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The Imo State (Nigeria) Drinking Water Supply and Sanitation Project, 2. Impact on dracunculiasis, diarrhoea and nutritional status

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Abstract

Morbidity due to dracunculiasis (guinea worm disease) and diarrhoea in persons of all ages, and nutritional status of young children, were used as health impact indicators in the evaluation of the Imo State Drinking Water Supply and Sanitation Project in south-eastern Nigeria. Data were collected using repeated cross-sectional surveys and longitudinal follow-up. The study area was found to have a low level of endemicity of dracunculiasis. While no impact could be demonstrated on overall period or point prevalence rates in the cross-sectional surveys, a prospective longitudinal survey showed a significant reduction in the percentage of person-fortnights positive for dracunculiasis in areas served by the project, while the control areas showed no such change. In the cross-sectional surveys it was found that, in the project villages, those persons drinking only borehole water had significantly lower period prevalence rates one year later than others. Moreover, those living further from the nearest borehole had higher rates of dracunculiasis. An impact of the project on diarrhoea morbidity was found only in limited sub-groups of the population. A greater association with water availability rather than quality was suggested for rates in young children. The prevalence of wasting (<80% weight-for-height) among children aged less than 3 years decreased significantly over time in all 3 intervention villages; there was no such decline in the control villages.

Introduction

In Nigeria several state governments have recently undertaken collaborative drinking water supply and sanitation projects with UNICEF assistance, the first of which was implemented in Imo State in the south-eastern part of the country. In accordance with the goals of the International Drinking Water Supply and Sanitation Decade (1981–1990), the elimination of dracunculiasis (guinea worm disease) and the reduction of diarrhoea morbidity were 2 of the main objectives of the project and were thus used as health impact indicators in the project's evaluation.

This is the second of 2 papers summarizing the main findings from the evaluation of the Imo State Project. The first paper described the design of the evaluation and its impact on intervening variables (Blum *et al.*, 1990). Here we present the impact of the project on dracunculiasis, diarrhoea and nutritional status. Epidemiological features of diarrhoea in this community have been presented in an earlier publication (Huttly *et al.*, 1987), as have the results of a study on disability caused by dracunculiasis (Smith *et al.*, 1989).

Materials and Methods

Study area

Details of the project and evaluation designs are described in the accompanying paper (Blum *et al.*, 1990). Five farming villages in the most north-eastern part of Imo State were studied; 3 (Amata, Amena, Amenu) were intervention villages and 2 (Amankanu and Umumgbala) were control villages. Rainfall was seasonal, dividing the year into fairly well-defined seasons—wet (March/April to October) and dry (November to February/March). Before the introduction of boreholes, water for all purposes was obtained from traditional sources which varied according to the season and geographical area. In the wet and early dry seasons, important water sources included rainwater, ponds, unprotected springs, streams, and rivers. As the dry season progressed and surface water dried up, the only available water sources became unprotected springs and rivers. In March 1984 borehole drilling began in the first of the intervention study villages, and by October 1984 all 3 intervention villages were supplied with boreholes at an average borehole-to-population ratio of 1:400. Twice-yearly questionnaire surveys indicated that virtually all households in the intervention villages were using borehole water for drinking by the 1985 dry season. Households in the control area continued to use water from traditional sources. Sanitation facilities before the intervention were poor (mostly bushes and fields). The promotion and construction of ventilated improved pit (VIP) latrines had a delayed start, so that by the end of the study period adults in only 46% of household units in the intervention area were using them. The health education component of the project was found to have limitations. Some changes in knowledge, attitudes and practices related to water and sanitation, and in the management of childhood diarrhoea, were found, but often in both the intervention and control areas.

Data collection

Questions on the prevalence of dracunculiasis and

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diarrhoea were included in twice-yearly water, sanitation, and hygiene surveys conducted over the period February 1983 to May 1986. The 5 villages were surveyed one after another, with a given village surveyed at approximately the same time each season. About 935 wife/child household units in the intervention area and 470 in the control were interviewed, with respective populations of approximately 5100 and 2300. Information was also obtained on water supply and use; water collection time (estimated from the number and time of return trips to the household's main water source per day); sanitation practices; knowledge, attitudes and practices related to water and sanitation; and management of childhood diarrhoea. Data on socio-demographic and socio-economic variables, namely education, occupation and wealth indicators, were collected yearly.

