Epidemiol. Infect. (1990), **105**, 377–389
Printed in Great Britain

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

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(*Accepted 25 May 1990*)

SUMMARY

An intervention study was developed from risk-factors associated with faeco-oral transmission, based on the levels of contamination in stored water and fingertip-rinses from households in rural north-east Thailand. This was designed to improve: (a) handwashing, particularly before cooking/eating and after defecation; (b) washing dishes immediately after use. Verbal messages were administered to two intervention groups, one also received a plastic container with a tap to assist these activities. Indicators of compliance were the direct observation of soaking dishes and the presence of faecal streptococci from fingertip-rinses; the main outcome indicator was *Escherichia coli* contamination of stored water. The intervention group receiving the container was significantly better than the control for indicators of compliance ($P < 0{\cdot}001$ and $P < 0{\cdot}01$) and its stored water was significantly less contaminated ($P < 0{\cdot}001$). There was no significant improvement to the other intervention group, although some features of the intervention had clearly been made available to the control group. Humidity was significantly correlated with fingertip contamination ($r = 0{\cdot}2$; $P < 0{\cdot}001$) and with the peak of reported diarrhoea around the beginning of the rainy season.

INTRODUCTION

The diarrhoeal diseases are a major cause of morbidity and infant mortality in developing countries [1]. Low-cost water supply and sanitation systems are designed as part of a strategy to prevent faeco-oral disease transmission. It is usually easier to identify 'hardware' components such as wells and latrines than 'software' components such as the adoption of these facilities and changes in users' behaviour. Personal and domestic hygiene is perhaps the most neglected aspect of all 'software' components. This is understandable as it is difficult both to change people's behaviour and to measure any resulting effects of such changes. However, if the altered behaviour patterns can be shown to reduce disease then highly cost-effective interventions may be provided which can complement 'hardware' initiatives such as improved water supply and excreta disposal systems. Clemens & Stanton [2] reasoned that such interventions would most likely succeed if they consisted of relatively few messages whose prescribed behaviours already occurred in the community. In their study of the incidence rates of childhood diarrhoea was used to select relevant behaviours.

This paper is concerned with faeco-oral transmission of bacteria within domestic water systems in rural Thailand and uses faecal indicator bacteria to assess the outcome of the intervention. The intervention has been developed from a case study in a neighbouring village (Ban Sahart) as described in a companion paper [3].

MATERIALS AND METHOD

Study outline

Baseline data for the selected village (Ban Daengnoi) were obtained from another study conducted by the Epidemiological Division, Ministry of Public Health. Only those households with children under the age of 6 years were considered for this study. Sixty households were then randomly selected by stratified sampling. If no-one was found present at the selected household, the nearest adjacent household fitting the above requirements was selected. Each household was visited on four separate occasions during the rainy season, twice before the intervention took place and twice after. All water containers were coded on a plan of the household, and all persons present were coded accordingly. Information on socio-economic status, water users' practices and water source was obtained by questionnaire and observation. On each visit, water samples and fingertip-rinses were examined for certain faecal bacteria.

The 60 households were first ranked according to the bacteriological contamination of both fingertip-rinses and stored water from the first visit. They were then grouped into 20 adjacent triplets, so that households in each triplet had similar levels of contamination. Within each triplet, households were randomly assigned to the following groups, 20 in each: 'Control'; 'Education only'; 'Education & tap'. On the second visit, the intervention (described in the next section) was administered verbally to the maternal heads of households in the two intervention groups. Concept questions were used in order to make sure the messages had been understood and this procedure was repeated on each subsequent visit. In addition to these messages, householders from the group 'Education & tap' were loaned a translucent plastic container with a tap. No verbal messages were given to householders in the control group.

Formulation of the intervention

Variation of hygienic behaviours between households was thought to be particularly important when selecting an appropriate intervention. This follows the premise that if an identified behaviour is already practised in at least some households, then problems of acceptability should be minimized. Furthermore, if messages are simple and few in number, and little extra effort or expenditure is required by adopting the behaviour, then the chances of success in promoting behavioural change must improve. The identification of risk factors in relation to the outcome indicator, in this case faecal bacteria, is the usual way of selecting the most effective intervention. However, risk factors are not necessarily causal and may be correlated with causal factors not identified by the measuring tools.

