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The Imo State (Nigeria) Drinking Water Supply and Sanitation Project, 1. Description of the project, evaluation methods, and impact on intervening variables

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Abstract

A health impact evaluation was conducted in conjunction with the Imo State Drinking Water Supply and Sanitation Project in Nigeria. The project consisted of a package of water supply, sanitation, and health and hygiene education given by village-based workers. The evaluation was a quasi-experimental study covering pre-, peri- and post-intervention periods. Data were collected from 3 intervention and 2 control villages. Baseline surveys indicated that the intervention and control areas were similar with respect to most socio-demographic variables. Use of the improved water supply was high, although this was influenced by borehole-to-population ratios and household-to-borehole distances. Water collection time was consequently greatly reduced. Data from a small sample of households showed that borehole water became heavily contaminated during collection and storage, and that there was no significant change in consumption of water per person. Adults in 46% of household units in the intervention area were using ventilated improved pit latrines by the end of the study period. Use by young children (2–5 years old), however, was low. Limitations in the success of the health education component of the project were found. Although changes were found in knowledge, attitudes and practices related to water and sanitation, and in management of childhood diarrhoea, this occurred in both the intervention and control areas.

Introduction

The Imo State Drinking Water Supply and Sanitation Project is a pilot project in which rural communities in Imo State, Nigeria, participated in an intervention package of water supply (boreholes with hand pumps), construction of ventilated improved pit (VIP) latrines, and supportive health and hygiene education. The specific objectives of the project were to reduce the incidence of water-related diseases and thereby reduce child mortality, and to provide at least 20 litres of clean water per person per day. A health impact evaluation was included in the project's design, specifically focusing on dracunculiasis (guinea worm disease) and diarrhoea. Since failure to obtain proper use of the improved facilities or to improve related practices is likely to be accompanied by little or no impact on health, the evaluation also attached importance to measuring the impact on intervening variables which mediate between project implementation and improvements in health.

We describe here the project, the evaluation design, and the impact on a range of intervening variables. In the accompanying paper we assess the impact on dracunculiasis, diarrhoea morbidity and nutritional status (HUTTLY *et al.*, 1990).

Project Description

Imo State was selected by the Federal Government of Nigeria as the pilot area for the project, which was launched in December 1981. The project was implemented by project teams in a sequence of overlapping steps as follows: community mobilization, promotion and construction of VIP latrines, selection and training of village-based workers (VBWs), and borehole drilling and hand pump installation. The average borehole-to-population ratio achieved by the project in the villages studied in the evaluation surveys was 1:440 (BLUM *et al.*, 1987a). Communities participated in a number of ways: providing labour and materials for hand pump platforms, VIP latrines, and road clearing; selecting VBWs; and forming village steering committees to supervise activities and take appropriate actions to support the project.

The VBWs were the main means by which health and hygiene education was provided to villagers. Topics covered in training included breast-feeding, nutrition, water use, personal hygiene, environmental sanitation, diarrhoea prevention, and oral rehydration therapy (use of sugar-salt solutions). Some education was also provided through a small team of evaluation workers who were conducting a continuous diarrhoea morbidity study in 2 of the intervention villages and 2 control villages. The team instructed the mothers on the preparation and use of oral rehydration therapy and management of childhood diarrhoea.

Study area

Imo State occupies an area of 11 850 km^2 in the south-east of Nigeria, where the major ethnic group is the Ibo. The health impact evaluation was conducted in Ohoazara, one of the 21 local government areas of Imo State located in the most north-eastern part of the state. It has an estimated population of 300 000, and is a rural farming area in which people live in villages composed of scattered compounds. Ohoazara, largely

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unserved by improved water supply and sanitation facilities, was the site of cholera outbreaks in 1979 and 1980, and for that reason was chosen as an early focus of the project.

Intervention and control villages for the health impact evaluation were chosen after a decision had been made by state government officials on which subdivisions (autonomous communities) of Ohoazara would be included in the initial stages of the project. The control villages were drawn from those areas scheduled to be included in the project at a later date (1986).

