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A LONGITUDINAL STUDY OF THE IMPACT OF BEHAVIOURAL CHANGE INTERVENTION ON CLEANLINESS, DIARRHOEAL MORBIDITY AND GROWTH OF CHILDREN IN RURAL BANGLADESH

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Abstract—A community-based intervention was developed through direct participation of the target population in assessment and iterative trials to improve hygiene practices and to reduce childhood diarrhoea in lowland rural Bangladesh. A total of 185 (98%) households with children ages 0–18 months in five contiguous villages were targeted for the interventions. A comparison site was selected for a detailed observational study and for use as a control for the intervention. About 97% of all households with children ages 0–18 months were enrolled for study at the control site. Children in this age group were targeted because at this developmental stage they were most vulnerable to diarrhoeal morbidity and malnutrition (related to unhygienic practices). The intervention was implemented with the assistance of village leaders through a "Clean Life" campaign by local project workers and volunteer mothers who were chosen from the target households. The intervention activities started in January 1986 and lasted for 7 months. Higher adoption rates of the intervention were associated with better cleanliness status, which was related to lower diarrhoea and malnutrition rates in the intervention site. The results of between-site longitudinal analyses showed that after the intervention, the intervention site had substantially higher cleanliness scores, lower diarrhoeal morbidity, and better growth status compared to those of the control site, with differences increasing over time. The findings suggest that this type of community-based intervention can be very beneficial in modifying hygiene behaviours and lowering childhood diarrhoea and malnutrition.

Key words—community-based, hygiene, diarrhoea, Bangladesh

INTRODUCTION

Diarrhoea is a leading cause of morbidity and mortality among children in the world [1], and has adverse effects on growth [2–4]. In Bangladesh, it is estimated that diarrhoea accounts for up to 60% of deaths among the 1–4 year age group [5] and that 90% of preschool children suffer from some degree of malnutrition [6]. The malnutrition and mortality rates of children of Bangladesh are among the highest in the world [7]. In Bangladesh, as many other countries, diarrhoea is a major contributor to malnutrition [8] and child mortality [5, 9]. Poor hygiene practices and environmental sanitation are major contributors to diarrhoea [10].

In developing countries, most hygiene interventions to reduce diarrhoea have been found to be either ineffective, unfeasible, inappropriate, or too costly [11, 12], having been developed without examining the cultural context. These interventions were alien to the local situation [12] and did not meet the real need of the people [13, 14]. In contrast, the intervention activities described here were developed and implemented in rural Bangladesh by involving the villagers through a community-based trial model [15]. The objective of the interventions was to reduce childhood diarrhoea by modifying hygiene behaviours, using solutions from within the community.

Many studies evaluate the effect of interventions by comparing pre–post differences in intervention and control groups without examining seasonal patterns of change over time. In contrast, this paper reports changes in daily rates of childhood diarrhoea, monthly cleanliness practices, and nutritional status in both intervention and control communities. This study also investigates the relationship between the rates of adoption of the intervention and health indicators within the intervention site in order to understand how the intervention may have affected the outcomes.

METHODS

Sites and target population

Longitudinal research was conducted from November 1985 to July 1986 in two rural sites, each consisting of five contiguous villages situated on the northern bank of the Padma River in Manikgonj District, 100 km northwest of Dhaka. This low-lying area was selected for the program because of its poor hygiene conditions and high diarrhoea and malnutrition rates [16]. Environmental sanitation, personal cleanliness, and food hygiene were difficult year round. These problems were aggravated by lack of water in the hot dry season (April–May) and too much water in the flood season (July–September).

The intervention and comparison sites were selected based on similarities in ecological and demographic characteristics, cultural practices, child care, and hygiene and sanitation behaviours. The intervention site was 5 km away from the control site and accessible by a 2-hr boat ride most of the year, and by foot over narrow foot paths in about 1.5 hr during the driest months. At the time of the study, there were no other developmental projects in these sites. At the control site, a detailed observational study [17] without intervention exposed the villagers to about the same amount of contact with researchers. The intervention was implemented in the poorer and less hygienic of the two sites in order to increase the probability that observed conservative results would be attributable to intervention.

Following baseline surveys at the two sites in August and September, a census was conducted in October, 1985 in five selected villages at each site to enlist the families with children below 19 months of age who were targeted for intervention and for structured observational study. This census was also used to collect socioeconomic and demographic information of the target households. Initially, the intervention site had 194 families comprising 98% of all households with children under 19 months, while the control site had 193, or 97%, of all the targeted families. Nine deaths and eight children who left the area subsequently reduced the sample to 185 in each site.

Field methods

One Tufts doctoral candidate in nutrition and one local Master's degree research assistant/field supervisor lived at each site for the duration of the study during which they trained and supervised 10 field workers at each site. These paid workers were high-school graduates from the study communities selected for their interest and ability to work in the field. At each site, two of the workers were specially trained for anthropometry, two for morbidity surveillance and one for data coding. Five workers were responsible for implementing, organizing, and facilitating the campaign activities in the intervention site, while five others conducted structured observations in the control site. In the intervention site, the field workers, research assistant, and doctoral candidate became the working group who communally discussed, tried, and decided upon interventions.

Anthropometry began in November, 1985 and formal morbidity surveillance in February, 1986. Preliminary qualitative research started in November and the community-based intervention process in January, 1986. The campaign in the entire community began in February. The cleanliness observations were conducted three times per household in March, June, and July, 1986.

The intervention

The intervention was developed and implemented through a campaign called "Porichchhanna Jibon" (clean life). First, rapport was established with village leaders, who were in a position either to facilitate or to resist changes in their villages. Several discussions were organized with leaders and local officials to explain the project in order to seek full co-operation.