The case study in Ban Sahart provided both qualitative and quantitative evidence for selection purposes [3]. There was a significant association between *E. coli* contamination of fingertip-rinses and the individual's activity prior to testing with child care and with food and water-related activities corresponding to much higher levels than other activities ($P < 0{\cdot}0001$). Water was stored in separate containers and used for different activities. Faecal contamination of this stored water greatly exceeded that of water sources and was significantly related to water use ($P < 0{\cdot}0001$). In particular water used for toilet, washing dishes and cooking-related activities (wash dishes) was much more contaminated than that used for drinking (D/W) and cooking (cook). Dirty utensils used for cooking and eating were usually left to soak and bacterial growth occurred in this grossly contaminated soak-water. Cross-contamination via water handling was found to be the main mechanism of stored water pollution.

Multiplication of faecal bacteria has been shown to occur on stored cooked food, particularly at high ambient temperatures [4] and this has important implications considering the high dose of bacterial pathogens generally needed to cause infections. However, it was not thought that householders would readily change the practice of storing cooked food as this would require greater effort in cooking time, and an increased food wastage. Instead, the emphasis was placed on reducing the risk of contamination to the food and the subsequent risk of cross-contamination around the kitchen and to other areas. The observed methods of handwashing may directly contaminate water, or vice versa, when hands are dipped into water directly, or a dipper without a handle is used. Handwashing was not frequently practised during the study, although it was more likely to occur when hands were visibly dirty (e.g. after eating) rather than due to more hygienic considerations. Bars of soap were observed in 36/60 households but their presence did not necessarily mean hands were always washed with soap and water.

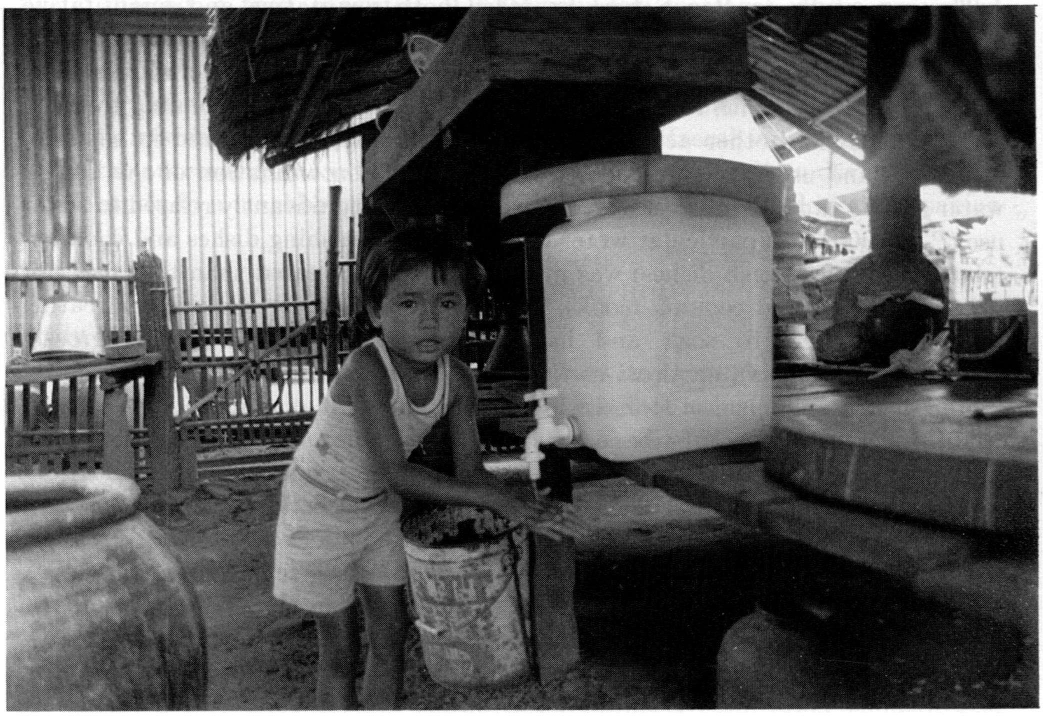
The two main activities selected for the intervention were as follows:

(i) The practice of soaking dishes or utensils directly increased the number of potentially dangerous bacteria. Householders were therefore asked to wash dishes immediately after use. In addition, householders were asked to rinse the dishes and then put them out to dry, thereby helping the process of bacterial desiccation.

