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Diarrhoea and effects of different water sources, sanitation and hygiene behaviour in East Africa

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Summary Apart from *Drawers of Water* (DOW I) published in 1972, there have been only a handful of published studies on domestic water use and environmental health in East Africa, based on direct observations or other reliable research methods. The objective of this study was to carry out a repeat analysis of domestic water use and environmental health in East Africa based on DOW I. The study was conducted in the same sites as DOW I. Field assistants spent at least 1 day in each household observing and conducting semi-structured interviews. They measured the amount of water collected, recorded the amount of water used in the home, and noted household socio-demographic characteristics, prevalence of diarrhoea, state and use of latrines, sources of water and conditions of use. We surveyed 1015 households in 33 sites in Uganda, Tanzania and Kenya in 1997. From 1967 to 1997, the prevalence of diarrhoea, in the week preceding the survey, increased from 6% to 18% in Kenya and from 16% to 21% in Uganda; it declined slightly in Tanzania (11–8%). Determinants of diarrhoea morbidity included poor hygiene (unsafe disposal of faeces and wastewater), education level of household head, obtaining water from surface sources or wells and per capita water used for cleaning. Hygiene practices are an important complement to improved water and sanitation in reducing diarrhoea morbidity.

keywords East Africa, water, sanitation, hygiene, diarrhoea

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Introduction

Ill health associated with inadequate water supply and sanitation facilities is one of the most significant concerns in many developing countries. Indeed, the primary causes of many childhood illnesses and poor health in Kenya, Uganda and Tanzania are water-related (Sharma *et al.* 1996). Amongst these illnesses, diarrhoea remains one of the most important environmental health problems in developing countries. According to the most recent Global Water Supply and Sanitation Assessment (WHO/UNICEF 2000), there are four billion cases of diarrhoea each year with 2.2 million deaths, most of which occur in children under the age of five. In order to address this and other environmental health issues, the 1990 World Summit for children set a global goal for the provision of universal access to safe drinking water and sanitary conditions by the year 2000 (Bellamy 2000).

This paper draws upon the findings of a large-scale, long-term, repeat, cross-sectional study of domestic water use and environmental health in East Africa, based on the landmark book *Drawers of Water* by White *et al.* (1972) (DOW I). The major objective of our research, in 1997, was to carry out a comprehensive repeat cross-sectional analysis of domestic water use and environmental health in East Africa in the sites covered by DOW I, and to chart major changes and trends that have occurred in domestic water use and environmental health. We also investigated issues related to environmental health, particularly the links between the prevalence of diarrhoea and the nature of water supplies, sanitation facilities and hygiene behaviour.

The issues

The original *Drawers of Water* (White *et al*. 1972) study distinguished between four alternative means of transmission of water-related diseases: water-washed, water-borne, water-based and by water-related insect vectors. Since then there has been a great deal of emphasis on water and sanitation improvement to reduce transmission by these routes.

In a review of more than 60 studies, Esrey *et al*. (1985) found that the median benefits of service improvements in reducing diarrhoea morbidity were 25% from improved water availability, 22% from improved excreta disposal, and 16% from water quality improvements.

But controversy still rages in this area with several consultants questioning the role of water improvements in reducing diarrhoea morbidity. In a cross-sectoral analysis involving eight countries (including Uganda), Esrey (1996) found that sanitation improvements conferred much larger benefits than water improvements. In Indonesia, Wibowo and Tisdell (1993) provided additional evidence of the efficacy of water and sanitation in improving health status.

In a review of 29 studies of diarrhoea prevalence in Uganda, Burton and Wamai (1992) found that the prevalence of diarrhoea, in the 2 weeks preceding the surveys, was 8.6–19.5%. Higher rates of diarrhoea were associated with unprotected sources of water and lack of latrines. In the light of studies such as these, considerable effort has gone into the development of improved water supply and sanitation facilities. However, despite investments in water and sanitation programmes, the population with access to safe water in East Africa remains low as shown in Table 1, which lists WHO/UNICEF figures for service coverage in 1990 and 2000 (WHO/UNICEF 2000). Indeed, in some cases estimated coverage has fallen: the urban water supply in Kenya and Uganda and rural sanitation in Uganda have deteriorated. Changes in total coverage are also affected by the increasing urban population. Almost 42 million people in the three countries do not have access to 'improved' water supply and 13 million do not have access to 'improved' sanitation facilities.