Lectures were then delivered to the villagers at the weekly Friday prayer gathering at the mosque. This occasion was chosen because the majority (83%) of the households were Muslim. As the Islamic leaders stress cleanliness as an essential part of their faith, the project also emphasized cleanliness as a common goal in order to gain wider acceptance of the clean life campaign.

A community-based trial model described elsewhere in detail [15] was used to develop interventions. In brief, first specific hygiene practices and sanitary conditions associated with diarrhoea, as well as cultural beliefs regarding causes of diarrhoea, were identified through a rapid assessment survey, field observations, in-home problem diagnosis, and focus group discussions with the community.

The project working group met to assess community resources to use in the intervention and to generate ideas for new hygiene practices and products for the trials. All proposed behaviours and products were tested and revised through iterative in-home trials at three levels: the 10 project workers; 25 volunteer mothers; and 25 of the poorest community mothers. The project workers trained and supervised the community volunteer mothers, who in turn taught the rest of the mothers in the community.

New hygiene behaviours and products that proved feasible in the project workers' trials were then tried by the volunteers. The results were synthesized, with successful behavioural advice translated into simple action messages based on locally popular proverbs, poems, and folk songs. Final pre-testing and minor revisions in the messages took place in the trials with the poorest mothers during the education campaign [15].

Campaign strategy

The intervention site was divided into five geographical blocks. For each block, five volunteer mothers and one worker were responsible for teaching the other community mothers in their neighborhoods in groups of three to five, at least twice a week. The small group was chosen to ensure active involvement of each mother in group activities. For the group discussions, mothers chose their least busy time, usually in the late morning or late afternoon. The teaching approach was participatory, emphasizing questions and answers and discussion among the volunteer and community mothers. In the sessions, they learned from each others' contributions.

The germ theory of disease was taught as a first step, in order to develop an understanding about the transmission of disease, as most people believed that the origins of diarrhoea were the "evil eye", "bad air", spirits, teething, or too early introduction of the adult diet. In addition, some considered that the child's eating its own feces helped teeth to come through in the teething process; only 4% of mothers had heard about germs [15]. The mothers were encouraged to identify their problems in light of what they learned about transmission of germs and to find their own solutions through group participation and discussions. The volunteers usually initiated the discussions by asking mothers to identify the biggest health problem in the village. "Diarrhoea" was a commmon response. The issues brought up typically related to cleanliness and hygiene. Next, they explored possible causes and solutions to the problems based on the mothers' thinking and talking. Hygiene and sanitation behaviours were actively demonstrated by the volunteers, and taken up by group participation so as to dramatize how these behaviours affect health. They also discussed ways to protect people from diseases. The mothers were receptive, and messages were presented theme by theme to be integrated into their daily lives.

The following interventions were developed, implemented, and adopted in the community.

Theme I: Ground Sanitation—keeping babies from touching and eating disease-causing matter on the dirt surface of the compound

(1) Sweep the baby's play area four times a day.

(2) Use a dirt thrower (similar to a flat garden trowel provided by the project at US \$0.30) to immediately remove the baby's or animal feces from the compound surface, so that the crawling baby could not be contaminated by feces from the ground.

(3) Construct a feces pit to dispose of feces and other filthy matter from the compound. The feces pit was about 2 ft deep, with a narrow neck.

(4) Wash babies in a particular place after defecation so that germ-contaminated water did not spread everywhere.

(5) Keep crawling babies in a playpen (locally constructed, provided by the project at a cost of US \$1.00) instead of permitting them to crawl in the dirt.

Theme II: Personal Hygiene—reducing the transmission of germs from defecation and other personal hygiene behaviours

(1) Wash parent's and child's hands with ashes or soap after defecation as well as before and after feeding or eating.

(2) Use the "bodna" (water pitcher used for cleaning after defecation) with the right hand only so that the germs from the left hand (used for cleaning after defecation) do not contaminate the bodna for the next user.

(3) Clean the baby immediately after defecation so that the baby could not be contaminated with his/her feces.

(4) Use a razor blade to cut the nails of all family members, including babies, at least once a week. Since the custom in Bangladesh is to eat with the hand, long nails can regularly transport germs to the mouth.

(5) Use a clean hand rag to dry the mother's hands after defecation instead of using her own sari.

(6) Clean the baby rug or mat immediately whenever it becomes soiled so that the baby would not come into contact with dirty matter.

Theme III: Food Hygiene—reducing the transmission of germs during supplementary and bottle feeding

(1) Do not use any feeding bottles (small brown medicine bottles were used) if possible.

(2) If using a bottle, soak it in strong salt water and/or wash it in hot water and boil the nipple before feeding.

(3) Prepare only the quantity of bottle mixture that the baby could drink at one time. Mothers were taught that germs would contaminate any left-over bottle mixture.

(4) Use only tubewell water for drinking and for mixing food for baby.

(5) Wash both caretaker's and child's hands and eating plates with tubewell water before eating. Wash both hands and utensils before food preparation.

(6) Do not feed left-over food which might be contaminated.

(7) Keep all food covered from flies, dirt, chickens and dogs.

(8) Store clean plates and pots and pans upside down or covering them to keep animals off.

(9) Cover water pitchers (storage vessels) so that animals or flies could not contaminate the drinking water.

Data collection

Data were gathered during home visits by the two field workers who were not involved in the intervention activities. Socioeconomic and demographic data were obtained from the household head or other responsible adult. The child's age was determined by discussion among family members based on a local festivals and events calendar and the date(s) of birth of the nearest sibling(s). The mother's day-by-day recall of illness was recorded by two morbidity workers, who visited households weekly in serial order from February to July. Each worker visited each mother on alternate weeks to limit interviewer bias.

During their weekly home visits, the morbidity investigators administered a monitoring questionnaire with questions regarding awareness, understanding of benefits, and adoption of each message.