(ii) The promotion of handwashing before cooking and eating, and after going to the latrine was designed to reduce the risk of transferring bacteria onto food and utensils. The observed method of handwashing was not thought particularly effective, so a 20-litre translucent plastic container with a tap was developed to assist in this practice (Photograph). The containers served two purposes. They helped to reinforce and facilitate the above messages as they were used to demonstrate handwashing and rinsing dishes. Moreover, observations of the container gave an indirect indication of use by the water level and evidence of waste-water directly below the tap.

Indicators of compliance

Indicators of compliance to the intervention were the presence or absence of dishes and cooking utensils left to soak, and the contamination of fingertip-rinses by faecal streptococci. Observation of soaking dishes were recorded on each visit to the households and this gave a direct indication of this message's adoption.



Photograph. Young girl demonstrates handwashing using the container with tap.

Observations of changes in handwashing practices were not undertaken due largely to financial and time restraints. However, faecal streptococci from fingertip-rinses were retrospectively selected as an indication of handwashing. This organism was preferred to *E. coli* for the following reasons. The survival of faecal streptococci on the skin was much longer than *E. coli* and hence it was more frequently present in fingertip-rinses. Unlike *E. coli*, faecal streptococci did not show any significant relationship to individuals' activities immediately before testing. There was a fairly even distribution of faecal streptococci from fingertip-rinses between each group before the intervention took place. In addition to these indicators of compliance, observation and questions regarding the containers were administered to the 'Education and tap' group.

Bacteriology

Water samples were measured into a sampling jar (100 ml) and media used for fingertip-rinses contained 1/4 strength Ringer's solution supplemented with 0.1% (v/v) Tween 20, modified with Penicillin 'B' (50 mg/l) [3]. Sterile containers contained enough solution to cover the fingertips when a hand was inserted and the subject was told to rub the thumb back and forth across the fingertips for approximately 5 seconds. Membrane filtration equipment was used on site and all non-sterile equipment was sterilized with acetone before each use. All samples were divided equally between two membrane filters (0·45 μm pore size), one was placed on pads saturated with Membrane Lauryl Sulphate Broth (Oxoid MM615) for the enumeration of presumptive faecal coliforms, and the other on KF

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streptococcus agar (Oxoid CM701) for the enumeration of faecal streptococci. At the end of the day samples were incubated at 44.5 °C, faecal coliforms for 24 h and faecal streptococci for 48 h. A selection of individual colonies from all plates which contained presumptive faecal coliforms were inoculated into test tubes containing tryptone water and lactose peptone water. After incubation (24 h) isolates were identified as *E. coli* by their ability to produce indole from tryptophan and gas from lactose at 44 °C [5].

Analysis of data

Initially households were ranked and matched in an attempt to follow the methods described by Stanton & and Clemens [6]. However, it became apparent during the analysis of the results that the distribution of *E. coli* from fingertip-rinses was markedly different from that in stored water. This could adversely effect the results as the number of fingertip samples taken depended on the household members present at each visit. For this reason contamination of stored water and fingertip-rinses are analysed separately. However the original matched pair analysis is included at the end of the results section using Student *t* test. The distributions of bacteria are non-normal and the more conservative non-parametric statistics are employed in the main analysis. The Mann–Whitney *U* test was used to test whether two samples were from a similar population. All statistical comparisons of categorical variables were made using the chi-squared test or Fisher's exact test where applicable.

RESULTS

Baseline data

There was a total of 422 households in the village (Ban Daengnoi) and a population of 2110, giving an average of 5 persons per household. Twenty-nine percent of households had an infant aged 1–5 years and 9% had a baby less than 1-year-old. Farming was the main occupation and 90% of households claimed that it was their main source of income. The level of education of the household head was very uniform with 90% completing only 4 years schooling. Rainjars or raintanks were owned by 67% of the households and 95% had access to a toilet. In comparison to Ban Sahart the households selected for this study were slightly worse off in terms of the material possessions listed but there are no large differences between the three groups (Table 1). The answers to questions on causes and prevention of diarrhoeal disease showed a similar pattern of response as Ban Sahart [3].

