Away-from-home drinking water consumption practices and the microbiological quality of water consumed in rural western Kenya

W. Onyango-Ouma and Charles P. Gerba

ABSTRACT

A cross-sectional descriptive study was conducted to examine away-from-home drinking water consumption practices and the microbiological quality of water consumed in rural western Kenya. The study involved adults and schoolchildren. Data were collected using focus group discussions, questionnaire survey, observations, diaries and interviews. The findings suggest that away-from-home drinking water consumption is a common practice in the study area; however, the microbiological quality of the water consumed is poor. While some respondents perceive the water to be safe for drinking mainly because of the clear colour of the water, others are forced by circumstances to drink the water as it is owing to a lack of alternative safe sources. It is concluded that there is a need for new innovative approaches to address away-from-home drinking water consumption in resource-poor settings in order to complement and maximize the benefits of point-of-use water treatment at the household level.

Key words | drinking water quality, Kenya, Lifestraw™, point-of-use water treatment, resource poor settings, water consumption practices

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INTRODUCTION

In many resource-poor settings microbial contamination of household drinking water is implicated in the prevalence of various diseases (Gundry *et al.* 2004). In such settings water sources are communal and are either unimproved (e.g. unprotected wells, springs and rivers) or improved (e.g. protected wells, boreholes and springs). Numerous studies have clearly shown that improving the microbiological quality of household water on-site, or point-of-use treatment and safe storage in improved vessels reduces diarrhoeal and other waterborne diseases in communities and households of developing countries (Makutsa *et al.* 2001; Sobsey 2002; Clasen *et al.* 2006; Tiwari & Jenkins 2008). A variety of technologies for the treatment of household water (point-of-use water treatment technologies), including physical and chemical methods, have been developed and are widely used in many parts of the world. Interventions to improve the microbiological quality of drinking water include conventional improvements at the water source (e.g. protected wells, boreholes and stand posts) and point-of-use interventions at the household level (e.g. chlorination, filtration, solar disinfection and combined flocculation and disinfection) (Clasen *et al.* 2006). These methods can be used to ensure that drinking water in the home is free from microbial contamination.

Point-of-use household water quality interventions have been recommended for improving water quality in resource-poor settings (Freeman *et al.* 2009; Nadine *et al.* 2009) partly because of the costs involved in the provision of safe water supply to households. Home water treatment and safe storage (HWTS) often incorporates water treatment, safe storage containers and behaviour change communications as is the case with the Safe Water System developed by Centers for Disease Control and Prevention and the Pan American Health Organization (CDC 2000; Freeman *et al.* 2009). Available evidence from field trials shows that

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HWTS is now recognized as a cost-effective means of reducing diarrhoeal disease, and improving water quality and access to safe drinking water.

However, although HWTS has been proved to be effective, its protective benefits are limited to the home environment and it does not take into consideration away-from-home drinking water consumption practices. In settings where people spend a substantial part of the day outside their homes looking for means of livelihood, away-from-home drinking water consumption is likely to be the norm rather than an exception. The challenge is how to maximize the benefits of HWTS to vulnerable populations by minimizing the risk of drinking contaminated water outside the home. As noted by Elsanousi *et al*. (2009), the potential health impact of HWTS is lost if people still drink contaminated water outside of the home. This calls for a multiple barrier approach (Sobsey 2002) where two or more treatment technologies are used to maximize benefits by creating multiple barriers in and away from home.

There is a shortage of information on water consumption outside the home especially in rural areas. However, it is possible that point-of-use water treatment in the household including protection from waterborne pathogens is compromised by the consumption of poor quality drinking water away from home. Little is known about the quantities or quality of water consumed by people in the course of their daily activities away from their homes, and the need for technological or behavioural solutions to reduce the potential health risk resulting from away-from-home water consumption is also unknown.

This study explores water consumption practices away from home in rural Africa as well as the microbiological quality of water consumed. The results of this study show that there is a need to focus attention on away-from-home drinking water consumption practices and treatment since this represents a significant proportion of the daily drinking water consumed.