A response to a question testing understanding was scored 1 if it completely matched a prerecorded answer; if it did not match completely it was scored 0. A positive response to each question regarding adoption was confirmed by observation whenever possible and scored 1; negative responses and observed non-adoption were scored 0. Verbal responses generally were observed to be accurate.

The cleanliness of hands, face, and clothes of the child, the mother's sari, and the play areas of children were observed by the morbidity workers and rated on a three-point scale, which was condensed for analysis to 1 if completely clean and 0 otherwise.

Anthropometric measurements were obtained through visiting each home on approximately the same date of each month, except to return to cover children absent during regular visits. Two field workers were trained and their measurements standardized for all anthropometric techniques according to the Zerfas Method [18]. The child's weight was recorded to the nearest 0.1 kg using a beam scale and length to the nearest 0.1 cm using a measuring board as specified by WHO [19].

Data collection throughout was supervised by a senior member of the research team with a supervisor to interviewer ratio of 1:2. Records were checked in the field, each evening, for inaccuracy, inconsistency or missing data and every attempt was made to reobtain incomplete or inaccurate data the following day using the data control worker whose schedule was not fixed.

Measures

Household wealth and agricultural wealth scales were created for each household, replicating the model derived from factor analysis by a previous study [17] using the same data set. In the scales, items were assigned monetary value according to their local market prices, added together, and divided by household size to obtain a per capita value. The agricultural wealth consisted of land, poultry, goats, cows, henhouses, cowshed, out-buildings and agricultural equipment; household wealth consisted of houses, beds, mats, pillows, brass/bronze pots, aluminum pots, cooking pots, kitchen, bicycles, and umbrellas.

Understanding scales were constructed from the scores (1 = correct and 0 = not correct) of knowledge about the benefits of use for each individual product and behaviour within a theme. Weekly individual scores were averaged to produce weekly understanding scores for each theme: Ground Sanitation for theme I, Personal Hygiene for theme II and Food Hygiene for theme III. An overall understanding scale was calculated by averaging the scores for all themes together. Adoption scales based on the weekly scores of adoption (1 = adoption, 0 = no adoption) were created in the same manner as the understanding scales.

Ground cleanliness scoring was based on observation of absence of contaminants on two outside surfaces designated by the mother as the places where she usually put the baby down to play. An overall cleanliness scale was the average cleanliness score for the ground, child's face, child's hands and mother's sari.

Satisfactory Cronbach's alpha values (>0.57) showed internal consistency for the household wealth, agricultural wealth, understanding, adoption, ground cleanliness, and overall cleanliness scales.

The definition of diarrhoea was influenced by liquid breastmilk stool [20]. At the end of the study, more than 90% of the children were still breastfed. During the 5 months of instrument pretesting at the observation site [21], it was concluded that many breastfed subjects had five or more soft or liquid breastmilk stools per day that were nevertheless normal, and considered normal by their mothers, who did not seem to remember the exact frequency of these stools.

Therefore, mothers were asked to recall the presence or absence of diarrhoea according to their own perceptions. If diarrhoea was reported, the mother was asked if the stool was: softer than usual, 1–5 stools; watery, 1–5 stools; softer than usual, 5–10 stools; watery, 5–10 stools; watery more than 10 stools per day; or dysentery.

Frequency distributions of the responses showed almost no occurrence in categories with more than five stools. Therefore, diarrhoea was recategorized into two levels: any diarrhoea and severe diarrhoea (all reported watery stools and dysentery).

Prevelance for any and for severe diarrhoea were calculated. Daily prevalence was defined as number of children sick with diarrhoea over total children observed, expressed as a percent.

Weight-for-Age-Z-scores (WAZ) were calculated according to the National Center for Health Statistics [22] and WHO [19] Standards for age and sex.

Analysis

The objective of between-site analyses was to investigate the differences in cleanliness, diarrhoeal morbidity, and growth at the intervention and the control sites over the 6 month period of the community campaign. The intention of within-intervention site analyses was to explore the relationships between the level of adoption of the interventions and the outcome variables in order to understand how the

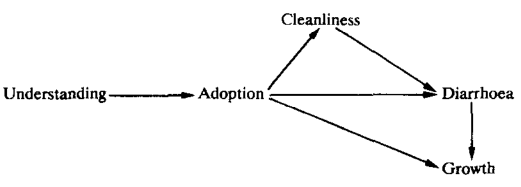

Fig. 1

Table 1. Sociodemographic hygiene characteristics of the intervention and control site households: means (SD) and %

Characteristics	Intervention	Control
Infant's age (months)	8.8 (5.2)	8.9 (5.3)
Infant's sex: male	49%	44%
Religion: Muslim/Hindu****	83%/17%	57%/43%
Mother's age (years)	27.6 (6.6)	26.4 (6.6)
Mother's education***	0.7 (1.9)	1.6 (3.0)
No education	87%	75%
1–4 years	6%	6%
5+ years	7%	19%
Father's education****	2.0 (3.5)	3.5 (4.3)
No education	69%	51%
1–4 years	8%	11%
5–9 years	15%	22%
10+ years	8%	16%
Father's occupation****		
Salaried job	11%	22%
Petty trade and crafts†	12%	28%
Own farming	30%	15%
Farm/other labours‡	47%	35%
Housing structure/materials		
All tin	7%	14%
Tin roof	63%	61%
Thatch–bamboo–thatch	30%	25%
Persons per bedroom*	5.4 (2.0)	4.9 (1.9)
Source of drinking water: Tubewell	97%	98%
Latrine type: Cement, wood or bamboo	97%	89%
None	3%	11%
Distance (yards): latrine to playarea	18.4 (7.7)	19.0 (7.4)
Amount (acres) of land owned***	0.85 (0.17)	0.47 (0.11)
Landless	48%	75%
Up to 2 acres	42%	14%
>2.0 acres	10%	11%
Animal ownership		
Cows****	45%	24%
Goats****	34%	15%
Chickens/ducks***	64%	49%

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; ****$P < 0.0001$.
†Cottage industries, potter, cobbler, blacksmith, mustard seed grinder etc.
‡Day labours, boatmen, fishermen.

intervention may have worked. Correlation programs were run to examine the relationships in Fig. 1 after controlling for prior status of the outcome variable and a common set of covariates (mother's age, mother's education, child's age, child's sex, agricultural wealth and household wealth).