From July 1984, measurements were made of length (using a stadiometer) to the nearest 0·1 cm and weight (using a calibrated Salter scale) to the nearest 0·1 kg of children under 3 years of age. Weight and height were compared with the National Center for Health Statistics standards (HAMILL *et al.*, 1979). Children with weight-for-height below 80% of the standard were considered wasted, while those with height-for-age below 90% were considered stunted.

In addition, daily diarrhoea information was obtained throughout on all children under 6 years of age in the study population in 2 of the intervention villages and both control villages. A dracunculiasis disability survey was also conducted during the final 2 years in a sample of the households participating in this longitudinal diarrhoea survey.

Dracunculiasis

Dracunculiasis is well known and easily recognized in this community, and the questions were asked in the local language, Ibo. Some difficulties were encountered, however, and the questions on dracunculiasis were not standardized until the 1984 wet season. Information collected before this time has therefore been discarded. Two questions were posed, as follows. (i) Does—have guinea worm now? (ii) Did—have guinea worm this season last year? The first question obtained information on the current point prevalence and the second on the period prevalence for the corresponding wet or dry season of the previous year. These data were obtained for all members of a houshold; when present, adults were questioned individually, while mothers responded for their children. There was a lower number of respondents for point prevalence than period prevalence, reflecting the fact that some people were absent from the household unit so that their current disease status could not be assessed. Period prevalence data for the previous year could, however, usually be given by another member of the household.

In May 1986, following the final water, sanitation, and hygiene survey, all households surveyed during the 1985/1986 dry season were revisited to obtain complete dracunculiasis morbidity information for that entire dry season. The following question was posed: Did—have guinea worm at any time during this dry season?

Since virtually no dracunculiasis was recorded during the wet season, only dry season morbidity data are presented from these cross-sectional surveys. The classification into pre- and post- intervention for the data analysis reflect the approximately one year incubation period of the disease and the timing of the water supply intervention.

In addition, a detailed study of dracunculiasis disability was conducted on a sample of household units included in the longitudinal diarrhoea morbidity survey (see below) between February 1984 and May 1986. The methods and results of this survey have been described in detail by SMITH *et al.* (1989): it involved about 15% of the total study household units in 4 villages, with fortnightly visits carried out to determine the presence of dracunculiasis and the extent of the associated disability for each member of the study household unit. Although the primary purpose of this study was to establish the extent and duration of disability associated with dracunculiasis, data on the incidence and prevalence of this disease over a 2-year period (covering pre- and post-intervention periods) were also obtained. This study sample was not representative of the village population; because it was drawn from the sampling frame created for the longitudinal study of childhood diarrhoea, young children were over-represented and adults under-represented. However, this is unlikely to have caused any major bias in the intervention-control comparisons.

Diarrhoea

In the twice-yearly cross-sectional surveys, eight-day period prevalence rates of diarrhoea, corresponding to 2 Ibo weeks, were obtained for all persons living in the household in the 8 d before interview. Diarrhoea in the previous 24 h was also recorded for children under 6 years of age. Diarrhoea was defined as 3 or more stools of a consistency less than normal in a 24 h period.

In addition, all chidren under 6 years of age from the study households in 4 of the villages (2 intervention, 2 control) were included in a longitudinal diarrhoea morbidity survey, involving about 50% of the total study household units in these villages. A system of daily recording of diarrhoea using diaries was coupled with fortnightly home visits. Each mother was issued with a 2-week calendar showing a photograph of each of her children under 6 years of age, and was asked to record daily for each child + or − according to whether or not the child had diarrhoea. The calendars were collected by field workers at the end of each 2 weeks, new ones distributed and information obtained on medications taken during the 2-week period. Further information was also obtained for each episode of diarrhoea that had occurred. Mothers were asked about the perceived cause of the episode, its treatment (including the use of oral rehydration therapy), and the maximum number of stools passed in any 24 h period. Diarrhoea incidence rates and duration of episodes were computed; an episode was defined to be new if preceded by at least 3 diarrhoea-free days.