The intervention timetable and logistical considerations narrowed down the choice of subdivisions for study to a single intervention area (Ugwulangwu) and a single control area (Oshiri). Candidate intervention and control villages were visited to identify those which were similar in size, availability of health facilities, socio-economic status, traditional water sources, compound size, sanitation facilities, and accessibility. Through this process 3 intervention villages (Amata, Amena, and Amenu) and 2 control villages (Amankanu and Umumgbala) were selected. The choice of 3 and 2 in each category was a compromise between the desire to improve statistical validity by selecting many villages and the constraints of personnel and logistics in an area with a poor road network. Similar considerations dictated that only 2 of the intervention villages (Amata and Amenu) and the 2 control villages were included in the detailed longitudinal study of diarrhoeal diseases.

Within the selected villages, the sampling unit used was the household, defined as a group of persons whose food was provided with money from a common purse. In the first 2 villages studied, Amata and Amankanu, a systematic sample of 50% of households was taken. This percentage was increased to 100% in the remaining villages to give greater numbers of children under 6 years of age.

Timing of interventions

Borehole drilling began in Amata in March 1984 and progressed through Amenu and Amena to be completed by October 1984, except in Amena where a scheduled third borehole was not drilled until April 1986. Promotion and construction of VIP latrines began in 1984 but little progress was made until mid-1985, so that, even by the end of the evaluation in June 1986, not all households in the intervention area had built, or were using, latrines. Training of VBWs was conducted during January to March 1984. Their performance throughout the study period was patchy and modifications to this health education approach were necessary. Until April 1985, they visited individual households to deliver education messages; thereafter 'mass rallies' were held in the villages, approximately monthly, and specific topics were discussed on each occasion.

Evaluation outline

The evaluation was a quasi-experimental study. Baseline data were collected in intervention and control areas in 1983, at regular intervals as the interventions were taking place (1984), and for 1·5 years after the water supply had been introduced. Data were collected through a combination of longitudinal and cross-sectional surveys. Two categories of indicator were included: impact indicators and intervening variables. The impact indicators investigated were time-savings, dracunculiasis prevalence, and the prevalence and incidence of acute diarrhoea, particularly in children under 6 years of age. The intervening variables used were water quality, water supply, latrine use, and selected health and hygiene behaviours.

Evaluation surveys

Several different evaluation surveys were conducted throughout the study period, as shown in the Figure. Only those surveys relevant to the data presented in this paper are described here.

Water, sanitation and hygiene survey

This survey was carried out twice a year (during the February–May late dry season and period of early rains, and during the wet season months of July–October). The purpose of the survey was to determine the prevalence of selected water- and sanitation-related diseases, and to gather knowledge, attitude, and practice data relating to facility use, health, and hygiene. Where households were polygamous with more than 1 wife or wife/child unit, questionnaires were administered separately to all units of the household. The respondent was usually the female head of each unit. Data were collected from an average of 935 household wife/child units in the intervention area and 470 in the control at each survey, with respective populations of 5100 and 2300, representing about 90% of the total populations. Almost all of the 10% failure to interview was due to temporary absence from the home.

The questionnaire recorded the prevalence of illness, and more specifically the prevalence of diarrhoea and dracunculiasis plus upper respiratory infections (a non-water-related illness, included for quality control purposes); sources and uses of water; time taken for water collection; defaecation practices; various health and hygiene behaviours, including handwashing, use of soap, and breastfeeding; and attitudes and behaviours relating to diarrhoeal diseases. From July 1984, data on vaccination status and measles during the previous 6 months were collected for children aged 0–5 years, and the heights and weights of children under 3 years of age were measured. In the second part of the survey, observations were made regarding storage and handling of drinking water, possession of soap, and environmental sanitation, including a detailed latrine inspection.

Socio-demographic survey

A socio-demographic survey was carried out once per year in conjunction with the water, sanitation and hygiene surveys: during the wet season for Amata and Amankanu and during the dry season for the other 3 villages. One questionnaire per household was administered. The respondent was usually the head of the household. An average of 770 households in the intervention area and 380 in the control area were interviewed, representing about 90% of the total populations. A larger number were interviewed during the baseline year (see Table 1) as special efforts were made to follow up those temporarily absent from the home.