RESULTS

Socioeconomic and demographic characteristics

The demographic and socioeconomic characteristics of the intervention and control households are summarized in Table 1. The mean age of the infants in both sites was approx. 9 months in November

Table 2. Observed cleanliness of child and environment by sites

Variables		Intervention (%) (N = 185)	Control (%) (N = 185)
Child's completely clean	March	36	35
	June	79	40
	July	90	39
Child's face clean	March	48	38
	June	79	55
	July	90	60
Child's hands clean	March	36	35
	June	73	37
	July	80	42
Feces in play area			
Cow droppings	March	29	24
	June	10	21
	July	2	22
Goat pellets	March	39	27
	June	17	9
	July	5	4
Chicken/duck feces	March	59	24
	June	24	11
	July	9	11

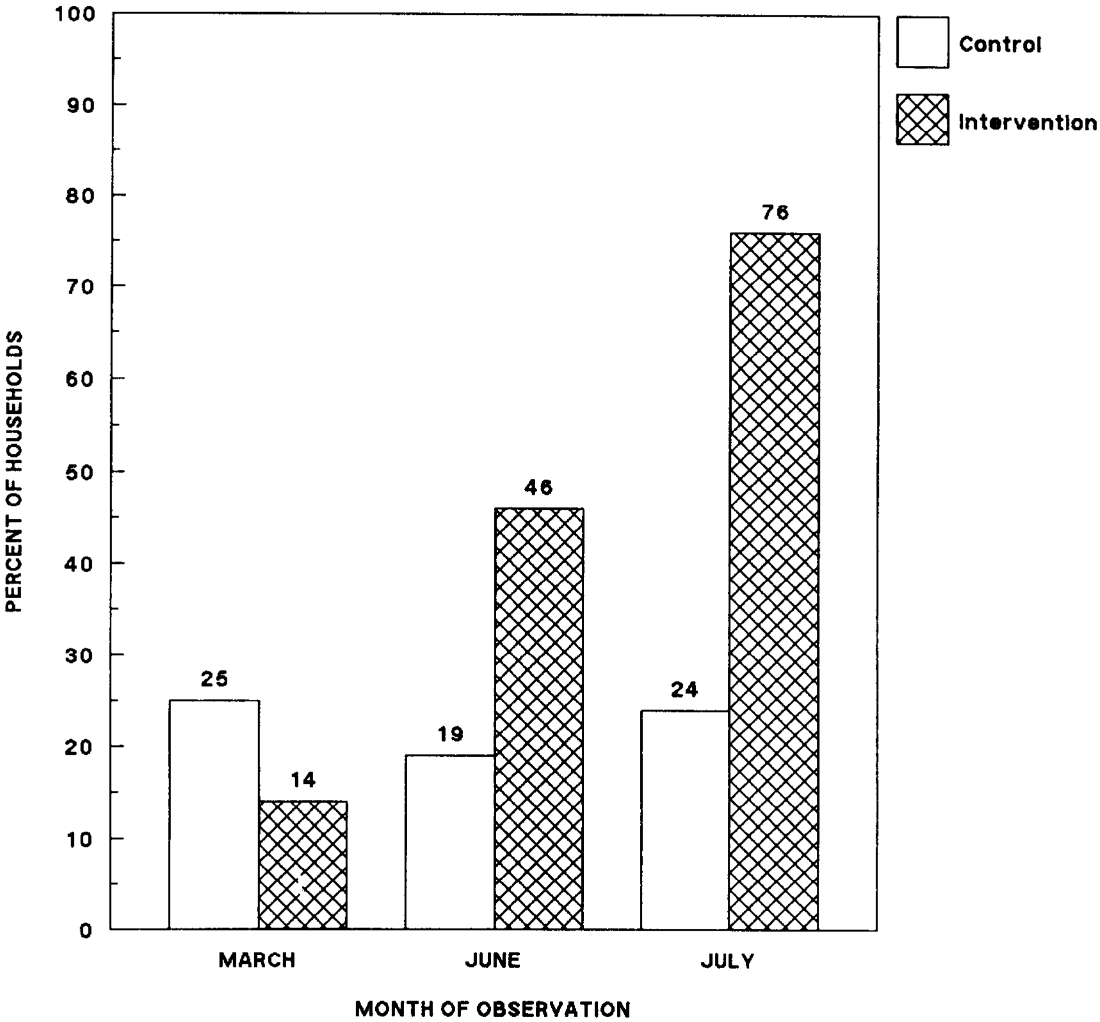

Fig. 2. Mother–child pairs and playarea rated clean.

1985, and ranged from 0 to 19 months. Age distributions of the children by month were similar in both sites.

The intervention site was similar to the control site in the following variables: mother's age, father's age, radio ownership, source of drinking water, and distance between the latrine and the children's play area. The intervention site, however, had more Muslims (83% vs 57%) and fewer mothers who had attended school (13% vs 25%). In the intervention site, only one mother had completed 10 years of education compared to ten mothers in the control site. The father's education was also lower in the intervention site (31% vs 49% school attendance). About half as many intervention as control fathers had 10 or more years of education. The intervention site had a larger percentage of households owning land and animals and employed in agriculture and fishing. The control site had more salaried jobs, traders and craftsmen, and better housing with fewer persons per room. Though the control site was also very rural, it bordered on the upazilla (subdistrict) center, where there were small offices, an open market, schools, a rural health center and a 3-bed hospital.