Results

Impact on dracunculiasis

Longitudinal survey. 465 people were enrolled in the dracunculiasis disability study and followed-up for 2 years, yielding a total of 23 062 person-fortnights of observation. The seasonal pattern was found to be

Table 1. Percentages of person-fortnights positive for dracunculiasis and incidence (data from the longitudinal survey)

	September 1984–May 1985 (pre-intervention)	September 1985–May 1986 (post-intervention)	χ^2 value pre- vs post-intervention
Intervention			
Fortnights positive (%)	49/3593 1·4%	15/3291 0·4%	14·4 ($P<0·001$)
Incidence (per 1000 person-years)	66	24	
Control			
Fortnights positive (%)	78/3321 2·3%	59/2929 2·0%	0·7 ($P>0·25$)
Incidence (per 1000 person-years)	97	73	

Table 2. Period prevalence rates of dracunculiasis (data from the cross-sectional surveys)

Morbidity year[a]	Intervention	Control
1983–1984 (pre-intervention)	90/4862 1·8%	66/2220 3·0%
1984–1985 (pre-intervention)	51/5021 1·0%	55/2179 2·5%
1985–1986 (post-intervention)	96/4515 2·1%	92/1981 4·6%

[a] Disease reported for this dry season (November–February/March) but contracted approximately one year previously, and reported one year later for 1983–1984 and 1984–1985 and a few months later for 1985–1986 (see text).

similar in both areas, with almost all dracunculiasis occurring during September–May and peak rates around November–February/March (dry season/early wet season). The percentage of person-fortnights positive for dracunculiasis during September–May, in 1984–1985 and 1985–1986, is shown in Table 1, together with incidence rates for the same periods. Although this percentage was significantly higher in the control area than in the intervention area in both years, there was a significant decrease in the intervention area from 1984–1985 to 1985–1986 ($P<0·001$) and no such decrease in the control area. This result was confirmed by fitting a log-linear model to the data, which showed that the excess of dracunculiasis in the control area was larger in 1985–1986 than in 1984–1985 ($P<0·005$). Incidence rates during the same periods showed the same trends, but numbers were small and no statistically significant difference in rates was found between the 2 areas or between the 2 years.

Cross-sectional surveys. The point prevalence rates of dracunculiasis, in the intervention and control areas respectively, were 1·1% vs 3·4% in 1985 (pre-intervention period disease contraction) and 0·7% vs 2·6% in 1986 (post-intervention period disease contraction). Period prevalence rates are shown in Table 2, by area and year. Both the point and period prevalence rates were low and the point prevalence showed no significant difference between the pre- and post-intervention periods in either area. It was difficult to make any reliable comparison of period prevalence rates between these 2 periods, since the recall periods were different for the pre- and post-intervention data (one year and a few months, respectively). Analysis by village yielded no different conclusion.

Data from persons enrolled in both the longitudinal and cross-sectional surveys enabled us to assess the under-reporting rates of dracunculiasis over different recall periods. A low reporting rate of 16% (3/19) for one-year recall was found, increasing to 62% (5/8) for the shorter recall period in 1986. Some people reported having dracunculiasis when, according to the longitudinal survey, they did not (2/235 for 1 year recall, 3/335 for the shorter recall period). We have no reason to believe that respondents under- or over-reported dracunculiasis in the longitudinal survey and so we assume that this survey reflects the 'true' results. Thus, overall, the period prevalence rate estimated from the cross-sectional surveys was only 5/344 instead of 19/344 in 1984–1985, suggesting that a recall period of one year underestimated the true rates by a factor of about 4.

Association with drinking water source. When the drinking water sources in the year previous to the survey were considered (reflecting the approximately one-year incubation period of the disease), persons drinking pond water had significantly higher prevalence rates of dracunculiasis during 1983–1984 than those drinking water from other sources, mostly river water. This was true in both the intervention area (2·3% vs 1·1%) and the control area (6·8% vs 2·7%); the summary χ^2 test was highly significant (Mantel-Haenszel $\chi^2=13·8$, 1 degree of freedom, $P<0·001$). Although the same pattern of differences was observed during 1984–1985, the prevalence rates were lower than in 1983–1984, and the difference between the 2 drinking water groups was not significant (1·1% vs 0·5% in the intervention area, 3·4% vs 2·3% in the control area; Mantel-Haenszel $\chi^2=2·5$, $P>0·1$). No significant difference was found in the rates between those who claimed to purify their drinking water and those who did not.