Data on a wide range of socio-demographic vari-

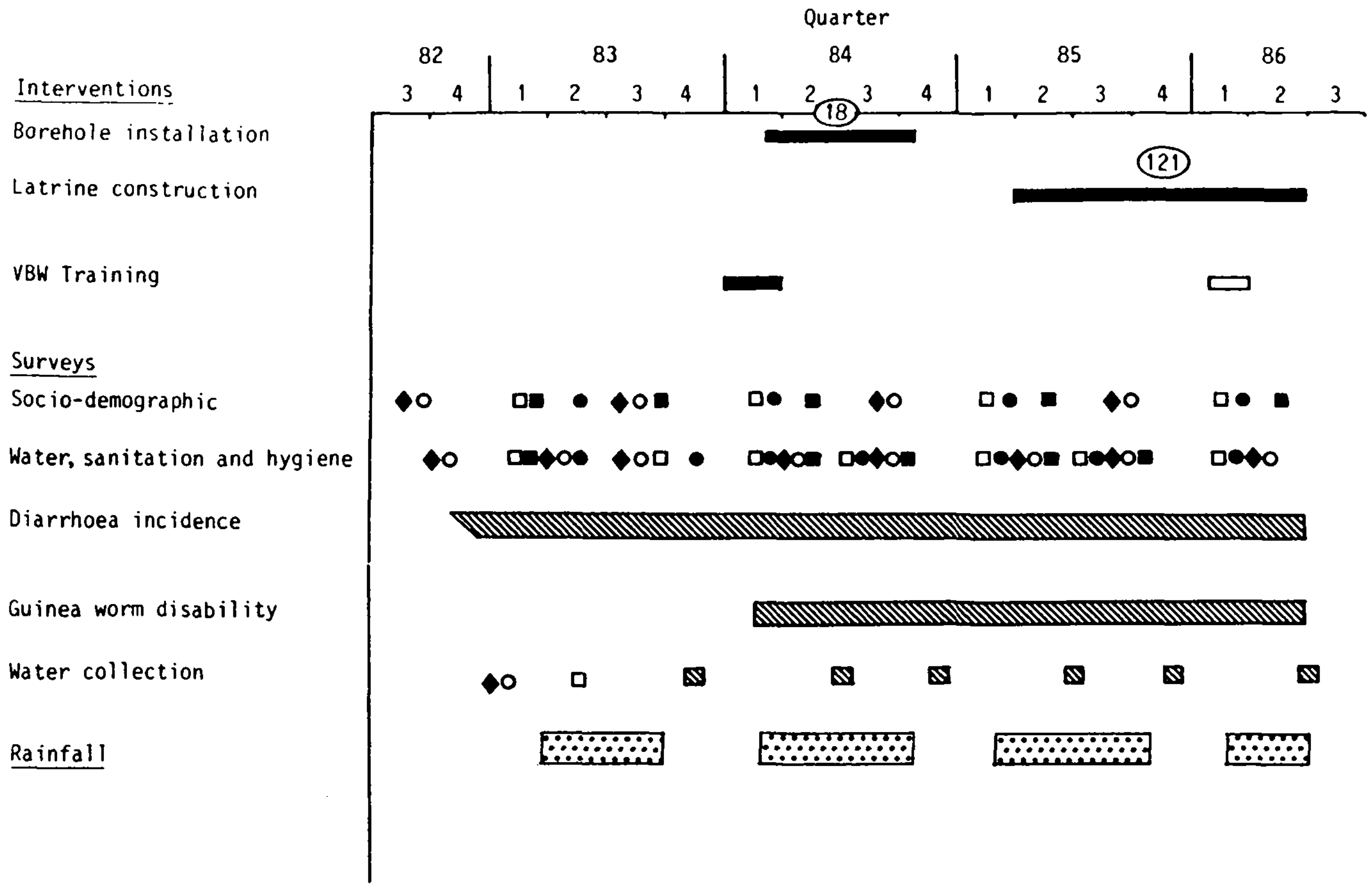

Figure. Chronology of project intervention and evaluation surveys. Intervention villages (solid symbols): Amata (diamond), Amena (square), Amenu (circle); control villages (open symbols): Amankanu (circle), Umumgbala (square); Amata, Amenu, Amankanu and Umumgbala (hatched rectangles); intervention area (solid squares or bars); control area (open bars); total number of boreholes or latrines completed by June 1986 shown by circled numbers; occurrence of rainfall on more than 20% of the days in each month indicated by stippled rectangles.

ables were collected, both at the individual level (for example, age, sex, education, occupation and literacy), and at the household level (for example, number of housing units occupied, housing structure, religion of head of household, and household possessions).