Between-site comparison

The intervention began in the community in February and continued through to July. The measures taken in February are considered initial and those taken in July are final measures.

Cleanliness and sanitation

Table 2 presents the individual observations of cleanliness of children, mothers, and play areas at three points of intervention, whereas Figure 2 shows the percentages of households in which the child–mother pairs and the play areas were rated completely clean. It illustrates a dramatic improvement in cleanliness at the intervention site. Table 2 shows that in March, the intervention site cleanliness rates were lower than or similar to the rates in the control site except in the cleanliness of the children's faces. At the end of the study period, cleanliness indicators in the intervention site differed dramatically from the control site. Cleanliness of children's faces and the play areas increased in both the sites; however, far greater increases were observed in the intervention site compared to the control site.

Diarrhoeal morbidity

Figures 3 and 4 depict the comparative prevalence of any diarrhoea and of severe diarrhoea per day over the 6-month period in the intervention and control sites. In February, both types of diarrhoea were more prevalent in the intervention site, but from March to June the prevalence in the intervention site was consistently lower than that of the control site. In the final month, the difference between the sites in diarrhoeal rates disappeared. The overall patterns of diarrhoeal morbidity were similar in both sites, with peaks in April and May, which are the hottest months of the year.

Growth status

In February the percentage of children in the normal growth category with WAZ above -2SD was 53% in the intervention site and 58% in the control site. While the percentage of normal children did not differ significantly, Fig. 5 illustrates that the percentages of severely malnourished children (below -3SD WAZ) were reduced over time in the intervention site compared to the control site. These rates were higher in the intervention group from November to March; in April, both sites had about the same rates. From May to July, these percentages were significantly lower in the intervention site.

An analysis of same data shows that a sharp decrease from 40 to 5% in the rate of bottle feeding in the intervention site from the beginning to the middle of the study. This is consistent with the finding that height-for-age Z scores were lower in the intervention children compared to the control children, with differences that increased over time. In contrast, weight-for-height Z scores were higher for the intervention children compared with the control site children, with a similar trend of increasing differences between the two sites.

Within-intervention site analysis

The adoption rates of the intervention varied from 85 to 98% for different themes. The mother's education was correlated with her understanding score ($r = 0.18$; $P = 0.008$), cleanliness score ($r = 0.31$; $P = 0.0001$), child's WAZ ($r = 0.29$; $P = 0.0001$), and marginally with her overall adoption score ($r = 0.10$; $P = 0.09$). The child's age correlated negatively with both food hygiene score ($r = -0.20$; $P = 0.004$) and overall adoption score ($r = -0.12$; $P = 0.05$). As shown in Table 3 the mother's understanding score was significantly associated with all outcome variables. Food hygiene and overall adoption scores were correlated negatively with diarrhoea and positively with cleanliness and the weight-for-age Z-score. The data also confirm expected associations among cleanliness, diarrhoea and WAZ scores.

DISCUSSION

A blind or double blind and randomized intervention trial was beyond the scope of this study. Therefore, we took other measures to minimize selection, interviewer, and respondent biases. Intervention research that mobilized the community to participate in problem solving, message/product design and implementation and intervention was too intensive to conduct simultaneously in a statistical sample of randomly selected communities. The best we were able to achieve was an N of two comparable communities. As noted in the Methods section, we selected the less developed and more environmentally contaminated community for intervention, to increase the probability that measurable differences after the program would be attributable to the intervention rather than to site differences.

The intervention could not be blinded from its participants, although the purpose of the observational hygiene study at the control site was concealed. Moreover, it was not possible to randomly assign study subjects at the same community to intervention vs non-intervention groups due to the highly contaminative nature of our community mobilization campaign.

In order to minimize interviewer/observer bias, we did not involve the personnel who were implementing the intervention in data collection. All project workers, including the data collectors, took an oath which had a strong religious value, to perform their duties exactly as instructed. The penalty for breaking this oath was job loss.

To reduce respondent bias, hygiene and cleanliness

Table 3. The correlation coefficients† among understanding, adoption, final measures of cleanliness, diarrhoea and weight/age scores

	Food hygiene	Overall adoption	Cleanliness	Diarrhoea	Weight/age
Understanding score	0.43****	0.56****	0.43****	−0.25***	0.13*
Food hygiene score	—	—	0.46****	−0.56***	0.34****
All adoption score	—	—	0.55****	−0.64****	0.16**
Cleanliness score	—	—	—	−0.78****	0.32****
Diarrhoea prevalence	—	—	—	—	−0.36****

*$P = <0.05$; **$P = 0.01$; ***$P = 0.001$; ****$P = 0.0001$.

†Partial values after controlling for initial status, child's age and sex, mother's age and education, agricultural and household wealth.