MATERIALS AND METHODS

Study site and population

The study was carried out in Matete Division, Lugari District, western Kenya. The study covered rural communities, mainly subsistence agriculturalists and small traders as well as schoolchildren. Sites were chosen on the basis of feasibility in terms of logistics and community contacts and were representative of such communities in that area. Households included in the study represented a balance between subsistence agriculturalists and small traders spread across the four locations in the division.

The study was conducted in collaboration with World Vision, Kenya. World Vision has identified Matete Division in Lugari District as a programme development area and intends to initiate water and sanitation projects in the near future. It is envisaged that future programmes by World Vision in the area would benefit from the results of this study.

Methods of data collection

The study used a combination of qualitative and quantitative methods. Multiple methods allowed triangulation of findings to help ensure accuracy. The methods included questionnaire surveys, focus group discussions (FGD), diaries and interviews, and water quality assessment techniques. The data collection tools were pilot tested and revised before use in the final data collection.

Assessment of away-from-home water consumption practices

Questionnaire survey. A questionnaire survey was used to determine away-from-home drinking water consumption practices and to get an indication of the frequency with which water was consumed outside the home. Households (105) were conveniently selected from the four locations in the study area and the questionnaire administered to the household head. The questionnaire dealt with, among others, socio-demographic information, activity patterns, water handling and treatment practices, and water consumption outside of the home.

Focus group discussions. Focus group discussions (FGD) were used to generate a general picture of activity patterns and associated water consumption practices. Separate discussions were held with men, women, schoolboys and schoolgirls, with 8–10 participants enrolled in each focus group. Adult participants were conveniently selected ensuring gender and location representation. Primary schoolchildren were randomly selected from students in grade six. Adult FGD were mixed while separate FGD were held for boys and girls. Focus groups were exploratory and sought to clarify issues emerging from the survey and observations. The FGD covered a range of issues including the daily/weekly activity patterns, food and drink consumption patterns, and water consumption away from home. A total of eight FGD were held (four for adults and four for schoolchildren).

Observation. Direct observation was used to triangulate the findings of the FGD and to uncover additional information. Observations were made on daily activities, sources of drinking water outside the home and the physical status of water sources (e.g. whether protected or not).

Water consumption diary and interview. Water consumption diaries were used as a quantitative survey tool to investigate the frequency with which different drinks were consumed and an indication of the quantities. The diaries were developed following the FGD and observations and used locally appropriate drink categories. Diaries were supplemented with follow-up interviews at the end of the day to ensure that all relevant events have been recorded.

Ten households were randomly selected from the 105 survey respondents to complete water consumption diaries. The head of the household, man or woman, completed the diary depending on who was available at the time of the study. In addition 10 schoolchildren (5 girls and 5 boys) were asked to complete water consumption diaries. Semi-structured interviews were used to explore the reasons why particular sources of drinking water were chosen and the dimensions along which water quality was assessed.

Assessment of the quality of water consumed outside of the home

To assess the microbiological quality of away-from-home drinking water, samples were collected from 12 sources identified in the questionnaire survey and during observations. The samples were collected as aseptically as possible and kept at about 4 °C immediately after collection (cool box with ice used). Two samples were collected from each source. The enumeration of the total coliforms and *Escherichia coli* were done via the membrane filtration technique using m-ColiBlue24® (Grant 1997) incubated at 37 °C (results read after 24 h of incubation) and the Colilert® Quantitray® 2000 technique (IDEXX Laboratories, Inc., USA) with a 35 °C incubation during 24 h. Turbidity was measured by use of a calibrated and standardized turbidimeter. The analysis of the samples was conducted at the Government Chemist Laboratories in Kisumu City, Kenya.

RESULTS

Socio-economic and demographic profile of the study population

Questionnaires were administered to 105 adult residents in four locations in Matete division, Lugari district. The respondents had a mean age of 38.9 years and a median of 36 years. Most respondents (92%) had children with the average number five. Table 1 captures the socio-economic and demographic characteristics of respondents.

From the results it is evident that most of the respondents only had a primary education (40%) and were mainly peasant farmers (51%) and petty traders (17%). Average monthly incomes were also very low with 80% earning Ksh10,000 (US$134) or less while 14% had no reliable monthly income.