Sanitation service coverage is generally defined as the proportion of the population with access to 'at least adequate excreta disposal facilities that can effectively prevent human, animal and insect contact with excreta'. Suitable facilities range from simple but protected pit latrines to flush toilets with sewerage (WHO 1996). Water supply coverage refers to the proportion of the population with adequate access to safe drinking water in a dwelling or located within a convenient distance from the user's dwelling. Reasonable access implies that the housewife does not have to spend a disproportionate part of the day fetching water for the family's needs; 200 m is regarded as a convenient distance (Rosen & Vincent 1999).

In recent years, the historical emphasis on water and sanitation facility improvements to reduce the transmission of diarrhoeal diseases has shifted, or rather been complemented, by increased attention given to the effects of hygiene behaviour rather than service improvements *per se* (Kolsky 1993; Varley *et al*. 1998). In policy terms, some of the emphasis has shifted to promotion of hygiene behaviour rather than service improvements alone (Kolsky 1993; Esrey 1996). Personal hygiene programmes tend to reduce transmission of water-washed diseases (spread through inadequate personal hygiene) and possibly water-borne diseases (spread through contaminated water) as well.

This study has given us the opportunity to explore the relative importance of different means of transmission of water-related diseases, particularly diarrhoea. The extensive nature of the *Drawers of Water* (DOW II) survey allows for an analysis of the relative importance of different transmission routes, and thus the effectiveness of different policy interventions. The results relating to water source choice and access and water use have been published elsewhere (Thompson *et al*. 2002). This paper sheds light on the possible effects of water and sanitation use patterns, and some aspects of hygiene behaviour, on the prevalence of diarrhoea in Kenya, Tanzania and Uganda.

Materials and methods

The data and results presented in this paper are based upon a survey of households in East Africa. The survey was carried out in 1997 in the 33 East African sites studied in

Table 1 Water supply and sanitation coverage in East Africa 1990 and 2000

	Water supply coverage in 2000 (1990 in parentheses)			Sanitation service coverage in 2000 (1990 in parentheses)		
Country	% Urban	% Rural	% Total	% Urban	% Rural	% Total
Kenya	87 (89)	31 (25)	49 (40)	96 (94)	81 (81)	86 (84)
Tanzania	80 (80)	42 (42)	54 (50)	98 (97)	86 (86)	90 (88)
Uganda	72 (80)	46 (40)	50 (44)	96 (96)	72 (82)	75 (84)

Source: WHO (1996); WHO/UNICEF (2000).

the original 'Drawers of Water' (DOW I) study (White *et al.* 1972). Selection of these sites by the DOW I study team was 'purposive', employing the available field assistants who returned to their home areas to conduct the study. Returning to the original sites, similar research methods were used in 1997 for DOW II. The field assistants were university graduates (DOW I used university undergraduate students) who spoke the local languages and were trained for 2 weeks. The training involved intensive workshops and fieldwork sessions and provided an opportunity for the field assistants to familiarize themselves with the study's objectives and methodology.

Sampling and statistical methods

Sampling

Sample households in sites without a piped water supply were selected using a grid of 21–27 cells over an area of 8 km^2, using the original sampling method of White *et al.* (1972). A point within each cell was selected by using the co-ordinates of randomly selected numbers, and the household nearest the point was chosen for interview. Sampling in piped sites was quite different. Selected households in the piped sites were chosen by systematic random sampling, taking every 10th house beginning at a number selected at random. Piped sites were limited to the original urban areas studied in DOW I.

Data collection

In both DOW I and the present study, respondents were asked whether any cases of diarrhoea had occurred in the household in the last 7 days. The proportion responding positively was used as the 7-day period household prevalence of diarrhoea, and is referred to as the prevalence throughout this paper.

At each unpiped household, we conducted semi-structured interviews with the head of the household or the spouse or the main drawer of water depending on who was available, and collected data on domestic water use, sociodemographic characteristics, prevalence of diarrhoea, state and use of latrines, sources of water and conditions of use.