Detailed water collection surveys

A small sample of households (12 from each of 2 of the intervention villages and both control villages) were chosen randomly from different geographical areas in the village to study water collection practices. These households were observed for 2 consecutive days each dry and wet season. An enumerator followed all water collection activities and recorded the volumes collected and the time and distance of each journey. On one of the days, samples of water were collected from the household's source, from the carrying container, and after storage in the house (between 2 and 24 h after collection). Faecal coliform and faecal streptococci counts per 100 ml of water were obtained from each sample using the membrane filtration technique; the water analysis methods have been described elsewhere (BLUM *et al.*, 1987b).

Distance to water source survey

In November and December 1985 a survey was conducted in the intervention area to establish the distance to the 3 main water sources used in the dry and wet seasons by each household. Details have been presented by BLUM *et al.* (1987a). In brief, an enumerator walked to the sources named by a household, using a stride which had been measured beforehand. Where the distance could be motored, it was recorded using the mileage indicator of the vehicle.

Study population

The socio-demographic characteristics of the population, collected during the baseline surveys of 1983, are shown in Table 1. Overall the population was young (50% below 15 years of age), lived in basic housing (62% mud and thatch), and had low levels of formal education (literacy rate 46% for adult males, 15% for adult females). The intervention and control areas were similar with respect to age-sex composition, adult education levels and wealth indicators. The main differences found were that households in the intervention area were less likely to have more than one wife/child unit, more likely to have an unimproved housing stucture, less likely to be of Christian religion, and more likely to be engaged in farming.

Water sources

The types of water source used by household units during the 8 days before the interview are shown for each survey in Table 2. One village (Amenu) in the intervention area was surveyed during the wet–dry transition seasons in the baseline year and so has been excluded from water source analyses for that year.

Table 1. Socio-demographic characteristics of the study populations at baseline, 1983[a]

Characteristic	Intervention area	Control area	χ^2	DF	*P*
No. of households interviewed	801	402			
Households (%) with:					
1 unit	83	77	12	2	<0·01
2 units	13	18			
≥3 units	4	5			
Households with ≥1 luxury item (%)	63	60	0·6	1	NS
Households with mud walls, thatched roofs and mud floors (%)	66	54	34	1	<0·001
Christian households (%)	45	73	88	1	<0·001
Population (%) aged 0–4 years	19	18	1·9	2	NS
5–14 years	31	33			
≥15 years	50	49			
Female population (%)	52	52	0·1	1	NS
Adults with at least primary education (%)					
males	51	54	1·6	1	NS
females	19	22	2·0	1	NS
Literate adults (%)					
males	44	50	5·3	1	<0·05
females	14	16	0·3	1	NS
Occupation (%): males					
farmers	33	18	240	3	<0·001
small traders	32	14			
skilled workers	4	26			
other	31	42			
females					
farmers	59	13	832	3	<0·001
small traders	11	7			
skilled workers	3	58			
other	27	22			

[a]Abbreviations: χ^2=value of chi squared; DF=number of degrees of freedom; *P*=probability.

Table 2. Percentage of household units using each type of water source during the 8 days before interview, based on an average of 935 household units in the intervention area and 470 in the control area

Source	Area[b]	Dry season 1983[c]	Dry season 1984[d]	Dry season 1985[e]	Dry season 1986[e]	Wet Season 1983[c]	Wet Season 1984[d]	Wet Season 1985[e]
Pond	I	8	1	<1	0	78	47	18
	C	6	12	14	4	83	74	89
River	I	33	20	<1	<1	1	0	1
	C	92	95	58	29	4	0	4
Unprotected spring	I	72	88	22	40	5	0	0
	C	14	7	48	97	1	1	1
Well	I	0	3	2	6	3	8	3
	C	0	0	1	<1	0	<1	1
Rain	I	–	–	–	–	80	82	80
	C	–	–	–	–	79	83	92
Borehole	I	0	0	88	96	0	34	88
	C	0	0	0	0	0	0	0

[a]Households using more than one source were counted in each source category.
[b]I=intervention area, C=control area.
[c]Baseline data.
[d]Peri-intervention data.
[e]Post-intervention data.