Water sources

Although the water sources were similar to those at Ban Sahart [3], this study took place during the rains which greatly improved rainwater availability. Figure 1 shows water use by source and clearly demonstrates the preference of using shallow well and rainwater for drinking because of the preferred taste. Apart from rainwater, there was 1 pond, 1 shallow well, 4 public and 18 private tubewells used by the households in this study. Thirteen households owned a tubewell which

Table 1. *Socio-economic and demographic data of households in the study*

Socio-economic and demographic indicators	Control	Education only	Education & tap	Total
Demographic				
Number of households	20	20	20	60
Households with				
Baby(s) (< 1 yr)	5	5	8	18
Infants (1–5 years)	15	15	17	47
Mean number person/hh	5·4	5·4	6·7	5·8
Education: 1–4 years (median = 4)				
Maternal	18	20	20	58
Paternal	19	16	17	52
Type of house				
Traditional Thai	12	16	15	43
Improved Thai	8	4	5	17
Amount of land farmed per household (mean 'acres')	5·2	5	6·4	5·5
Ownership of material goods				
Electricity	19	20	20	59
Toilet	17	17	19	53
T.V.	11	13	10	34
Motor bike/car	7	6	4	17
Rotavator	0	1	2	3
Pumped water	0	1	1	2
Glass windows	1	2	0	3
Hygiene (observation)				
Dirty toilet	5	9	5	19
Dirty kitchen	8	10	9	27
Dirty utensils present	16	19	18	53

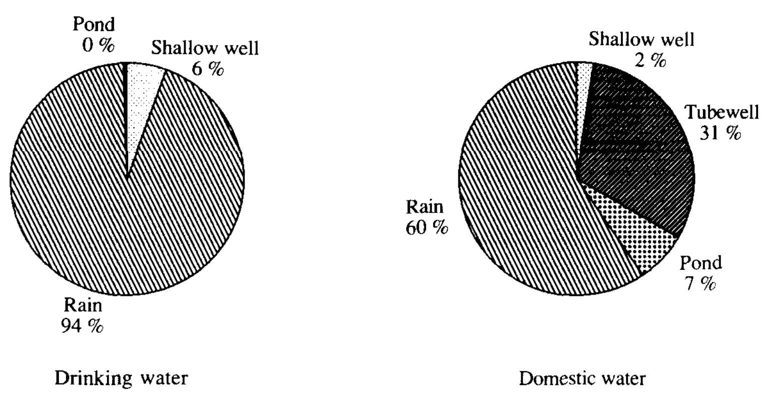

Fig. 1. Water sources by water use of households studied in Ban Daengnoi.

was situated in their compound, the others belonged to neighbours or relatives of the study group.

The results prior to intervention reveal that a total of over 82000 *E. coli* were isolated from stored water samples, only 19800 of which were the estimated contribution from the water sources. Most of the contamination occurred after water collection and contamination of stored water was primarily a function of water use. Consequently the contribution by water sources is ignored. Figure 2

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compares *E. coli* contamination of stored water by water use for Ban Sahart and Ban Daengnoi prior to intervention (rainjars with taps not included). With the exception of the category 'all domestic' (W/W), the similarities between the two villages are remarkable. Moreover, the case study revealed that the households with the least contamination were, coincidently, the main holders of this particular category.

Pre-intervention data

Table 2*a* shows the results from direct observation of the presence of soaking dishes and this was similar for each group before the intervention took place. Faecal streptococci from fingertip-rinses also showed an even distribution between the three groups prior to the intervention (Table 2*b*). Table 2*c* presents the *E. coli* contamination of stored water. The Mann–Whitney *U* test separately compares each intervention group with the control and a 'Z' value close to 0 indicates that two samples have similar distributions; the '*' sign is used to designate a significant difference between the samples. In addition, this analysis is repeated for each category of water use, but only included in the tables when the difference is significant. In Table 2*c* then, the overall distributions of each group are similar but the water use category 'D/W & cook' is significantly higher in 'education only' when compared to the control ($P < 0{\cdot}05$).

Post-intervention data

The number of households leaving dishes to soak declined in *all* groups (Table 3*a*). From three separate observations there was a sequential reduction to the control group while the other groups remained at similar levels. This gradual improvement to the control group was expected and may be attributed to the dissemination of the message through friends, neighbours and relatives. A study covering such a small area cannot control for this type of influence. Despite this 'contamination' of the control, there was still a stronger impact of the hygiene messages on the intervention groups. In particular, the education & tap was the best at adopting these messages which provides evidence to support methods of reinforcing verbal messages.