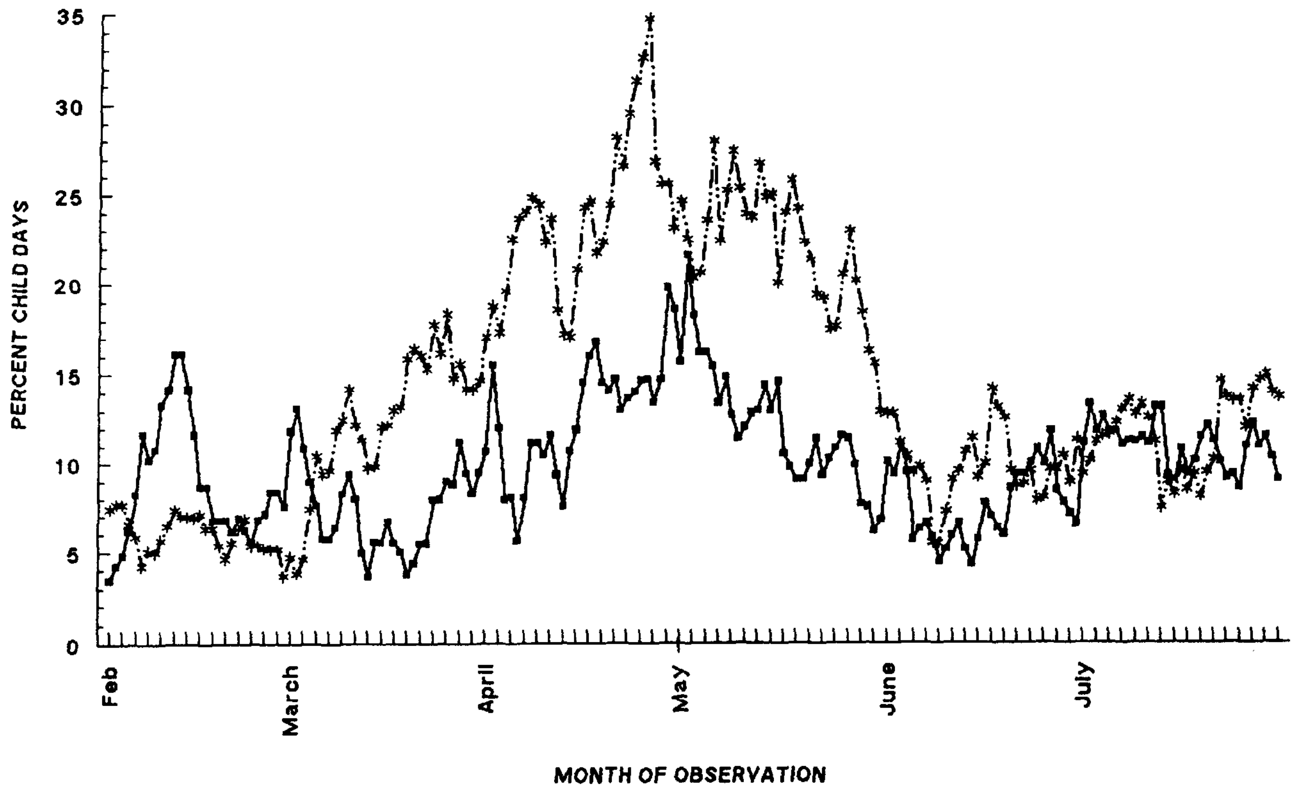

Fig. 3. Daily diarrhoeal prevalence in the intervention vs control group from February to July 1986. *—· · —*, Control group; ■——■, intervention group. Prevalence = (total days sick/total days observed). Expressed in %.

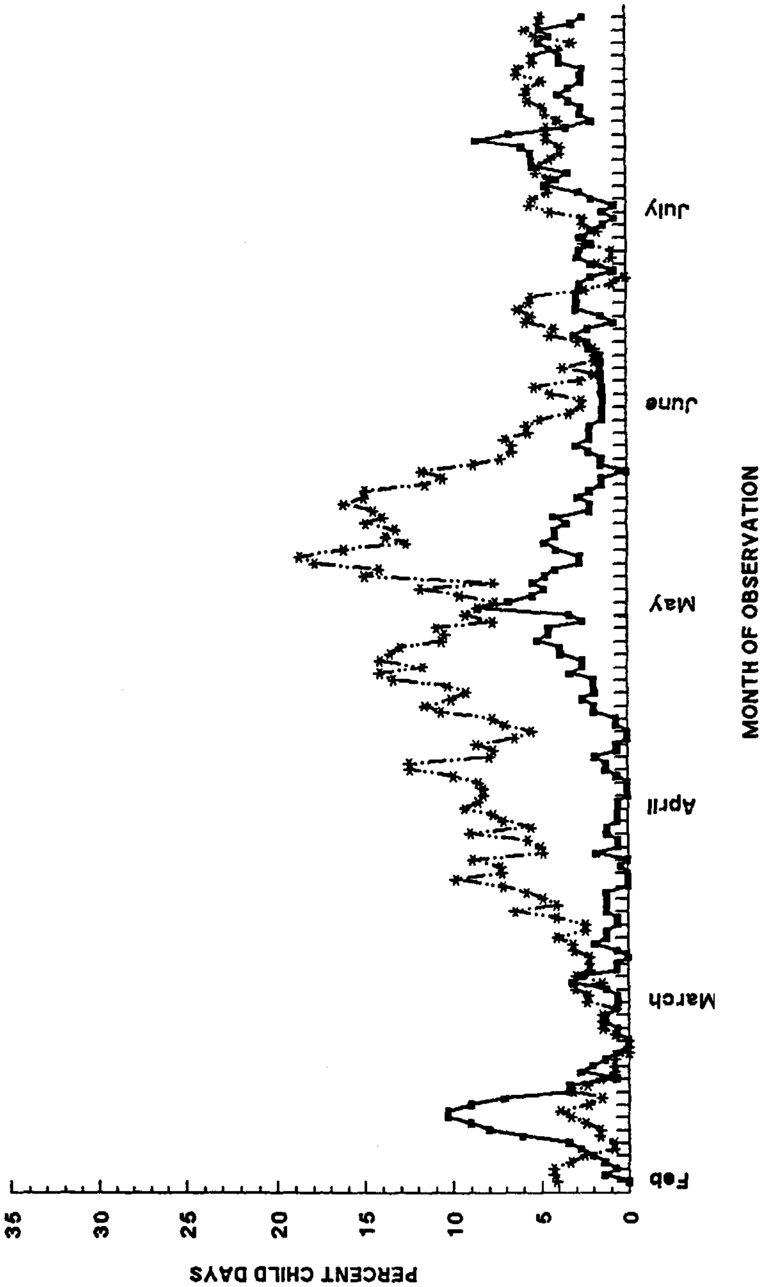

Fig. 4. Daily severe diarrhoeal prevalence in the intervention vs control group from February to July 1986. *—·:—*, Control group; ■——■, intervention group. Prevalence = (total days sick/total days observed). Expressed in %.