Wherever possible, reported water use was cross-checked by interviewing other respondents in the household and by observing the actual number of trips to the water source(s). Observations were carried out for 1 day per household, from 6 a.m. to 8 p.m. The actual amount of water used was measured by weighing it on a scale. Water use between 8 p.m. and 6 a.m. was estimated by interviewing household members. Information on environmental health, particularly on the prevalence of diarrhoea and state and use of latrines, was obtained by interview and observation. For piped households, meter readings for a full year were obtained, where available, from the local water or town council office. As in the unpiped households, the interviewers spent a whole day, from 6 a.m. to 8 p.m., in each house to cross-check the information on water use, state and use of toilets, socio-demographic characteristics and prevalence of diarrhoea.

Statistical analysis

This was carried out using SPSS 8.0 (SPSS Chicago) and Shazam 8.0 (White 1997). Normally distributed continuous variables were compared using the Student's *t*-test. Categorical data were compared using the χ^2 test. The logistic regression was carried out on household data and the outcome was whether the household had a case of diarrhoea in the previous week or not. In the first instance, the entire data-set for unpiped households was used.

The independent variables used in the model were as follows (expected directions of association with diarrhoea are shown in parentheses): country (Tanzania, Kenya or Uganda), urban residence (?), litres of water per household member used for cleaning (–) [laundering, washing clothes, bathing and personal hygiene], disposal of children's faeces by 'burying in soil' or 'throwing in garden' (+), using 'open access' water sources, that is surface or well water (+), 'unimproved' pit latrines (+), observed evidence of faeces in the region of the sanitation facilities (+), education level of the head of the household, to reflect socioeconomic status and 'awareness' of environmental health concerns (–), size of household (+), and proportion of children in the household (+). The variables used in the final model were selected based upon consistency in the estimates for the coefficients (both in terms of sign and significance) under different sub-samples and model structures. The final choice of model was also confirmed using SPSS's model choice algorithms.

Results

We surveyed 1015 households in 33 sites in Uganda, Tanzania and Kenya in 1997; 40% were in rural areas and the rest in urban sites, ranging from small towns to capital cities. Fifty per cent (504) of the households had access to a piped water connection. Only 5% of households in rural areas had piped water, against 80% of urban households.

Water consumption rates differed markedly between households with and without piped water. Mean water consumption for those with access was 57.8 l/capita/day, while people without piped water used just 20.7 l/capita/day. However, more remarkable are the figures for water

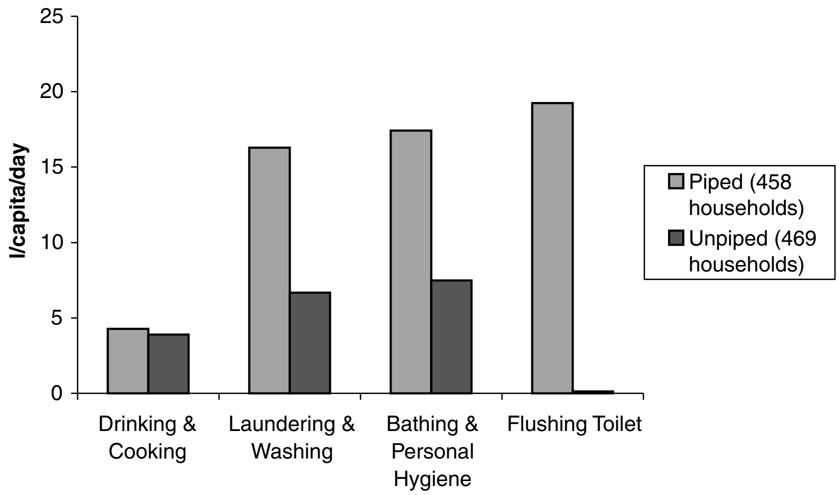

Figure 1 Water use rates for piped and unpiped households by type of water use.

use by type of use (Figure 1). A comparison of DOW I and DOW II reveals a significant decline in mean per capita water use from 61.4 l in 1967 to 38.7 l in 1997.

