8%	0.53*
Garbage organized in little heaps or not present	171	33%	32%	0.36
Garbage (if present) >2 varas[c] from house	115	55%	56%	0.31
Water hygiene				
Cover on well is in use	122	21%	20%	0.65*
Vessel to draw water is clean	86	91%	94%	0.25
Vessel to store water is cleaned before filled with water	31	71%	71%	0.53*
>2 water vessels in the house	170	40%	45%	0.46*
>25 gallon water stored in the different vessels	170	50%	50%	0.69*
All water vessels for drinking water covered	162	56%	59%	0.38
Safe faeces disposal				
No dirty paper in and around latrine	108	91%	91%	0.23
No faeces on slab of latrine	108	94%	98%	–0.03
No human faeces in the house	171	97%	98%	0.43*
No human faeces on the patio	171	93%	90%	0.36
No animal faeces in the house	171	80%	80%	0.28
No animal faeces on the patio	171	35%	33%	0.49*
No faeces <5 varas from house	157	59%	59%	0.42*
Child uses a diaper or underclothes	170	78%	77%	0.56*
Child defaecated and bottom was cleaned	22	86%	82%	0.15
Faeces removed from where deposited	22	91%	77%	0.18
Mother washes hands after visiting latrine	3	33%	33%	–
Water and sanitation facilities				
Good water source (tap or protected well)	172	65%	66%	0.96**
Distance to water source <150 varas	168	86%	84%	0.79**
Well has a cover on wellhead or cover is nearby	123	42%	42%	0.78**
Existence of a latrine	172	63%	65%	0.95**

[a] Frequency of 'good' practice during first observation of all families in which practice could be observed on both visits.

[b] Frequency of 'good' practice during second observation of all families in which practice could be observed on both visits.

[c] 1 vara = 0.8359 m.

Kappa < 0.40 = poor repeatability.

Kappa 0.40–0.75 = good repeatability*.

Kappa >0.75 = excellent repeatability**.

Table 2 The proportion in which 'good' practice was observed on both visits in 'diarrhoea-free' and 'diarrhoea' families

'Good' hygiene practices	Families observed 2×	'Diarrhoea-free' families (N = 54)	Families with diarrhoea (N = 118)
Food hygiene			
Hands washed before preparing food	113	81%	60%**
Hands washed when contaminated during cooking	87	29%	24%
Fruit washed before eating	41	23%	7%
All food in covered pans or no food left	171	39%	46%
Utensils covered	171	9%	4%
Hands of mother washed before eating	50	13%	14%
Hands of child washed before eating a meal	47	13%	0%
Hands of child washed before eating a snack	53	10%	3%
Child is assisted when eating	39	55%	46%
Baby's bottle hygiene			
Hands washed before preparing baby's bottle	85	58%	36%*
Hands washed before giving bottle or breast feeding	103	25%	10%*
Hands of child washed before drinking bottle	90	16%	6%
Bottle given by adult (against child holds bottle)	93	27%	34%
Bottle used is clean	84	96%	93%
Bottle covered	91	60%	52%
Personal hygiene around the child			
Hands washed before picking up child	153	6%	4%
Child taken care by own mother not by caretaker	170	76%	75%
Clean appropriate place for child to stay	163	24%	21%
Mother/caretaker attends the child all the time	164	36%	28%
Domestic hygiene			
Table was cleaned within half hour after eating, cooking	138	51%	39%
Utensils cleaned within half hour after being used	142	33%	24%
Kitchen floor clean at onset of the observation	171	33%	9%***
Living room floor clean at onset of the observation	170	24%	14%*
Barrier against animals in the house	171	4%	1%
Chase dogs out of the house when they enter	95	7%	2%
Chase pigs out of the house when they enter	54	24%	14%
Chase chickens out of the house when they enter	116	6%	5%
Garbage organized in little heaps or not present	171	26%	15%*
Garbage (if present) >2 varas[a] from house	115	49%	34%
Water hygiene			
Cover on well is in use	122	18%	13%
Vessel to draw water is clean	86	89%	87%
Vessel to store water is cleaned before filled with water	31	80%	58%
>2 water vessels in the house	170	49%	42%
>25 gallon water stored in the different vessels	170	49%	39%
All water vessels for drinking water covered	162	49%	39%
Safe faeces disposal			
No dirty paper in and around latrine	108	84%	85%
No faeces on slab of latrine	108	95%	92%
No human faeces in the house	171	100%	94%
No human faeces on the patio	171	93%	84%
No animal faeces in the house	171	67%	68%
No animal faeces on the patio	171	30%	19%
No faeces <5 varas from house	157	53%	42%
Child uses a diaper or underclothes	170	80%	66%*
Child defaecated and bottom was cleaned	22	83%	69%
Faeces removed from where deposited	22	83%	69%
Mother washes hands after visiting latrine	3	–	33%