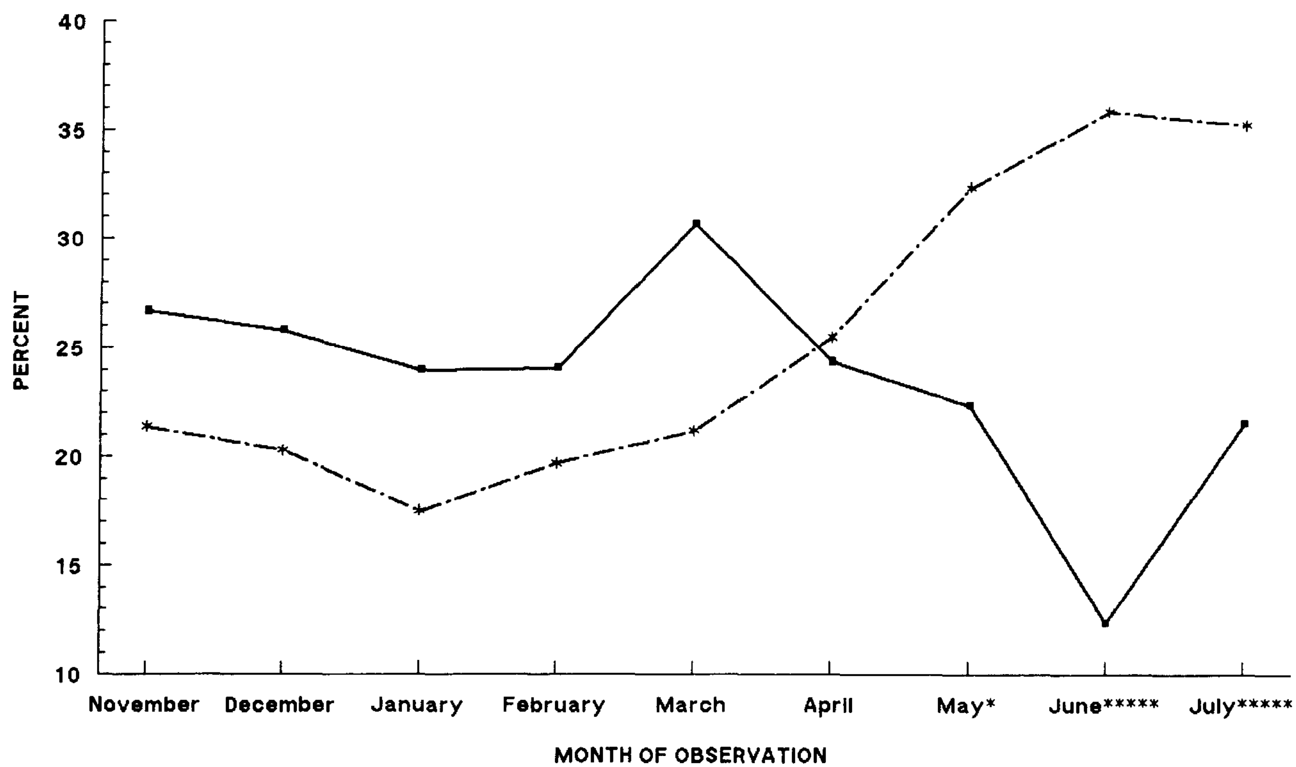

Fig. 5. Percentage of children below 3 SD weight-for-age Z scores according to WHO standards observed from November 1985 to July 1986. *—·—*, Control group; ■——■, intervention group. *$P < 0.05$; ****$P < 0.0001$. Intervention group: $n = 150 \pm 5$, control group: $n = 148 \pm 5$. Controlling for age, sex, household wealth, agricultural wealth and mother's education.

conditions were assessed by observation rather than self report. No incentive was provided to the mothers for reporting or showing better hygiene practices or absence of diarrhoea, and no medicine or other treatment was given for reporting diarrhoea.

To gather reasonably accurate information, we began training the two field workers who collected morbidity and hygiene information 3 months before the intervention. As they practiced gathering weekly information over the 3 months, the data recording procedures were refined and standardized and the respondents become experienced in recalling and providing information. To help mothers to recall dates, for example, we used weekly local market days and Friday, the weekly prayer gathering day, as landmarks. We did not use this first 3 months of data. In the absence of an intervention there would have been little or no motivation to bias the data during this learning period. It was expected that the reporting habits acquired during this time would have continued for the duration of the study. In view of these procedures and our close attention to data quality control, we believe it is unlikely that the data suffer from serious biases or inaccuracies.

The intervention and control communities were similar in many crucial aspects including source of drinking water, latrine condition and location, child care and cultural practices, wealth as measured by household possessions, and demographics (age, sex, mother's and father's age). Both were located in low-lying area and exposed to similar sources of environmental contamination.

Yet the intervention site was somewhat more rural and agricultural and the control site more exposed to modernizing influences. A quarter of the control vs half of the intervention households owned agricultural land while 22% of the controls vs 11% of the intervention fathers had salaried jobs. Although few mothers had attended school in either sample; the difference in proportions and in average years of schooling for both mothers and fathers were statistically significant. As found in other studies [17, 23, 24], these pre-existing differences favoured the health of the children in the control site. The more agricultural intervention site families owned more animals and had more animal feces littering the children's play areas. The presence of feces in the play area was associated with higher prevalence of diarrhoea. Maternal education was associated with better cleanliness and growth status. These disparities, therefore worked against the intervention rather than giving unattributable impact to it.

The results of this study suggest that community-based intervention can improve hygiene knowledge, modify relevant practices, lower diarrhoeal disease, and reduce malnutrition even in an impoverished setting with many undesirable cultural beliefs that interfere with child health.