In the intervention area, those persons drinking only borehole water in the 1984–1985 survey had significantly lower period prevalence rates of dracunculiasis in 1985–1986 than those drinking water from traditional sources, sometimes in addition to borehole water (1·9% vs 3·3%, Mantel-Haenszel $\chi^2=12·3$, controlling for the confounding effect of village, 1 degree of freedom, $P<0·001$), whereas their pre-intervention prevalence rates during 1983–1984 and 1984–1985 were similar. Significantly higher 1985–

1986 period prevalence rates of dracunculiasis were also found amongst those living 500 m or more from a borehole than amongst those living closer (2·6% vs 1·4%, Mantel-Haenszel $\chi^2=5{\cdot}4$, 1 degree of freedom, $P<0{\cdot}05$), reflecting decreasing exclusive use of borehole water for drinking as household-to-borehole distance increases (BLUM *et al.*, 1990). Prevalence rates during the pre-intervention years were similar in the two groups.

Impact on diarrhoea

Two aspects of the impact of the project on diarrhoea were considered; the first related to intervention-control comparisons and the second to comparisons within the intervention villages. Where appropriate, confounding variables (for example, age and education) have been taken into account in the analysis by assessing impact on diarrhoea within subgroups.

Intervention-control comparisons. Incidence rates of diarrhoea per child per year and the percentage of days with diarrhoea are shown in Table 3 by village and year for children less than 6 years of age. Overall incidence rates were highest in the early part of the study and tended to fluctuate thereafter, except in one of the control villages, Umumgbala, where rates declined steadily. The incidence of prolonged diarrhoea (defined either as duration ≥8 or ≥15 d) showed some evidence of decreasing over time in one of the intervention villages, Amenu. However, no consistent effect was found either within separate age groups, or in different seasons.

The 8 d period prevalence rates of diarrhoea measured in the cross-sectional surveys were highest in the 0–4 year age group (up to 40%), peaking amongst those aged 6–23 months; they varied between village and survey. No clear indication of a reduction in prevalence rates over time was seen; decreases occurred in some age-village groups but in control as well as intervention areas. Prevalence of diarrhoea in the previous 24 h amongst children under 6 years of age similarly showed no obvious trend. No age-specific or seasonal impacts were found.

Within intervention comparisons. Use of the improved water supplies and sanitation facilities varied among households within the intervention area (BLUM *et al.*, 1990). The 8 d period prevalence of diarrhoea was therefore studied in relation to the exclusive use of borehole and/or rainwater for drinking or for all domestic purposes, the distance to the borehole, household daily water collection time, purification of water, use of a VIP latrine, and knowledge, attitudes and practices related to water and sanitation, controlling for potential confounding variables as appropriate.

Of these factors, only those related to borehole distance, borehole usage, and water collection time showed any consistent relationship with diarrhoea prevalence rates. A household daily water collection time of more than 2 h in the wet season was associated with an approximately three-fold increased risk of diarrhoea among children aged 0–4 years (odds ratio [OR]=2·91, 95% confidence interval [CI]=1·39, 6·09). A similar relationship, although not statistically significant, was found for children aged 5–14 years

Table 3. Incidence rates of diarrhoea per child per year and percentage of days with diarrhoea in children less than 6 years of age, according to village and year