Table 3 shows that stored water from the 'education & tap' was significantly less contaminated than the control ($P < 0{\cdot}001$) and the indicators of compliance to the intervention significantly better ($P < 0{\cdot}001$ and $P < 0{\cdot}01$). The water use categories 'W/W', 'wash dishes' and 'toilet' were also significantly less contaminated than the control (Table 3*c*). The 'education only' was better than the control in both water quality and indicators of compliance but not significantly so. It was, however, significantly less contaminated than the control in the category 'W/W'. In comparison to the pre-intervention levels of water contamination (Table 2) the control had slightly higher and 'educational only' slightly lower levels while the 'education & tap' showed a dramatic overall reduction. The control showed an unexpected increase in water contamination on the first visit after the intervention, this may be due to seasonal effects which would tend to mask any improvements awarded to the intervention.

The analysis for *E. coli* contamination from fingertip-rinses is presented separately for reasons given earlier. The short survival time of *E. coli* on the skin

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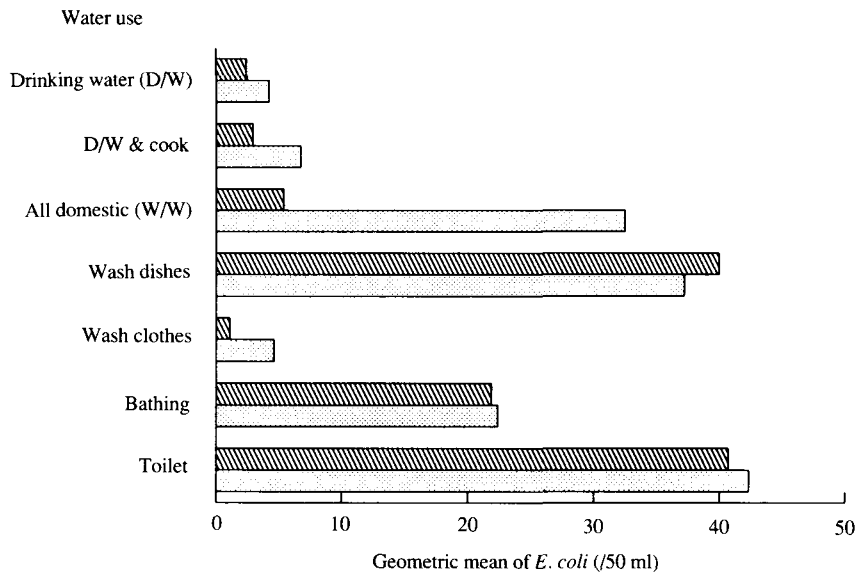

Fig. 2. Geometric mean of *E. coli* in samples of stored water (/50 ml) by water use in both villages. ▧, Ban Sahart; ▨, Ban Daengnoi.

Table 2. *Pre-intervention results*

(*a*) *Observation of the practice of soaking dishes*

Dishes observed soaking (%)	Control ($n = 20$)	Education only ($n = 20$)	Education & tap ($n = 20$)
Yes	16 (80%)	19 (95%)	18 (90%)

(*b*) *Indicator of handwashing practice* (*faecal streptococci in fingertip-rinses*)

Geometric & arithmetic ()	Control[a] ($n = 102$)	Education[b] only ($n = 103$)	Education &[c] tap ($n = 113$)
means:	16·7 (85)	14·2 (73)	19·1 (77)
Mann–Whitney Z values:		(a vs. b) −0·62	(a vs. c) 0·54

(*c*) *Geometric and arithmetic* () *means of* E. coli *in stored water* (*/50 ml*)

Water use	Control[a] ($n = 177$)	Education[b] ($n = 163$)	Education &[c] tap ($n = 211$)
Drinking water (D/W)	3·2 (17)	3·8 (53)	6·0 (51)
D/W & cook	3·8 (30)	11·9 (74)*	6·0 (75)
All domestic (W/W)	47·9 (334)	29·4 (107)	27·8 (191)
Wash dishes	42·5 (259)	55·9 (197)	24·7 (162)
Wash clothes	1·9 (8)	— (−)	3·1 (17)
Bathing	27·9 (143)	11·6 (113)	27·3 (193)
Toilet	49·3 (256)	44·6 (251)	36·0 (259)
All	14·0 (143)	17·6 (128)	14·8 (141)
Mann–Whitney Z values:		(a vs. b) −0·82	(a vs. c) −0·25

* $P < 0{\cdot}05$.

gives a greater proportion of negative samples than stored water. The pre-intervention levels of contamination were not similar for the three groups (Table 4*a*) and 'education only' was significantly less contamination than the control ($P < 0{\cdot}01$). This renders any further analysis highly dubious. However, fingertip

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Table 3. *Post-intervention results*