Diarrhoea prevalence

There is considerable discrepancy between the three countries in terms of the household prevalence of diarrhoea, with Tanzania showing much lower reporting rates (Figure 2). The reported prevalence of diarrhoea has increased in Kenya and Uganda over the three decades and declined a little in Tanzania. The overall household prevalence of diarrhoea in the full study population (all three countries) has hardly changed in 30 years.

Among the sites lacking a water supply, the greatest amount of diarrhoea was reported from Alemi in northern Uganda, a situation similar to what had been observed in DOW I. The focus group discussions in Alemi attributed the high prevalence of diarrhoea to use of contaminated water drawn from seeps, lack of latrines and indiscriminate disposal of children's faeces into the compound. In Iganga, in eastern Uganda, the key informant interviews and direct observations revealed that the town water and sanitation system had broken down, leaving trenches overflowing with sewage and uncollected garbage.

About one-third of the households relying on surface water as their primary source reported at least one case of diarrhoea in the week preceding the survey. Vendors and kiosks appear to be the safest water sources, apparently much safer than water directly accessed through a piped connection (Figure 3).

'Well hand-pumped' means a well fitted with a hand pump. 'Well-pumped' means a well fitted with any other pump such as a diesel pump. 'Reservoir/pond', means ponds and open wells. The 95% confidence intervals are shown by the vertical lines.

The type of sanitation facility also appears to be closely related with diarrhoea morbidity. Among the piped households, 14% of those with a pit latrine had had at least one case of diarrhoea compared with only 7.4% of the households with a flush toilet (Figure 4). Among the unpiped households without sanitation, the prevalence was

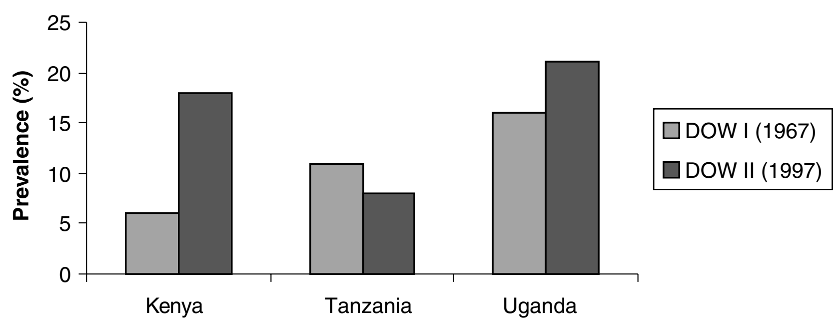

Figure 2 Household prevalence of diarrhoea by country, East Africa 1967 and 1997.

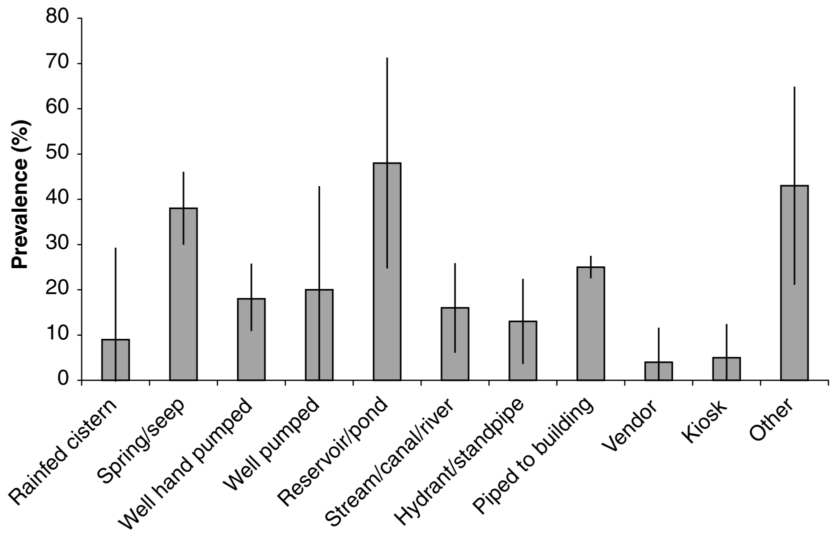

Figure 3 Household prevalence of diarrhoea by type of water source, East Africa 1997.