Table 2 Continued

'Good' hygiene practices	Families observed 2×	'Diarrhoea-free' families (N = 54)	Families with diarrhoea (N = 118)
Water and sanitation facilities			
Good water source (tap or protected well)	172	65%	64%
Distance to water source <150 varas	168	85%	81%
Well has a cover on wellhead or cover is nearby	123	41%	35%
Existence of a latrine	172	69%	60%

[a] 1 vara = 0.8539 m.

Significance tests compare proportions performing the 'good' practice of the 'diarrhoea-free' and the 'diarrhoea' group. * $P = 0.05$–0.1; ** $P < 0.05$; *** $P < 0.001$.

Table 3 The proportion of 'diarrhoea-free' families according to whether 'good' practice was observed twice, once or not at all

'Good' hygiene practices	Families observed 2×	Twice[a]	Once[a]	Not at all[a]
Food hygiene				
Hands washed before preparing food	113	39%	18%	19%**
Hands washed when contaminated during cooking	87	36%	38%	29%
Fruit washed before eating	41	60%	30%	27%
Hands of mother washed before eating	50	29%	42%	23%
Hands of child washed before eating a meal	47	100%	29%	29%
Hands of child washed before eating a snack	53	67%	42%	34%
Baby's bottle hygiene				
Hands washed before preparing baby's bottle	85	39%	25%	16%**
Hands washed before giving bottle or breast feeding	103	53%	26%	31%
Hands of child washed before drinking bottle	90	50%	31%	22%*
Bottle given by adult (against child holds bottle)	93	23%	33%	29%
Bottle used is clean	84	28%	20%	-
Bottle covered	91	31%	26%	21%
Personal hygiene around the child				
Hands washed before picking up child	153	43%	26%	32%
Domestic hygiene				
Table was cleaned within half hour after eating, cooking	138	37%	22%	33%
Utensils cleaned within half hour after being used	142	37%	29%	27%
Kitchen floor clean at onset of the observation	171	62%	35%	22%***
Living room floor clean at onset of the observation	170	45%	40%	23%**
Barrier against animals in the house	171	67%	17%	32%
Chase dogs out of the house when they enter	95	67%	38%	25%*
Chase pigs out of the house when they enter	54	44%	33%	27%
Chase chickens out of the house when they enter	116	33%	44%	29%
Garbage organized in little heaps or not present	171	45%	35%	25%**
Garbage (if present) >2 varas[b] from house	115	39%	31%	19%*
Water hygiene				
>2 water vessels in the house	170	35%	35%	24%
>25 gallon water stored in the different vessels	170	36%	19%	31%
All water vessels for drinking water covered	162	38%	29%	30%
Safe faeces disposal				
No animal faeces on the patio	171	42%	18%	33%
No faeces <5 varas from house	157	37%	25%	29%
Child uses a diaper or underclothes	170	36%	27%	16%**
Child defaecated and bottom was cleaned	22	31%	20%	0%
Faeces removed from where deposited	22	31%	20%	0%

[a] Number of times 'good' practice was observed.

[b] 1 vara = 0.8539 m.

Differences in proportions tested for trend (different levels of performing 'good' practices: twice, once, not at all) * $P = 0.05$–0.1; ** $P < 0.05$; *** $P < 0.0001$

children in families where the 'good' practice was performed on both visits had lower rates of diarrhoea than those where it was observed on just one visit, and these had lower rates than children in families where the 'good' practice was not realized on either visit. Thus a clear trend is seen of decreasing number of 'diarrhoea free' families with increasing poor hygiene.