(*a*) *Observation of the practice of soaking dishes*

Dishes observed soaking (%)	Control[a] ($n = 60$)	Education[b] only ($n = 60$)	Education &[c] tap ($n = 60$)
Yes	35 (58%)	29 (48%)	14 (23%)
Chi-squared:		(a vs. b) 0·84	(a vs. c) 13·8***

(*b*) *Indicator of handwashing practice (faecal streptococci in fingertip-rinses)*

Geometric & arithmetic ()	Control[a] ($n = 102$)	Education[b] only ($n = 93$)	Education &[c] tap ($n = 105$)
means:	20·8 (122)	12·7 (51)	9·9 (52)
Mann–Whitney Z values:		(a vs. b) −1·52	(a vs. c) −2·7**

(*c*) *Geometric and arithmetic () means of* E. coli *in stored water (/50 ml)*

Water use	Control[a] ($n = 171$)	Education[b] only ($n = 160$)	Education &[c] tap ($n = 209$)
Drinking water (D/W)	3·8 (40)	3·4 (25)	1·3 (22)
D/W & cook	4·1 (24)	6·3 (48)	4·2 (45)
All domestic (W/W)	54·0 (286)	10·6 (94)*	10·1 (68)*
Wash dishes	49·4 (201)	16·7 (145)	5·6 (34)**
Wash clothes	18·3 (41)	20·0 (20)	9·4 (107)
Bathing	21·4 (221)	72·5 (228)	11·3 (113)
Toilet	120·1 (310)	118·5 (365)	21·2 (200)*
All	19·1 (159)	14·9 (137)	6·5 (82)
Mann–Whitney Z values:		(a vs. b) −0·82	(a vs. c) −3·9***

* $P < 0·05$; ** $P < 0·01$; *** $P < 0·001$.

Table 4. E. coli *in fingertip-rinses*

(*a*) *Pre-intervention*

Geometric & arithmetic ()	Control[a] ($n = 102$)	Education[b] only ($n = 103$)	Education &[c] tap ($n = 113$)
means:	2·2 (76)	1·2 (10)	2·1 (48)
Mann–Whitney Z values		(a vs. b) −2·9**	(a vs. c) −1·4

(*b*) *Post-intervention*

Geometric & arithmetic ()	Control[a] ($n = 102$)	Education[b] only ($n = 96$)	Education &[c] tap ($n = 105$)
means:	2·6 (56)	1·5 (15)	0·3 (2)
Mann–Whitney Z values		(a vs. b) −0·8	(a vs. c) −3·7***

** $P < 0·01$; *** $P < 0·001$.

contamination did follow a similar pattern to that of water contamination with the 'education & tap' less contaminated ($P < 0·001$) than the control after the intervention took place (Table 4*b*). The post-intervention levels of fingertip contamination for 'education & tap' was consistently less than its pre-intervention levels whereas the 'education only' and control remained at comparable levels of contamination throughout.

The households were originally matched by the geometric means of (*E. coli* ($\times 2$) + faecal streptococci + thermotolerant coliforms (/10)) of stored water and fingertip-rinses. The same formula is used to calculate the levels of contamination from the two visits after intervention (Table 5). The 20 matched triplets are ranked from 20 (low contamination) to 1 (high) and the ratio of the

Table 5. *Contamination levels in matched households (post-intervention)*

	Index of faecal contamination			Relative faecal contamination	
Rank*	Control (A)	Education only (B)	Education & tap (C)	Education only (B/A)	Education & tap (C/A)
20	61·28	4·4	40·37	0·07	0·66
19	19·56	49·47	12·59	2·53	0·64
18	149·78	62·47	37·58	0·42	0·25
17	41·25	37·02	32·38	0·90	0·78
16	35·54	61·74	30·03	1·74	0·84
15	22·18	26·37	15·20	1·19	0·68
14	185·71	8·8	109·02	0·05	0·59
13	32·87	47·13	17·25	1·43	0·52
12	83·93	44·08	18·96	0·53	0·23
11	38·46	57·78	15·77	1·5	0·41
10	120·51	32·0	24·51	0·27	0·20
9	30·39	58·58	22·86	1·93	0·75
8	52·08	55·20	72·53	1·06	1·39
7	51·59	67·88	22·89	1·32	0·44
6	237·8	86·48	66·71	0·36	0·28
5	28·90	39·71	74·06	1·37	2·56
4	38·61	17·64	135·66	0·46	3·51
3	113·01	76·12	76·97	0·67	0·68
2	87·65	129·55	81·78	1·48	0·93
1	167·84	260·74	39·03	1·55	0·23
Totals	1598·94	1223·16	946·15	0·76	0·59†