Water consumption practices outside of the home

The study examined the practice of drinking water by people on a daily basis while away from their places of residence. Observational data and respondents' diaries indicate that a majority of the study population spent a significant amount of time outside their places of residence which necessitated obtaining drinking water from other sources. While schoolchildren spent most of the day in school (08.00–17.00 h), adults were engaged in occupations that kept them away from home for most of the day. Survey data shows that 51% of adults engage in peasant farming while another 17% were petty traders. Adults participate in agricultural activities more or less throughout the year because the area receives moderate to high rainfall throughout the year.

Table 1 | Respondents' socio-demographic characteristics

Characteristic	Frequency ($N = 105$)	Percentage
Sex		
Male	35	33
Female	70	67
Marital status		
Married	94	89.5
Single	4	3.8
Widowed	5	4.8
Divorced	2	1.9
Have children?		
Yes	93	88.6
No	12	11.4
Education		
No education/primary incomplete	35	33.3
Primary	42	40.0
Secondary	26	24.8
College	2	1.9
Main occupation		
None	16	15.2
Peasant farmer	54	51.4
Business/trader	18	17.2
Formal employment/teacher/chief etc.	8	7.6
Mechanic, factory worker, labourer	9	8.6
Average monthly income (Ksh)		
None	15	14.3
<1,000	45	42.9
1,001–5,000	31	29.5
5,001–10,000	9	8.6
>10,000	3	2.8
Not indicated	2	1.9

An investigation into the daily activity patterns in the area shows that adults spend most of the day in fields cultivating crops or looking after domestic animals (cattle, sheep, goats, etc.). Adult men also engage in brick-making for commercial purposes. Focus group data revealed that most adults and schoolchildren only returned to their residences in the evening after completing their tasks for the day.

Respondents were more likely to consume water outside their homes since they engaged in daily activities, which kept them away from their homes. When asked the type(s) of drinks they consumed outside the home, 80% of the survey respondents mentioned water. Other drinks consumed included soda, traditional beer, tea and milk. Water was, however, the main drink consumed outside home and the frequency and amount tended to increase during the dry season when people were thirstier than during the rainy season. Survey results on the frequency of drinking water outside home showed that 11% of the adults consumed water every day, 86% occasionally, and only 3% never consumed water outside home. This is consistent with focus group data with schoolchildren which revealed that frequency of water consumption outside home was high.

When asked whether they took water outside the home the day preceding the interview, 41% said they did, 52.3% did not while 6.7% did not respond. Of those who stated they had consumed water outside the home, 19% took one glass (approximately 125 ml), 55% took 2 glasses (approximately 250 ml), and 26% took more than two glasses (>250 ml). Water consumption diaries data (Table 2) completed by 20 respondents provides additional information on the frequency of daily water consumption in terms of the specific hours respondents consumed water during the day at home or away from home. Given the daily activity patterns of the respondents (e.g. working in the fields or attending school) it is most likely that the water consumption during 9.00–11.00 and 15.00–17.00 occurs outside home.

Table 3 shows the sources of drinking water outside of the home in the study area. The main sources of drinking water were rivers (31%), boreholes (14%), springs (4%) and wells (4%). Two rivers (Chevaywa and Nzoia) traverse the study area and appear to be sources of water to many

Table 2 | Frequency of daily water consumption ($N = 20$)

Time/period (time of day)	No. of adults	No. of children	Total
6–8	6	7	13
9–11	7	8	15
12–14	9	10	19
15–17	6	9	15
18–20	10	8	18

Table 3 | Sources of water consumed outside the home

Source of drinking water	Frequency ($N = 42$)	Percentage
Rivers	13	31.0
Boreholes (privately owned)	6	14.3
Springs	4	9.5
Wells	4	9.5
Water kiosk (tap water)	2	4.8
Hotel/food kiosk	1	2.4
Bottled water	1	2.4
Source unknown[a]	11	26.1

[a]Represents those who took water from neighbours and did not know the source.

people while they are outside the home. This finding concurs with the daily activities of working on farms and herding animals where rivers and springs provide ready sources of drinking water. Boreholes and wells situated in schools and various strategic points in the village also provide easy sources of drinking water while outside of the home. Water kiosks/taps and hotel/food kiosks accounted for about 7.2% of sources of drinking water consumed outside the home. Individuals who consumed water from these sources were mainly traders and business people operating at the market. However, observation data showed that water found in water and food kiosks were from other sources such as rivers, springs, wells and boreholes.