Table 4 gives the proportions of 'good' behaviour on both occasions compared to two levels of education: 'low' when schooling is ≤3 years of primary school (54%) and 'good' when >3 years (46%). Of the 46 'good' practices studied, 32 were more often performed by mothers with 'good' schooling than by those with 'low' schooling, 13 less and for one the proportions were the same. Mothers with 'good' education covered their food, baby's bottle and water vessels and washed their hands before giving bottle or breastfeeding significantly more often than those with lower schooling.

When analysing the association between education and the incidence of diarrhoea we saw a borderline statistically significant relation: of the 12 mothers with >6 years of schooling 58% did not present diarrhoea during the entire study, meanwhile only 29% of those with ≤6 years of education stayed 'diarrhoea-free' ($P = 0.06$). Two socioeconomic indicators turned out to be important in this setting: type of floor and the presence of a radio. Of families with a 'good' floor plus a radio 48% stayed 'diarrhoea free'; of families with a 'good' floor or a radio 35%; and of those with an earthen floor and no radio only 16% (P for trend < 0.001). Education was strongly related to these socioeconomic indicators: of families with a 'good' floor plus a radio 68% had >3 years of schooling; of families with a 'good' floor or a radio 40%; and of those with an earthen floor and no radio 35% (P for trend < 0.01).

In order to have an idea in how far economic position influences the effect of education on hygiene practices, we analysed those behaviours that were statistically significant related to diarrhoea. All 'good' hygiene practices were most frequent in families where the mother had >3 years of schooling and where a radio was also present (Table 5).

Table 4 The proportion in which 'good' practice was observed on both visits according to level of schooling

'Good' hygiene practices	Families observed 2×	Level of schooling		
		All +/+	'Good' +/+	'Low' +/+
Food hygiene				
Hands washed before preparing food	113	67%	69%	65%
Hands washed when contaminated during cooking	87	25%	26%	25%
Fruit washed before eating	41	12%	10%	14%
All food in covered pans or no food left	171	31%	42%	23%***
Utensils covered	171	6%	7%	5%
Hands of mother washed before eating	50	14%	17%	11%
Hands of child washed before eating a meal	47	4%	4%	4%
Hands of child washed before eating a snack	53	6%	4%	8%
Child is assisted when eating	39	49%	52%	44%
Baby's bottle hygiene				
Hands washed before preparing baby's bottle	85	42%	51%	35%
Hands washed before giving bottle or breast feeding	103	15%	24%	7%**
Hands of child washed before drinking bottle	90	9%	12%	6%
Bottle given by adult (against child holds bottle)	93	32%	31%	33%
Bottle used is clean	84	94%	100%	89%*
Bottle covered	91	54%	66%	43%**
Personal hygiene around the child				
Hands washed before picking up child	153	4%	3%	6%
Child taken care by own mother not by caretaker	170	76%	78%	73%
Clean appropriate place for child to stay	163	22%	24%	20%
Mother/caretaker attends the child all the time	164	31%	30%	31%
Domestic hygiene				
Table was cleaned within half hour after eating, cooking	138	43%	46%	41%
Utensils cleaned within half hour after being used	142	27%	34%	21%*
Kitchen floor clean at onset of the observation	171	17%	22%	13%
Living room floor clean at onset of the observation	170	17%	22%	14%
Barrier against animals in the house	171	2%	1%	2%
Chase dogs out of the house when they enter	95	3%	6%	2%
Chase pigs out of the house when they enter	54	17%	13%	19%
Chase chickens out of the house when they enter	116	5%	2%	7%
Garbage organized in little heaps or not present	171	18%	19%	17%
Garbage (if present) >2 varas[a] from house	115	38%	41%	36%

Table 4 Continued

'Good' hygiene practices	Families observed 2×	Level of schooling		
		All +/+	'Good' +/+	'Low' +/+
Water hygiene				
Cover on well is in use	122	19%	18%	19%
Vessel to draw water is clean	86	87%	88%	86%
Vessel to store water is cleaned before filled with water	31	19%	23%	17%
>2 water vessels in the house	170	44%	49%	40%
>25 gallon water stored in the different vessels	170	42%	47%	38%
All water vessels for drinking water covered	162	43%	52%	35%**
Safe faeces disposal				
No dirty paper in and around latrine	108	84%	78%	92%**
No faeces on slab of latrine	108	93%	90%	96%
No human faeces in the house	171	96%	97%	95%
No human faeces on the patio	171	87%	84%	89%
No animal faeces in the house	171	68%	69%	67%
No animal faeces on the patio	171	87%	84%	89%
No faeces <5 varas from house	157	45%	51%	41%
Child uses a diaper or underclothes	170	70%	77%	65%*
Child defaecated and bottom was cleaned	22	73%	78%	69%
Faeces removed from where deposited	22	96%	100%	92%
Mother washes hands after visiting latrine	3	33%	50%	0%
Water and sanitation facilities				
Good water source (tap or protected well)	172	65%	77%	55%****
Distance water source <150 varas	168	82%	94%	74%****
Well has a cover on wellhead or cover is nearby	123	37%	52%	28%***
Existence of a latrine	172	63%	80%	50%****