The baseline dry season survey showed that the intervention and control areas differed in the types of source used, unprotected springs being more common in the intervention area and rivers less common. Rainwater, usually collected in large bowls around the home, and pondwater were the most common wet season sources.

By the end of the study period, 96% of households in the intervention area were using the introduced boreholes. In the dry season, the use of alternative traditional supplies dropped from 100% to 40%. Use of traditional sources also decreased during the wet season, except for use of rainwater which remained constant at about 80%. In the control area, the use of river water in the dry season greatly decreased over time, with a corresponding rise in the use of water from a natural unprotected spring which developed spontaneously, closer to the villages. The use of rainwater also increased in this area.

Borehole-to-population ratios and median household-to-borehole distances varied between the 3 intervention villages and this influenced the extent to

Table 3. Percentage of household units in the intervention area exclusively using borehole water for drinking and for all domestic purposes, by village

Village and usage	Borehole to population ratio	No. of household units	Median distance from borehole to household	Percentage of households >1 km to borehole	Dry season 1985[a]	Wet season 1985[a,b]	Dry season 1986[a]
Amata	1:370	240	484 m	9			
Drinking					92	24 (100)	93
All purposes					85	10 (86)	79
Amenu	1:400	325	499 m	15			
Drinking					72	16 (93)	78
All purposes					61	10 (75)	41
Amena	1:820	370	566 m	25			
Drinking					92	22 (82)	64
All purposes					90	17 (72)	40

[a]Post-intervention.
[b]Figures in parentheses are the percentage using only borehole and/or rainwater.

Table 4. Percentages of household units in the intervention area, based on an average number of 935 units, exclusively using borehole water for drinking and for all purposes, according to distance to borehole and season

Season	Usage	0–249 m	250–499 m	500–999 m	1000–1999 m	2000+m	χ^2 test for trend
Dry 1985	Drinking	90	86	86	73	36	38, $P<0{\cdot}001$
	All purposes	83	74	80	69	32	18, $P<0{\cdot}001$
Wet 1985	Drinking	26	24	20	6	3	21, $P<0{\cdot}001$
	All purposes	21	12	11	2	3	27, $P<0{\cdot}001$
Dry 1986	Drinking	91	85	79	68	3	83, $P<0{\cdot}001$
	All purposes	68	61	48	33	0	71, $P<0{\cdot}001$

Table 5. Daily water collection time to main source, based on an average of 935 household units in the intervention area and 470 in the control area

	Area[a]	Dry season 1983[b]	Dry season 1984[c]	Dry season 1985[d]	Dry season 1986[d]	Wet season 1983[b]	Wet season 1984[c]	Wet season 1985[d]
Median time	I	360	360	60	45	0	0	12
(min per household unit/d)	C	280	260	180	36	0	0	0
Units spending	I	15	10	82	92	91	97	100
≤2 h/d (%)	C	17	19	42	89	88	98	100
Units spending	I	36	45	2	0	0	0	0
>6 h/d (%)	C	31	33	15	0	0	0	0

[a]I=intervention area, C=control area.
[b]Baseline data.
[c]Peri-intervention data.
[d]Post-intervention data.

which borehole water was adopted for exclusive use (Table 3). In the best served village, Amata, almost all units were drinking only borehole water. This practice was less common in Amenu, widely dispersed farming causing some units to be several kilometers from the nearest borehole. In Amena, which was still awaiting a third borehole, the population appeared to revert to the use of traditional supplies in addition to borehole water after the initial period of borehole installation. Borehole usage rates were lower in the wet season, but if borehole and rainwater are considered together, the majority of units in intervention areas obtained all their drinking water from these safe sources.

The use of boreholes as the main (although not exclusive) water source decreased significantly as household-to-borehole distance increased during the wet season, but showed little relationship with distance during the dry season when the borehole was located less than 2 km away (BLUM *et al.*, 1987a). When the exclusive use of borehole water for drinking was considered, however, a significant decrease in use was found in both seasons (Table 4; $P<0{\cdot}001$). Similar patterns in the exclusive use of borehole water for all domestic purposes were seen (Tables 3 and 4), but the percentages were lower than those for drinking.