* Rank of households as matched by faecal contamination pre-intervention.
† $P < 0·05$ (Student *t*-test of intervention groups vs. control; $t = 2·57$).

intervention/control household contamination is calculated for both groups. A ratio of 1·0 indicates no difference between the intervention and the control households; ratios of < 1·0 signifies less and > 1·0 more contamination than the control. The interpretation of these results is in fact similar to that of Table 3 with 17/20 'education & tap' households less contaminated than the control but only 9/20 'education only' households had ratios < 1·0. The overall ratios for the 'education only' was 0·76 and the 'education & tap' gave 0·59 which was significantly less than the control ($P < 0·05$).

Although householders had previously been told the study was completed, a final visit was arranged in order to ascertain whether the intervention had been retained and the subsequent effect on water contamination. This took place 4 months later, when the rainy season had already finished and the cooler part of the dry season was encroaching. Despite a slight increase in the practice of soaking dishes by all groups, there was a dramatic reduction in the contamination of stored water and fingertip-rinses. The geometric means of *E. coli* in stored water (/50 ml) and fingertip-rinses were respectively; control 8·9 and 0·5 counts, 'education only' 10·1 and 0·3, 'education & tap' 5·2 and 0·4. This was in spite of a change to more contaminated water sources and an expected reduction in water quantity due to the greater effort expended in obtaining water. It was not thought that this reduction could be solely attributed to the intervention and the seasonal effects on water contamination are more likely to have a major influence. Faecal streptococci contamination of fingertip-rinses was also very low at this time which fits in well with this seasonal influence particularly as there is no comparative improvement in washing dishes.

DISCUSSION

Given the variation of faecal contamination within households between visits (Table 5) and small sample size, the reduced levels of contamination found in 'education & tap' after intervention is very encouraging. That this was obtained by altering just two principal practices suggests that the methodology employed has provided an optimal hygiene intervention. Furthermore at this level of water supply service, it would appear to be a more effective method of reducing water contamination within the household than improvements to water quality at source.

This study was not large enough to test different means of communication but the provision of a plastic container with tap did appear to reinforce the hygiene messages. During the rainy season all containers were said to be in use and all showed some evidence of use. Its separate effect on stored water and fingertip contamination cannot be analysed because of the difference in compliance by the intervention groups. However, such was the impact on the 'education & tap', that it is reasonable to suppose that the container itself was a contributing factor. Use of the tap was designed to change the practice of water activities without affecting water quantity, in particular handwashing which traditionally involved using a dipper or washing hands directly in the stored water. Water samples drawn from these taps were the least contaminated of all stored water (geometric mean = 0·8 *E. coli*/50 ml). As these plastic containers were well protected from water handling this supports the finding that cross-contamination within the domestic environment is the major cause of stored water contamination.

Information on the seasonality of the reported incidence of acute diarrhoeal disease in this region was collated as background information to this study [7]. There is a marked seasonal pattern of diarrhoea with peaks towards the end of the hot and beginning of the rainy season, cumulating in a dramatic reduction around the middle of the rains. This pattern fits in well with levels of cross-contamination found within the domestic environment. In order to quantify this, data on rainfall humidity and temperature were collected from the local weather station and compared with the results from both studies. In particular, a significant correlation was found between fingertip contamination and daily humidity for Ban Sahart (*E. coli*: $r = 0{\cdot}21$; $P < 0{\cdot}001$ and faecal streptococci: $r = 0{\cdot}19$; $P < 0{\cdot}001$) and Ban Daengnoi (*E. coli*: $r = 0{\cdot}21$; $P < 0{\cdot}001$ and faecal streptococci: $r = 0{\cdot}24$; $P < 0{\cdot}001$). A similar pattern emerged between reported diarrhoea and humidity around the beginning of the rainy season (Fig. 3).