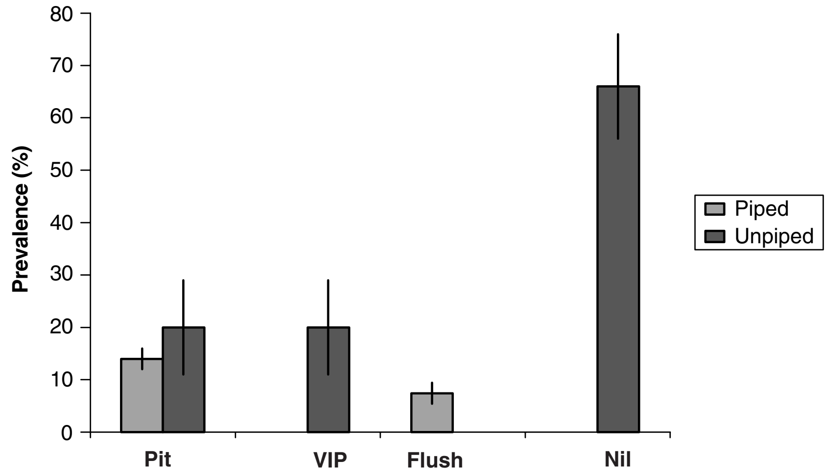

Figure 4 Household prevalence of diarrhoea by sanitation, in piped and unpiped households 1997. VIP: Ventilated Improved Privy. Vertical lines show 95% confidence intervals.

66%, while for those with a pit or VIP latrine the figures were about 20%. Comparison with figures for DOW I is not possible as no comparable data were collected on sanitation facilities in the DOW I study.

Table 2 summarizes the strength of the bivariate relationships which exist between the prevalence of diarrhoea and various factors associated with water supply, sanitation facilities and hygiene practices.

Results of multiple regression analysis

Multiple logistic regression analysis was used to disentangle the separate influence of various factors (White 1997). Perhaps most surprisingly, the variables for use of unimproved toilet facilities (pit latrines) and for the observed presence of faeces near the toilet were not significantly associated with diarrhoea in this analysis. However, a

Table 2 Factors associated with diarrhoea morbidity (in the bivariate analysis), East Africa 1997

Factor	Odds ratio	95% confidence intervals
'Unsafe' disposal practice for children's faeces	2.73	1.55–4.80
'Unsafe' method of waste water disposal	3.43	2.26–5.22
Faecal matter in toilet surroundings	2.60	1.26–4.04
Household has an unpiped water supply	2.40	1.76–3.29
Household is located in a rural site	3.06	2.27–4.13
Household lacks sanitation facility	2.40	1.76–3.29

Table 3 Coefficient estimates for diarrhoea morbidity in the multivariate estimation, East Africa 1997

	Coefficient (B)	Standard error	*P*-value	Odds ratio
Urban location	−0.547	0.260	0.036	0.579
Number of household members	0.061	0.031	0.053	1.063
Use surface waters	0.556	0.282	0.048	1.745
Own private latrine	−0.853	0.309	0.006	0.426
Water use for cleaning and bathing	−0.044	0.014	0.001	0.957
Bury children's faeces in the soil	1.213	0.351	0.001	3.362
Constant	−0.533	0.418	0.202	0.587

number of other variables did show significant associations of the expected sign. Interestingly, the type of sanitation facility was not important, but ownership of a toilet (of whatever kind) was, with a corresponding odds ratio of 0.43. The use of surface water was also of the expected sign and significance. The result indicates that households which used surface water as their primary source increased the odds of reporting diarrhoea in the last week by 1.75 (Table 3).

Two behavioural variables were important: use of water for household cleaning (laundering, washing clothes, bathing) and personal hygiene was significant, with each unit increase in water consumption (l/capita/day) reducing the odds by a factor of 0.96. Similarly, burial of children's faeces in the soil appears to be positively and significantly associated with reported incidence of diarrhoea, with an odds ratio of 3.36.

None of the dummy variables for the countries was significant, indicating that the differences between countries were explained by other factors included in the model and not other country-specific effects. The model predicts over 85% of the reported cases correctly.