	1982[a] Baseline	1983[a] Baseline	1984[b] Peri-int.	1985[c] Post-int.	1986[c] Post-int.
Amata (intervention)					
Incidence: all episodes	5·74 (65)[d]	4·10 (436)	3·32 (315)	4·36 (931)	3·19 (270)
episodes duration ≥8 d	0·71 (8)	0·37 (39)	0·28 (27)	0·54 (116)	0·36 (31)
episodes duration ≥15 d	0·0 (0)	0·06 (7)	0·02 (2)	0·09 (20)	0·12 (10)
Days with diarrhoea (%)	5·4	4·2	3·3	5·0	3·8
Amenu (intervention)					
Incidence: all episodes	–	4·82 (366)	2·62 (495)	2·66 (835)	2·08 (278)
episodes duration ≥8 d	–	0·46 (35)	0·27 (52)	0·25 (79)	0·17 (23)
episodes duration ≥15 d	–	0·09 (7)	0·04 (7)	0·04 (11)	0·01 (2)
Days with diarrhoea (%)	–	4·6	2·5	2·6	2·0
Amankanu (control)					
Incidence: all episodes	–	5·75 (315)	2·81 (368)	3·05 (531)	2·51 (169)
episodes duration ≥8 d	–	0·16 (9)	0·11 (14)	0·24 (42)	0·15 (10)
episodes duration≥15 d	–	0·02 (1)	0·02 (3)	0·07 (12)	0·0 (0)
Days with diarrhoea (%)	–	4·0	2·1	3·2	2·4
Umumgbala (control)					
Incidence: all episodes	–	6·74 (292)	4·51 (419)	3·42 (428)	2·91 (160)
episodes duration ≥8 d	–	0·60 (26)	0·31 (29)	0·37 (46)	0·31 (17)
episodes duration ≥15 d	–	0·16 (7)	0·06 (6)	0·06 (8)	0·11 (6)
Days with diarrhoea (%)	–	7·0	4·2	3·7	3·3

[a] Baseline data.
[b] Peri-intervention data.
[c] Post-intervention data.
[d] Figures in parentheses are numbers of episodes

Table 4. Percentage of children aged less than 3 years with weight for height below 80% of reference value, according to village and survey

	Survey			
	Wet, 1984	Dry, 1985	Wet, 1985	Dry, 1986
Intervention area				
Amata	6·8 (146)[a]	4·3 (116)	3·9 (154)	2·9 (136)
Amena	4·1 (98)	4·1 (122)	0·9 (115)	3·4 (118)
Amenu	7·7 (221)	4·9 (226)	3·7 (187)	2·2 (179)
Overall[b]	6·7	4·5	3·1	2·8
Control area				
Amankanu	4·0 (126)	4·2 (142)	9·5 (116)	6·4 (109)
Umumgbala	4·9 (82)	2·0 (98)	2·0 (98)	4·4 (90)
Overall[c]	4·3	3·3	6·1	5·5

[a] Numbers of subjects are shown in parentheses.

[b] Summary chi-squared for linear trend in proportions=8·83, 1 degree of freedom, $P<0·005$.

[c] Summary chi-squared for linear trend in proportions=1·02, 1 degree of freedom, $P>0·05$.

(OR=1·97, 95% CI=0·58, 6·62) and for adults (OR=1·08, 95% CI=0·26, 4·44). Children aged 0–4 years who lived in households further than 250 m from a borehole also experienced more diarrhoea (OR=1·23, 95% CI=0·97, 1·55). However, adults from households where water from traditional sources was used, with or without the addition of borehole and/or rainwater, had lower rates of diarrhoea than those from households where borehole and/or rainwater was exclusively used (OR=0·73, 95% CI=0·54, 0·98, for partial use; OR=0·67, 95% CI=0·39, 1·16 for no use of borehole or rainwater).

Impact on nutritional status

The proportions of children with weight-for-height below 80% of the reference value (wasted) are shown by village and survey in Table 4. These proportions declined over time in all 3 intervention villages (summary χ^2 for linear trend=8·83, 1 degree of freedom, $P<0·005$), whilst no such trend was found in the control villages (summary χ^2 for linear trend=1·02, 1 degree of freedom, $P>0·25$). No change over time in the proportions of children with height-for-age below 90% of the reference value (stunted) was found.

Discussion

Our studies suggest that the new water supply had a positive impact on dracunculiasis, despite the low level of endemicity in the villages, which made statistical demonstration of impact difficult. The longitudinal survey showed a significant reduction in the percentage of person-fortnights positive for dracunculiasis in the intervention area while the control area showed no such changes. While not statistically significant, the incidence rates showed similar trends. Since the point and period prevalence rates were similar in the longitudinal survey sample and the village population overall, it is possible that this positive impact on the project occurred throughout the study area. The findings within the intervention area on consumption of borehole water and prevalence of dracunculiasis further demonstrated this impact. Some caution is needed in interpreting the water consumption history data, however, since the information was based on the assumption that an 8 d reference period was representative of the season as a whole. An additional problem, which may partly explain why dracunculiasis was not eliminated from the study area, is that persons continued to be at risk of infection from water consumed away from the home.