Water collection

Water collection was mainly the responsibility of adolescent and young adult women. In the baseline surveys, about one-third of women estimated that they spent more than 6 h per day collecting water in the dry season, while less than 20% spent under 2 h per day (Table 5). In the intervention area, the median daily collection time decreased from 6 h to 45 min in the dry season but increased slightly from 0 to 12 min in the wet season due to the introduction of boreholes and less reliance on the sole use of rainwater. From 1985 there was also a reduction in collection time in the control area. This was due to the decreased use of river water in favour of a nearer newly-formed unprotected spring, and the increased use of rainwater collected at home.

For households enrolled in the water collection surveys, water use per person, which varied inversely with household size, showed no significant change over time in either the wet or dry season. Although our sample size was small, this suggested that an improvement in water availability had no significant effect on use per person.

Water treatment

Purification of drinking water (by boiling or adding alum) varied according to source type: water from sources of clearer appearance (i.e. boreholes and rainwater) was less likely to be purified. Thus the proportion of household units in the intervention area treating their drinking water actually decreased once boreholes were introduced.

Laboratory examination of water samples showed that for households using borehole water, while the faecal bacteria counts in the water 'at source' were low (range 0 to 27 per 100 ml), high contamination levels were found for water obtained from the carrying containers and after storage (order of magnitude 10^2–10^4 per 100 ml). These high levels were similar to those obtained from traditional water source samples.

Water storage

The storage of water containers off the floor increased during the study period. Although this increase was evident in both areas, the rise was considerably higher in the intervention area (4% to 34%) than in the control (2% to 15%). Most containers were covered. Almost all units took their water from the storage container with a cup, so that contact was made between the person's hand and the water. In the baseline surveys this was found to be the same cup as that used for drinking in 99% of units. This percentage decreased over time in the intervention area to 88% but remained at the high baseline level in the control area.

Sanitation facilities

The sanitation facilities used were similar in the intervention and control areas during the baseline year. In most households it was stated that adults and children aged 2–5 years usually defaecated in the bushes or fields (86% and 74% respectively), while some used a traditional open log latrine called an *ogwe*. Children aged 12–23 months usually defaecated around the home.

In the intervention area the construction of VIP latrines progressed slowly over time so that, by the last survey, adults in 46% of units were using this facility. This corresponded with a decrease in the use of traditional facilities, particularly the bushes or fields. In 19% of households with a VIP latrine and children aged 2–5 years, the latrines were used by these children. No changes were found in sanitation facilities used by children of less than 2 years old, nor in those used by the control population.

During the baseline period, households possessing at least one luxury item were relatively more likely to have a traditional open log latrine and relatively less likely to use the bush or fields for defaecation. During the post-intervention period this group of households was more likely to have a VIP latrine. A survey conducted on 10% of study household units revealed that high cost was one of the most common reasons for not having a VIP latrine.

Hygiene-related behaviour

The importance of handwashing before eating and handling food, and after defaecating or handling a child's stool, was already appreciated by the population and no change was observed during the study period. Observations on environmental hygiene showed that the proportion of household units with no rubbish present in the yard increased in both areas (from 8–10% to 22–24%). The pattern was less clear with regard to the presence of human or animal faeces, varying over time but consistently similar between the intervention and control areas. Animals (mostly chickens, goats, sheep, cats and dogs) were present in the yards of almost all households, and frequently allowed inside the house. Animals were observed in 50% of households at baseline falling to 15% post-intervention, in both the intervention and control areas.

Hygiene-related knowledge

Respondents were asked whether they thought faeces could cause disease, and if so to name up to 3 diseases and their modes of transmission. Both areas showed an increase in the proportion aware of faecally transmitted diseases, mostly reflected in an increase in those naming a gastro-intestinal disorder (from 44% to 80% in the intervention areas and from 48% to 70% in the control area). Up to 12% of respondents in the intervention area and 23% in the control area thought that faeces could cause skin infections, which were not, in fact, faecally-related.

The most common modes of transmission named were contaminated food, 'bad air', bare feet, flies and poor personal hygiene. The reporting of contaminated food increased from 9% to 32% in the intervention area, but remained at the baseline level of 13% in the control area. Very few respondents in either area named contaminated water (0–1%). In more direct questioning, however, about what may happen if dirty water is drunk, the vast majority of respondents answered that it may lead to illness, naming in particular a gastro-intestinal disorder. Surprisingly the proportion naming guinea worm (endemic at a low level in this community) decreased over time from 26% to about 10% in the intervention area and from 35% to about 15% in the control area.