[a] 1 vara = 0.8359 m.

Significance tests compare proportions performing the 'good' practice of the families with 'good' and with 'low' schooling * $P = 0.05$–0.1; ** $P < 0.05$, *** $P < 0.01$; **** $P < 0.005$.

Table 5 The proportion of families in which 'good' practice was observed on both visits according to education and presence of a radio

'Good' hygiene practices	Families observed 2×	No radio present		Radio present	
		'Low'[a]	'Good'[b]	'Low'[a]	'Good'[b]
Food hygiene					
Hands washed before preparing food	113	69%	65%	58%	72%
Baby's bottle hygiene					
Hands washed before preparing baby's bottle	85	28%	41%	43%	59%*
Domestic hygiene					
Kitchen floor clean at onset of the observation	171	14%	18%	13%	26%
Living room floor clean at onset of the observation	171	14%	18%	13%	26%
Garbage organized in little heaps or not present	171	16%	15%	20%	23%
Safe faeces disposal					
Child uses a diaper or underclothes	170	58%	69%	75%	85%**

[a] 'Low' schooling is ≤3 years of schooling.

[b] 'Good' schooling is >3 years of schooling.

Differences in proportions tested for trend (for different levels of education and socioeconomic position) * $P < 0.05$; ** $P < 0.005$

Discussion

We investigated the relationship between a large number of hygiene practices and the transmission of diarrhoea. This knowledge is necessary to develop successful hygiene education with appropriate messages. We also validated the technique of direct observation of hygiene behaviour. This information is needed to be able to evaluate the impact of hygiene campaigns on this behaviour.

Tables 2 and 3 give an impression of the effect of each hygiene practice separately. For some of the practices the effective sample size was very small and results should be interpreted with caution. Also, the large number of statistical tests performed means that one can expect several significant results to occur through chance alone. Almost all hygiene practices studied such as hand washing, food and water hygiene, cleaning food preparation area, general cleanliness and safe faeces disposal showed a clear relationship with diarrhoea. The families without diarrhoea were the ones who practiced 'good' behaviours more frequently and more consistently. Presumably because of the small sample sizes, only the more pronounced hygiene behaviours were statistically significant on their own. If one looks however at the overall picture, it is striking how consistent the trend is of increasing diarrhoea incidence with poorer hygiene behaviour.

We also found a trend that the proportion of 'diarrhoea-free' families increases with the number of times a 'good' practice was observed (Table 3). This must be considered as a strong indicator of the importance of that specific hygiene practice in the transmission of diarrhoea. It was statistically significant for different types of hand washing, several practices within the category of domestic cleanliness and the use of a diaper or underclothes by the child. These practices might therefore be considered as targets for modification through health education campaigns. For each of these, earlier studies[3–30,45,53] have also shown a relationship with diarrhoea.

The facilities for water and sanitation have, of course, an excellent Kappa score; the few differences observed were caused by mothers who moved houses between the two observations. There was no less diarrhoea in families with piped-water or a protected hand-dug well than in those using untreated river water, so water quality does not seem to be a major risk factor in this setting. Distance to the water source and amount of water stored in the house (proxies for water consumption) seemed to have a weak association, as we had already found in the earlier study.[31]