An explanation for the seasonal pattern of diarrhoeal disease is presented as follows. First, conditions and practices within the household provide the necessary ingredients for the growth and transmission of *E. coli* and this bacterium has a loose association with at least some common agents of diarrhoea. If these conditions are constant, then humidity and temperature will contribute their effect by influencing the chances of bacterial survival and growth. High humidity

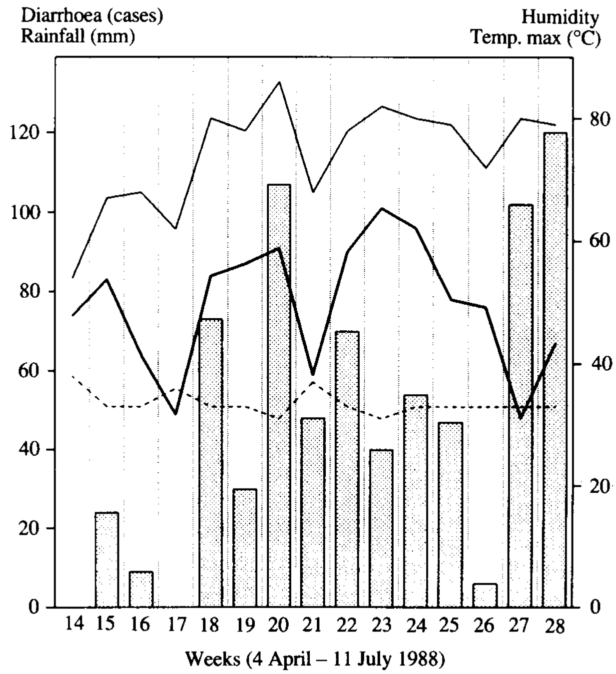

Fig. 3. Weekly reported diarrhoea in amphur Muang Khon Kaen with climatic conditions. —, Diarrhoea; ▩, rainfall; ----, temperature (maximum); —, humidity.

increases bacterial survival on the fingertips and, presumably, other articles such as food and food-related surfaces, leading to an increase in cross-contamination and, hence, a greater risk of ingesting pathogens. It would also assist bacterial growth by reducing moisture loss in food particles where the rate of growth is affected by temperature. This is countered by improvements to rainwater availability which gradually reduces the levels of faecal bacteria and pathogens by providing more water for domestic activities and personal hygiene. Low levels of both faecal bacteria within the household studied and reported diarrhoea appear to persist well after the rains have finished, despite a change to less convenient water sources. It is thought that the reduction in humidity and temperature after the rains suppresses any dramatic increase to the levels of faecal bacteria and bacterial pathogens.

A reasonable explanation has been provided for faecal transmission within households, but what of transmission between households? The movement of individuals between households was a common occurrence. Priority for fingertip-rinses was always given to residents, however, despite this bias, 31·9% of samples were from non-residents. Moreover, children and infants were often left in the care of neighbours, relatives or friends, meals were commonly shared and foods carried to and from households. Evidence to support this is provided by a study comparing patients seen at a hospital in the northeast, with their family, neighbours and persons not associated with these patients [8]. Enterotoxigenic *E. coli*, identified in 17% of patients, was more common in household contacts (22/141) and neighbours (18/147) of index cases than others (32/1318; $P < 0{\cdot}001$).

https://doi.org/10.1017/S0950268800047968 Published online by Cambridge University Press

Shigella (9% of patients) was isolated more often in family contacts (3/76) and neighbours (4/93) than others (13/1437; $P < 0{\cdot}001$).

This study is specific to a particular environment in rural north-east Thailand but it is interesting that one of the hygiene messages was similar to that developed in urban Bangladesh [6]. Stanton & Clemens found that although only one (handwashing before cooking) of the three promoted behaviours had notably improved, this significantly reduced the incidence of diarrhoeal disease in the intervention group. Although there is no direct reference to disease, the methodology used in this study has certain advantages over traditional health impact evaluation studies. The main outcome indicator does not suffer from the same problems of rarity, definition and recall as diarrhoeal disease and hence the study size can be much smaller, which can provide greater degree of control. More detailed information on faeco-oral transmission is provided and this is more specific to low-cost water and sanitation activities. The indicators of compliance used to detect behaviour change were simple and objective in comparison to direct observation which is both time consuming and difficult to standardize.

ACKNOWLEDGEMENTS

I am grateful for fieldwork assistance provided by Northeast Village Water Resource Project (NEVWRP) and Department of Environmental Engineering, Khon Kaen University. A special word of thanks is due to all the fieldworkers especially Praphaiphan Kloomchorchor and Kittiorn Ompetah, and to Dr Sandy Cairncross for his constructive criticisms of an earlier draft of this paper. This research was partially supported by the Science and Engineering Research Council, 85300104.

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