We will first focus on ways in which the intervention enabled its participants to gain some control over their environment, then on its interactions with environmental and climatic constraints. The occurrence of diarrhoea was believed to be primarily supernatural and beyond human control before the intervention [15]. The intervention provided some scientific understanding of disease by teaching germ theory and increasing mother's awareness of the danger of feces contamination. The intervention also empowered the mothers to take control over some aspects of their health.

The supportive group discussions, in which mothers shared their experiences, possibly contributed to their self-confidence and self-esteem. This process encouraged mothers to identify their problems and to understand the benefits derived from the interventions. Their better understanding appeared to inspire them to adopt these interventions at high rates into their daily lives and practice hygienic behaviours [15].

The project's products and messages made it more convenient for families to practice cleanliness and sanitation behaviours. For example, it was observed that once provided with a dirt thrower, other family members became more willing to clean feces, while previously it had been only the mother's task. This enthusiastic response was due to the fact that this product allowed users to keep their hands clean and to remove feces completely from the ground [25]. As expected, the higher adoption of the interventions was associated with a higher score in overall cleanliness behaviours. These in turn may have contributed to reduced diarrhoeal transmissions and improved WAZ.

While the intervention appeared to be effective in mitigating the effects of seasonal temperature changes, it was not adequate to cope with flooding. The effect of extreme seasonal variations in temperature and water level also were beyond the control of the intervention. In the hottest months, April–May, the high rates of diarrhoea were probably related to the use of contaminated water for cleaning, washing and food preparation. Although during these months rapid proliferation of microorganisms in foods and water was associated with the diarrhoea epidemic documented by Black in another study [26] in rural Bangladesh, the intervention site had substantially lower rates of diarrhoea than the rates at the control site. Consistent use of tubewell water for drinking, children's food preparation, and washing hands before meals in the intervention site may have contributed to this difference.

Floods are a major threat to life in Bangladesh. During flooding the quality of water is poor. The intervention recommended depositing all feces in a pit at the edge of courtyard. July floods carried this collection of feces in bulk and contaminated the source of bathing, washing and cooking water of low lying homes. In this month, a substantially higher diarrhoeal rate was observed among the children of households with flooded feces pits, possibly because water hygiene during flooding is already bad and feces-pit overflow made it worse [25]. In contrast, in the control site, where feces were thrown into a field or near the homestead and allowed to dry in the sun, there was no immediate source of heavy contamination in the homestead. In the future, it could be recommended that feces in the pit be buried with sand, ash or soil in layers every few days and then completely sealed over with enough soil, followed by constructing a new pit for further use.

During flooding, with contaminated water it may be suggested that tubewell water be used for washing and cooking purposes, although villagers resisted the use of tubewell water in cooking trials due to its strong iron flavor and tendency to discolor and spoil foods [15]. Further trials over a longer time could test storing the tubewell water before use so as to lower its iron flavor by sedimentation. The traditional use of alum, now proven to be effective to reduce bacteria loads [27], could be reintroduced for water purification of river/pond water.

The intervention positively affected children's health in several ways. While child diarrhoeal rates dropped rapidly in the intervention site, there appeared to be no significant impact on weight-for-age in the first few months. Initial growth status of the intervention children was lower, which had a negative effect on their growth status in the following months compared to the control site children. However, the malnutrition (WAZ, WHZ) rate at the intervention site was eventually lower than that at the control site. Like other studies [4, 28] which have shown diarrhoea to have an adverse effect on weight gain, our data suggest that the lower diarrhoeal prevalence in the intervention site decreased the malnutrition rates there.

As hypothesized, the effects of the intervention on child weight gain were mediated through reduced diarrhoea and improved food hygiene behaviours. Food hygiene behaviours, including avoiding overnight storage of cooked food which is usually contaminated under high environmental temperature [29] and using tubewell water for children's food, may have improved the absorption and utilization of food since a reduction in diarrhoea reduces catabolism and improves intestinal absorption [28]. Further growth improvement could be achieved by including improved diets in the hygiene interventions.

In the intervention site, the mother's understanding of germ theory and the workers' strong discouragement of bottle feeding possibly resulted in a sharp decline in the rate of bottle feeding. Although the reduction in bottle feeding presumably decreased diarrhoea, milk consumption among the children may have been reduced. This could account for the increasing difference in HAZ between the intervention and control site over time. An analysis of the control site data [30] showed that bottle feeding was strongly positively related to HAZ but had no association with WAZ. Improvement in WHZ in the intervention site may have been caused by increased weight with relatively delayed linear growth.

In designing food hygiene interventions, one should be careful about negative effects of any kind of food withdrawal or reduction in impoverished settings where a small incremental amount of food may make a relatively large contribution to child growth.

CONCLUSION

We believe the key factors that contributed to the effectiveness of the intervention were as follows:

(1) Obtaining a relatively comprehensive understanding of local norms and cultural beliefs during the early stages of intervention planning.

(2) Developing the interventions by a relatively long-term working group made up primarily of members of the target group and their opinion leaders in every phase of the process.

(3) Developing hygiene practices from within the community through iterative trials led by the working group in order to ensure their acceptance and high adoption rates.

(4) Developing simple, direct and specific messages resembling locally popular proverbs, poems and folk songs to make the messages memorable, motivating and effective.

(5) Teaching the germ theory through interactive small group discussions led by working group members in a manner that empowered mothers to identify their problems and to find their own solutions, and inspired them to action in a group of similar people.

It is often recommended that educational interventions should focus on small number of behaviours, to do so, however, may run counter to the process of community empowerment. This project attempted to provide the community with decision making skills. On the basis of their understanding of disease transmission, project participants identified their many hygiene problems, the conditions and practices responsible for these problems. They naturally sought a sense of closure in breaking the chain of diarrhoeal transmission. Our forcing them to focus on a small number of behaviours would have detracted from their completion of this task.

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