As one can observe in Table 2, the existence of a latrine has a beneficial effect, but this has been noticed in many other studies. Mothers' behaviour with regard to disposal of children's stools is at least as important.[8,17,45] In rural Nicaragua children aged <5 years only infrequently use a latrine because they are afraid of the 'black hole' while mothers regard their faeces as benign. Consequently, cleaning occurs more for cosmetic/aesthetic reasons than because of mothers' knowledge about transmission routes. This is also true for hand washing. As we discovered in the earlier study, knowledge about the importance of washing hands amongst the general population is quite prevalent, but limited to the hands of the mother when preparing food or baby's bottle; practices which also had a good Kappa score. Washing the child's hands before eating and the mother's before picking up the child are almost non-existent. This normative concept of mothers' behaviour performing the 'good' practice because it is socially acceptable behaviour, rather than effective in the prevention of diarrhoea has also been described elsewhere[28,47,48] and fits well with Fishbein and Ajzen's Theory of Reasoned Action.[49]

A complicated relation has been described between socio-economic status, education, cultural factors and hygiene practices. Recent research has suggested that, in the US, affluence and education in the last decade of the nineteenth century made little difference to child mortality, until scientific knowledge showed households how to reduce dangers to their health.[1] Since individuals with more education acquire and use new information more quickly, this emphasis on knowledge helps to explain the large differences in child mortality by mothers' education observed in developing countries today.[1,35] Most studies on hygiene show that practices improve as education (and affluence) increases, although in some studies only knowledge, and not practices, increased.[28] Several studies[28,50–54] found that the presence of certain material resources such as a latrine, water and soap should be considered as preconditions for a change in hygiene behaviour through health education. Without these preconditions, although knowledge exists, the 'good' practice simply cannot be performed consistently; meanwhile social and cultural factors may have a reinforcing or restraining influence.

In our study no pronounced differences in hygiene behaviour were found for education, probably because this rural population is quite homogeneous for schooling; only 12 mothers had more than primary school education. Nevertheless differences were seen and in the expected direction—more schooling producing better hygiene behaviour, this being slightly stronger in the presence of a radio.

Several transmission routes of diarrhoea usually coexist.[55] Our results suggest that some routes, such as hand washing play a more important role than others. Of course the performance of one 'good' hygiene practice will have a strong correlation with the realization of other 'good' practices and although the practice itself may only be related weakly to diarrhoea transmission, it could be indicative for other behaviour which plays a more important role in the transmission.

What would be a good indicator for hygiene behaviour in this setting? Indicators should at least be representative for general hygiene behaviour; easy to observe (no high education of field worker necessary); not costing much time (easy to observe during a certain time period); unambiguous (limited interobserver differences); almost all mothers can be observed for this particular practice (thus producing little missing data); not uniformly performed (e.g. >10–20% or <80–90% realizes the 'good' practice); accessible for the field worker (not necessary to enter bedrooms, etc). From the results of Tables 2 and 3 one can deduce that indeed hand washing has a relation with the transmission of diarrhoeal diseases, but only one of all types of hand washing had an effective sample size of more than 150 mothers and that one (before picking up the child) was performed by less than 10% of families, leaving us with none of the different types of hand washing being an appropriate indicator for general hygiene behaviour.

In our case the cleanliness of the floor of kitchen and living room, the disposal of rubbish and whether the child uses a diaper or underwear seem to be good indicators for the measuring of hygiene behaviour. These practices fulfill almost all requirements: they have a clear effect on diarrhoea transmission; are easy to observe; do not cost much time; all mothers can be observed on this particular practice; >15% and <80% of mothers perform the 'good' behaviour and they are accessible for the field worker. Although cleanliness of the kitchen and living room floor are not completely unambiguous, training and especially frequent supervision of the field workers can limit the

interobserver differences. Whether this finding can be generalized would require another study, preferably on another continent, although results of all hygiene studies together on three different continents[3–30,45–48,50–53,55] have given remarkably similar results. (e.g. domestic cleanliness [kitchen, living room, yard] was often found to have a relationship with diarrhoea incidence[5,8,11,12,17,18,45]).

It was not feasible to combine hygiene practices in possible models and composite hygiene scores since almost none of the hygiene practices could be observed for all mothers during both observations. Excluding all missing data would leave us with a very small sample size and possibly a high selection.

The results of the Kappa score in our study present a low repeatability of observations of hygiene practices, less than half has a good repeatability and none an excellent score. This high variability at the individual level has been found in other studies.[28,29] Although individual practices are variable, the study in Burkina Faso[29] which observed 10 families on six separate occasions concluded that analysis of these six observations revealed a pattern of repeatability consistent with that suggested by a comparison of two observations. In Table 3 one can observe that apparently two observations were sufficient to group mothers in such a way that a trend in diarrhoeal incidence related to the level of hygiene could be uncovered. This trend would not have been detected if we had analysed both observations independently. As expected, the frequency with which the community as a whole performed the 'good' practice was about the same during the second observation as during the first.