A methodological issue raised by our studies was that of illness recall. Illness recall periods influenced the reliability of reporting, particularly for milder illnesses. This has led to recommendations that the optimal recall period for usually mild, self-limiting illnesses, such as diarrhoea, be limited to 1–2 d (BLUM & FEACHEM, 1983). We believed that, since dracunculiasis is a debilitating disease, with more than half of all episodes resulting in severe disability (SMITH *et al.*, 1989), recall periods of one year would give reliable results. Although the numbers are small, our data showed, however, that the disease was not accurately recalled a few months later, and even less so when the recall period was one year.

Studies of water and sanitation projects in many developing countries have shown considerable variation in the impact of the projects on diarrhoea and other water-related diseases (ESREY *et al.*, 1985; FEACHEM *et al.*, 1983; SAUNDERS & WATFORD, 1976). Most of these studies claimed to have shown a positive impact on health, though critical review suggested that many were subject to serious methodological flaws (BLUM & FEACHEM, 1983). Those of a more superior design, however, generally showed the greater reductions both in diarrhoea morbidity rates and total mortality rates (ESREY *et al.*, 1985).

In this study, the degree of heterogeneity within the intervention communities in use of the improved water supply and sanitation facilities, and the fact that some changes in factors that may have an impact on diarrhoea occurred in both the intervention and control areas (BLUM *et al.*, 1990), meant that a straightforward intervention–control comparison of diarrhoea morbidity did not detect a clear impact of the project, and indeed was unlikely to do so unless the size of the effect was substantial. A significant reduction in diarrhoea morbidity was apparent only when the data were analysed by individual household characteristics. Thus only certain sub-groups of the population experienced a significant reduction in diarrhoea morbidity, for example children in households with a lower water collection time (≤2 h) in the wet season. As well as pointing to limitations of the implementation, these findings stress the importance of recording the use of facilities and other related factors.

Multivariate analysis showed that, for young children, factors associated with the availability, rather than quality, of water were associated with a lower diarrhoeal prevalence, supporting the view that water-washed transmission of endemic paediatric diarrhoeas may be more important than water-borne transmission (CAIRNCROSS, 1987). The findings from a small sample of households that no increase in average use of water per person was seen when boreholes were introduced (BLUM *et al.*, 1990), indicated one way in which the health impact of the project may have been limited.

The introduction of boreholes produced considerable savings in water collection times which may have resulted in a health benefit by providing women with more time for childcare and other household work (CAIRNCROSS, 1987; TOMKINS *et al.*, 1978). The similar time savings found in the control area due to the spontaneous formation of a nearby unprotected spring (BLUM *et al.*, 1990) may explain some of the changes in diarrhoeal morbidity rates found in that area. In addition, results from a small sample of households showed that water became heavily contaminated during collection and storage, regardless of the quality at source (BLUM *et al.*, 1990). If such contamination was widespread throughout the community, it would severely limit any impact on diarrhoea morbidity. Water consumed away from the home would also tend to play a limiting role.

It has been suggested that anthropometric indicators are as sensitive as diarrhoeal indicators to improvements in water supply and sanitation, and can be measured more precisely (Esrey & Habicht, unpublished observation, 1983). Furthermore, nutritional status is an indirect indicator of impact on diarrhoea because of the inverse relationship between time spent with diarrhoea and child growth (MARTORELL *et al.*, 1975; ROWLAND *et al.*, 1977). In this study we found a significant decrease over time in the proportion of children under 3 years classified as wasted in the intervention area, with no such decline in the control area, suggesting an impact of the project on acute malnutrition.

Several authors have concluded that sanitation may have a greater impact on diarrhoea morbidity than water supply (ESREY *et al.*, 1985; ESREY & HABICHT, 1986). Given the delay in the sanitation component of this project, a longer follow-up period might have shown a greater health impact than was found here. In addition, results within certain subgroups and indirect indicators suggested that a more 'global' impact would be seen with improvement of project implementation.

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