Discussion

In this study we had a unique opportunity to compare the prevalence of diarrhoea as recorded in 1967 and three decades later in 1997, in the same study sites in East Africa. The situation seems to have deteriorated with the prevalence going up considerably in the Kenyan and Ugandan sites, but with some improvement in the Tanzanian sites. We attempted to gain an insight into the determinants of diarrhoea morbidity in households in East Africa. The findings are consistent with previous reviews by Kolsky (1993) and Varley *et al.* (1998).

Multivariate regression did not indicate that the type of sanitation facility was a statistically significant determinant of the prevalence of diarrhoea. However, private ownership of sanitation facilities (of whatever type) was significant. Thus, it is not necessarily the type of sanitation facility which is important, but rather the conditions of use. Bivariate analysis indicated that the likelihood of there being a case of diarrhoea in a particular household was greater for unpiped households than those without a piped water connection. When multivariate analysis was performed on the entire data set including the piped households, whether or not a household had piped water connection did not emerge as a significant determinant of diarrhoea prevalence. This might be the result of the fact that it was mainly the surface water that predisposed to diarrhoea rather than the whole range of unpiped sources.

The effect of alternative water sources for unpiped households is telling: 33% of households which relied on surface water as their primary source reported at least one diarrhoea case in the week preceding the survey. However, the precise type of surface water is important, with households relying upon seeps, springs, reservoirs and ponds having much higher rates of incidence than those relying upon streams or rivers. Indeed logistic regression analysis revealed that use of surface water increased the odds of reporting a case of diarrhoea in the last week by a factor of 1.75. This is broadly consistent with findings by Manun'ebo *et al.* (1994) who reported a significant association between diarrhoea prevalence and drinking water source.

Vendors, kiosks, piped (direct and indirect) sources appeared to be relatively safe (at least in terms of prevalence of diarrhoea). However, when the confidence intervals are taken into account, this observation becomes statistically insignificant. There are assertions from other developing countries that vendors usually sell water of dubious quality (Oyemade *et al.* 1998), which seem to relate to 'mobile vendors.' Unfortunately one shortcoming of our study is that we did not distinguish between static and mobile vendors. Another shortcoming is the Hawthorne effect. It is possible, but difficult to verify, that people changed their patterns or amounts of water use because they were being observed.

Given that reliance upon particular types of surface waters was a significant determinant of diarrhoea rates, having access to piped water would seem to be important in areas where other alternatives are not available. This is both because of the potential benefits in terms of water quality, and because of the implications for water consumption rates. Mean daily water consumption for those with a piped water connection was 57.8/l/capita, for those without it was just 20.5/l/capita.

A comparison of DOW I and DOW II reveals a significant decline in mean per capita water use from 61.4 l in 1967 to 38.7 l in 1997. This decline in the amount of water available, especially in the urban areas in the region, means that people's health and hygiene are likely to be affected.

When there is not enough water to go round, it means that there is less water for cleaning utensils, for washing hands after defaecation or handling children's faeces, or for regular baths, cooking and eating. However, it is important to note that this decrease is largely a reflection of the almost universal decline in water use by households with a piped connection. While water use in unpiped households almost doubled, use by piped households decreased by more than 50%.

Despite the increase in the amount of water available per capita in unpiped households, the amount used (just over 20 l/capita/day) is hardly adequate. In particular, unpiped households use less than half the amount of water used by households with piped connections, for bathing, washing dishes, clothes and house cleaning. This is similar to findings by Cairncross and Cliff (1987) in Mozambique. Recent studies have demonstrated that many diarrhoeal diseases can be prevented or reduced by improving water-related hygiene behaviour (Esrey 1996; Hoek *et al.* 1999).

Other hygiene-related factors also appear to be important determinants of the reported prevalence of diarrhoea in the study sites. While there is no single proxy for hygiene behaviour, regression analysis showed that the means of disposal of children's faeces was important: Reported disposal of children's faeces by burying in the soil increases the odds ratio of reporting a case of diarrhoea rate by a factor in excess of three. It appears that the type of water source, the amount of water used for cleaning and bathing (which is linked to access to water sources), ownership of a latrine or other sanitation facility, and hygiene practices such as disposal of children's faeces are important determinants of the incidence of diarrhoea.

While there is a clear and pressing need for increased levels of investment in water and sanitation facilities in East Africa, well-designed hygiene programmes must accompany these improvements or some of the environmental health benefits will be lost.

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