Conclusions

This was the first investigation to study simultaneously a high number of hygiene practices hypothesized to relate to the transmission of diarrhoeal diseases. A consistent relationship between almost all hygiene practices and diarrhoeal disease incidence was detected, even if this was statistically significant in relatively few cases. More schooling produced better hygiene behaviour, this being slightly stronger in the presence of a radio.

Relatively few practices were found to serve as an indicator for general hygiene behaviour related to the transmission of diarrhoea. These were cleanliness of the kitchen and living room floor, disposal of rubbish and whether the child uses a diaper or underclothes.

The high variability of hygiene behaviour at the individual level requires repeated observations (at least two)—before and after the hygiene education in the event one wants to measure the impact of the campaign on the individual. The stable occurrence of practices in the community as a whole means that one observation before and one after the health education campaign should be sufficient to monitor its effect on the overall behaviour.

Acknowledgements

The authors would like to thank The Leverhulme Trust, of Great Britain, which contributed to financing the investigation. We are grateful to Carmen Gonzalez, Joost Hoppenbrouwer, Annemarie Sweep, Mayra Mejia, Gloria Garcia and Irza Picado for their participation in the field work. Our appreciation goes also to Prof. PG Knipschild for reviewing this paper.

References

[1] World Bank. *World Development Report 1993, Investing in Health*. Washington DC: World Bank, 1993.

[2] Feachem RG. Preventing diarrhoea: what are the policy options? *Health Pol Plann* 1986;**1**:109–17.

[3] Bertrand WE, Walmus BF. Maternal knowledge, attitudes and practice as predictors of diarrhoeal disease in young children. *Int J Epidemiol* 1983;**12**:205–10.

[4] Clemens JD, Stanton BF. An educational intervention for altering water-sanitation behaviors to reduce childhood diarrhea in urban Bangladesh. I. Application of the case-control method for development of an intervention. *Am J Epidemiol* 1987;**125**:284–301.

[5] Huttly SRA, Blum D, Kirkwood BR, Emeh RN, Feachem RG. The epidemiology of acute diarrhoea in a rural community in Imo State, Nigeria. *Trans R Soc Trop Med Hyg* 1987;**81**:865–70.

[6] Black RE, Lopez de Romaña G, Brown KH, Bravo N, Bazalar OG, Kanashiro HC. Incidence and etiology of infantile diarrhea and major routes of transmission in Husker, Peru. *Am J Epidemiol* 1989;**129**: 785–99.

[7] Alam N, Wojtyniak B, Henry FJ, Rahaman MM. Mothers' personal and domestic hygiene and diarrhoea incidence in young children in rural Bangladesh. *Int J Epidemiol* 1989;**18**:242–47.

[8] Han AM, Moe K. Household faecal contamination and diarrhoea risk. *J Trop Med Hyg* 1990;**93**:333–36.

[9] Henry FJ, Rahim Z. Transmission of diarrhoea in two crowded areas with different sanitary facilities in Dhaka, Bangladesh. *J Trop Med Hyg* 1990;**93**:121–26.

[10] Konde-Luie JK, Elasu S, Musonge DL. Knowledge, attitudes, and practices and their policy implications in childhood diarrhoea in Uganda. *J Dir Dis Res* 1992;**1**:25–30.

[11] Baltazar JC, Tiglao TV, Tempongko SB. Hygiene behaviour and hospitalized severe childhood diarrhoea: a case-control study. *Bull World Health Organ* 1993;**71**:323–28.

[12] Dikassa L, Mock N, Magnani R *et al.* Maternal behavioural risk factors for severe childhood diarrhoeal disease in Kinshasa, Zaire. *Int J Epidemiol* 1993;**22**:327–33.

[13] Motarjemi Y, Kaferstein F, Moy G, Quevedo F. Contaminated weaning food: a major risk factor for diarrhoea and associated malnutrition. *Bull World Health Organ* 1993;**71**:79–92.

[14] Feachem RG. Interventions for the control of diarrhoeal diseases among young children: promotion of personal and domestic hygiene. *Bull World Health Organ* 1984;**62**:467–76.