Management of childhood diarrhoea

Mothers of pre-school children (0–5 years old) were questioned on various aspects of the management of childhood diarrhoea. Knowledge of 'a special drink for diarrhoea' (oral rehydration therapy, sugar-salt solution) increased substantially (from less than 30% of respondents to 84% in the intervention area and to 76% in the control area). The proportion claiming to give plenty of fluids if a child had diarrhoea increased from 20% at baseline to 36% post-intervention in both areas. This increase in home-based therapy was reflected in a decrease in the proportion of mothers saying they would consult medically-related personnel for a mild episode of diarrhoea. Help for a severe episode of diarrhoea continued to be sought outside the home (mostly medically-related personnel or medicine dealers), though a few said they would consult a VBW. No change in the breastfeeding habits of the population occurred, and almost all mothers claimed they would continue breastfeeding if the child had diarrhoea. Interestingly, mothers from the 2 intervention and 2 control villages participating in a detailed study of diarrhoea morbidity (HUTTLY *et al.*, 1990) consistently showed greater awareness of issues related to diarrhoea than those from the intervention village not involved.

Discussion

The Imo State Drinking Water Supply and Sanitation Project represented a novel approach to the problem of rural environmental health in Nigeria. It emphasized low cost technology, linked sanitation to the provision of water, and recognized the importance of supportive education and community involvement. It was hoped that the health impact evaluation would demonstrate the benefits of this approach, lead to an understanding of how and why these changes came about, and ultimately provide information to improve the project design and implementation. The evaluation design and content was influenced by these expectations and by an appreciation of the methodological problems which are frequently encountered in health impact studies of environmental intervention projects (BLUM & FEACHEM, 1983; ESREY & HABICHT, 1986).

We have demonstrated considerable improvements in water collection time, water source choice, sanitation facilities, and in some knowledge, attitudes and practices. The low usage of latrines by young children and the results on water quality and quantity indicate, however, that the health education component of the project could be strengthened to maximize the potential health benefits. Most of the changes in knowledge, attitudes and practices related to diarrhoea occurred in the villages involved in the diarrhoea morbidity study, where health education by the evaluation staff took place. The fact that these changes occurred to a lesser extent in Amena, the intervention village not participating in the diarrhoea study, indicated the positive impact of this education compared to that provided by the VBWs.

The variation in facility usage observed within the intervention area, the impact on intervening variables, and the differences found between the 2 areas with respect to some socio-demographic characteristics, are considered in the evaluation of health impact in the accompanying paper (HUTTLY *et al.*, 1990). The policy implications of the evaluation findings, both for water and sanitation projects and health impact evaluation studies, have been presented elsewhere (IMO STATE EVALUATION TEAM, 1989).

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References

Blum, D. & Feachem, R. G. (1983). Measuring the impact of water supply and sanitation investments on diarrhoeal diseases: problems of methodology. *International Journal of Epidemiology*, **12**, 357–365.

Blum, D., Feachem, R. G., Huttly, S. R. A., Kirkwood, B. R. & Emeh, R. N. (1987a). The effects of distance and season on the use of boreholes in northeastern Imo State, Nigeria. *Journal of Tropical Medicine and Hygiene*, **90**, 45–50.

Blum, D., Huttly, S. R. A., Okoro, J. I., Akujobi, C., Kirkwood, B. R. & Feachem, R. G. (1987b). The bacteriological quality of traditional water sources in north-eastern Imo State, Nigeria. *Epidemiology and Infection*, **99**, 429–437.

Esrey, S. A. & Habicht, J.-P. (1986). Epidemiologic evidence for health benefits from improved water and sanitation in developing countries. *Epidemiologic Reviews*, **8**, 117–128.

Huttly, S. R. A., Blum, D., Kirkwood, B. R., Emeh, R. N., Okeke, N., Ajala, M., Smith, G. S., Carson, D. C., Dosunmu-Ogunbi, O. & Feachem, R. G. (1990). The Imo State (Nigeria) Drinking Water Supply and Sanitation Project 2. Impact on dracunculiasis, diarrhoea and nutritional status. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **84**, 316–321.

Imo State Evaluation Team (1989). Evaluating water and sanitation projects: lessons from Imo State, Nigeria. *Health Policy and Planning*, **4**, 40–49.

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