[15] Stanton BF, Clemens JD. An educational intervention for altering water-sanitation behaviors to reduce childhood diarrhea in urban Bangladesh. II. A randomized trial to assess the impact of the intervention on hygienic behaviors and rates of diarrhea. *Am J Epidemiol* 1987;**125**:284–301.

[16] Pinfold JV. Faecal contamination of water and fingertip-rinses as a method for evaluating the effect of low-cost water supply and sanitation activities on faeco-oral disease transmission. II. A hygiene intervention study in rural north-east Thailand. *Epidemiol Infect* 1990;**105**: 377–89.

[17] Ahmed NU, Zeitlin MF, Beiser AS, Super CM, Gershoff SN. A longitudinal study of the impact of behavioural change intervention on cleanliness, diarrhoeal morbidity and growth of children in rural Bangladesh. *Soc Sci Med* 1993;**37**:159–71.

[18] Haggerty PA, Muladi K, Kirkwood BR, Ashworth A, Manunebo M. Community-based hygiene education to reduce diarrhoeal disease in rural Zaire: impact of the intervention on diarrhoeal morbidity. *Int J Epidemiol* 1994;**23**:1050–59.

[19] van Wijk C, Murre T. *Motivating Better Hygiene Behaviour: Importance for Public Health Mechanisms of Change*. The Hague: IRC International Water and Sanitation Centre, 1994.

[20] Black RE, Dykes AC, Anderson KE *et al* Handwashing to prevent diarrhea in day-care centres. *Am J Epidemiol* 1981;**113**:445–51.

[21] Khan MU. Interruption of shigellosis by hand washing. *Trans R Soc Trop Med Hyg* 1982;**76**:164–68.

[22] Han AM, Oo KN, Aye T, Hlaing T. Personal toilet after defaecation and the degree of hand contamination according to different methods used. *J Trop Med Hyg* 1986;**39**:237–41.

[23] Sircar BK, Sengupta PG, Mondal SK *et al*. Effect of hand washing on the incidence of diarrhoea in a Calcutta slum. *J Dir Dis Res* 1987, **5**:112–14.

[24] Han AM, Hlaing T. Prevention of diarrhoea and dysentery by hand washing. *Trans R Soc Trop Med Hyg* 1989;**83**:128–31.

[25] Wilson JM, Chandler GN, Muslihatun, Jamiluddin Hand-washing reduces diarrhoea episodes: a study in Lombok, Indonesia. *Trans R Soc Trop Med Hyg* 1991;**85**:819–21.

[26] Laborde DJ, Weigle KA, Weber DJ, Kotch JB. Effect of fecal contamination on diarrheal illness rates in day-care centers. *Am J Epidemiol* 1993;**138**:243–55.

[27] Kalthenthaler EC, Pinfold JV. Microbiological methods for assessing hand washing practices in hygiene behaviour studies. *J Trop Med Hyg* 1995;**98**:101–06

[28] Boot MT, Cairncross S (eds). *Actions Speak, the Study of Hygiene Behaviour in Water and Sanitation Projects*. The Hague: IRC International Water and Sanitation Centre, London School of Hygiene and Tropical Medicine, 1993.

[29] Curtis V, Cousens S, Mertens T, Traore E, Kanki B, Diallo I. Structured observations of hygiene behaviours in Burkina Faso: validity, variability, and utility. *Bull World Health Organ* 1993;**71**:23–32.

[30] Stanton BF, Clemens JD, Aziz KMA, Rahman M. Twenty-four-hour recall, knowledge-attitude-practice questionnaires, and direct observations of sanitary practices. a comparative study. *Bull World Health Organ* 1987;**65**:217–22

[31] Gorter AC, Sandiford P, Davey Smith G, Pauw JP. Water supply, sanitation and diarrhoeal disease in Nicaragua: results from a case-control study. *Int J Epidemiol* 1991;**20**:527–33.

[32] Sandiford P, Gorter AC, Davey Smith G, Pauw JPC. Determinants of drinking water quality in rural Nicaragua. *Epidemiol Infect* 1989;**102**: 429–38.

[33] Sandiford P, Gorter AC, Orozco JG, Pauw JP. Determinants of domestic water use in rural Nicaragua. *J Trop Med Hyg* 1990;**93**:383–89.

[34] Gorter AC, Sánchez G, Pauw J, Pérez RM, Sandiford P, Davey Smith G. Diarrea infantil en la Nicaragua rural: creencias y prácticas de salud tradicionales. *Bol Oficina Sanit Panam* 1995;**119**:377–90.

[35] Sandiford P, Morales P, Gorter A, Coyle E, Davey Smith G. Why do child mortality rates fall? An analysis of the Nicaraguan experience. *Am J Public Health* 1991;**81**:30–37.

[36] Sandiford P, Alberts H, Orozco JG, Gorter A. The Nicaraguan rope pump. *Waterlines* 1993;**11**:27–30.

[37] Alberts H, Meza R, Solís D, Rodríguez M. How the rope pump won in Nicaragua. *Waterlines* 1993;**12**:3–5.

[38] Gorter AC, Alberts JH, Gago JF, Sandiford P, A randomized trial of the impact of rope-pumps on water quality. *J Trop Med Hyg* 1995;**98**: 247–55.

[39] IRC International Water and Sanitation Centre. *Evaluation of the Nicaraguan Rope Pump*. The Hague: IRC, 1995.

[40] Maclure M, Willett WC. Misinterpretation and misuse of the kappa statistic. *Am J Epidemiol* 1987;**126**:161–69.

[41] Fleiss JL. *Statistical Methods for Rates and Proportions, 2nd edn* New York. John Wiley & Sons, 1981.

[42] Feinstein AR, Cicchetti DV. High agreement but low Kappa: I. The problems of two paradoxes. *J Clin Epidemiol* 1990;**43**:543–49

[43] Cicchetti DV, Feinstein AR. High agreement but low Kappa: I. Resolving the paradoxes. *J Clin Epidemiol* 1990;**43**:551–58.

[44] Sandiford P, Pauw JP, Gorter AC, Davey Smith G, Morales P. *Can Children with High Rates of Diarrhoea be Identified from Records of Attendance at Health Services?* International Epidemiological Association (IEA), European Regional Meeting 1991, Basel 1991;10.

[45] Bukenya GB. Nwokolo N. Compound hygiene, presence of standpipe and the risk of childhood diarrhoea in an urban settlement of Papua New Guinea. *Int J Epidemiol* 1991;**2**:534–39.

[46] Mahmud MA, Chappell C, Hossain MM, Habib M, Dupont HL. Risk factors for development of first symptomatic Giardia infection among infants of a birth cohort in rural Egypt. *Am J Trop Med Hyg* 1995; **53**:84–88.

[47] Zeitlin S, Islam F. The use of soap and water in two Bangladeshi communities: implications for the transmission of diarrhoea. *Rev Infect Dis* 1991;**13**:S259–64.

[48] *Diarrhoea and Hygiene: What People Know, Believe and Do in a West African Town*. Report from the Project Saniya team in Bobo-Dioulasso, Burkina Faso. London: Maternal and Child Epidemiology Unit, London School of Hygiene and Tropical Medicine, 1994.

[49] Fishbein M, Ajzen I. *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research*. Reading, Massachusetts Addison-Wesley, 1975.

[50] Gilman RH, Marquis GS, Ventura G, Campos M, Spira W, Diaz F. Water cost and availability: key determinants of family hygiene in a Peruvian Shantytown. *Am J Public Health* 1993;**83**:1554–58.

[51] Koopman JS. Diarrhea and school toilet hygiene in Cali, Colombia. *Am J Epidemiol* 1978;**107**:412–20.

[52] Morgan J. Loughborough University of Technology, Water, Engineering and Development Centre, Urban Hygiene Behaviour in Ethiopia, abstract in *Highlights* 1996;**7**:25–26.

[53] Dargent-Molina P, James SA, Strogatz DS, Savitz DA. Association between maternal education and infant diarrhea in different household and community environments of Cebu, Philippines, *Soc Sci Med* 1994;**38**:343–350.

[54] Pinerman R. 'Parental incompetence' and 'selective neglect': Blaming the victim in child survival. *Soc Sci Med* 1995;**40**:5–13.

[55] Blaser MJ, Smith PD, Ravdin JI, Greenberg HB, Guerrant RL (eds). *Infections of the Gastrointestinal Tract*. New York: Raven Press, 1995.