Microbiological quality of water consumed outside the home

An assessment of the microbiological quality of water sources (Table 4) was conducted to provide an indication of the safety of drinking water consumed away from home. The sources were mentioned in the diaries and the survey questionnaire and respondents reported that they were used for both home and away-from-home consumption. For instance, the boreholes in the two primary schools, which schoolchildren depended on for drinking water while away from home, were also the sources of water for household use in the nearby homesteads.

Overall, the results show that all the water sources tested had water of poor microbiological quality and were unfit for consumption before treatment or filtration. Total coliforms were high in all sources and too numerous to count in shallow wells with no pumps, and in rivers and unprotected springs. While *E. coli* were absent or negligible in protected water sources (such as protected springs and boreholes), they were present in very high numbers in unprotected water sources such as rivers, shallow wells with no pump and unprotected springs. *Escherichia coli* were detected in all unprotected springs and shallow wells. All the water sources were within the acceptable range in terms of normal turbidity units with the exception of river sources.

Table 4 | Laboratory results: microbiological quality of water consumed

Source	Total coliforms/100 ml MF (37 °C)	Total coliforms/100 ml Colilert®	*E. coli*/100 ml MF (37 °C)	*E. coli*/100 ml Colilert®	Turbidity (NTU)	pH
Chepsai primary school (borehole)	62	74	5	6	3.0	6.6
Wafula shallow well (no pump)	TNTC	>2,420	4	5	12.5	6.5
Chevaywa (river)	TNTC	>2,420	TNTC	>2,420	61.6	6.8
Cheusi spring (unprotected)	TNTC	>2,420	TNTC	>2,420	29.4	6.7
Nzoia river	TNTC	>2,420	TNTC	>2,420	146	6.8
Kivaywa school spring (protected)	53	60	NIL	<1	1.2	6.6
Musitia s/well (no pump)	TNTC	>2,420	TNTC	>2,420	13.8	6.6
Simiyu s/well (no pump)	TNTC	>2,420	64	99	5.4	6.5
Kaburengu spring (protected)	TNTC	>2,420	7	9	9.7	5.9
Matete primary school (borehole)	6	10	0	<1	2.7	6.1
Ngovilo spring (unprotected)	TNTC	>2,420	26	22	16.6	6.2
Khisa s/well (no pump)	TNTC	>2,420	TNTC	435	15.3	6.2

Notes: Results expressed in CFU/100 ml (colony-forming units); TNTC = too numerous to count; MF = membrane filtration.

Observations confirmed that water from wells, springs and boreholes was very clear and not muddy.

The Kenya standard, KS 05-459 PART 1:1996 (KEBS 1996), for potable water requires that the total and faecal coliform counts *must* be nil/100 ml and turbidity *must* be less than or equal to 5 NTU. While no Kenyan standard has been formulated for untreated water, the World Health Organization (WHO 2008) requires that for untreated water the total coliform count *must* not be more than 9/100 ml for three consecutive samples and the faecal coliform count *must* be nil/100 ml.

Perceptions of the quality of water consumed outside of the home

Sixty-three per cent of those who consumed water outside the home did not know whether or not the water was treated, 25% were sure the water was untreated and only 12% thought the water they took was treated. Those who claimed the water they consumed was treated reported that it was from borehole and tap sources. It could well be that these respondents thought the water was treated simply because it was from protected sources such as taps and boreholes. But when asked whether they considered their sources of water safe for drinking without any treatment, a significant proportion (65.4%) reported that they considered the water safe for consumption.

FGD explored the study population's perceptions of quality of water consumed away from home. The findings revealed that nearly all the participants perceived the water they consumed away from home as safe for consumption. This perception was reinforced by the clarity of water collected from the water sources in the area. Participants argued that since the water was clear it was safe for consumption without purification or treatment.

Reasons behind choice of drinking water outside of the home

Respondents were asked the reasons behind their choice of drinking water away from home (Table 5) and the findings show that cleanliness (63%) and colour (61%) are the most important factors influencing choice of drinking water outside the home in the study area. Other factors include safety, water source, smell and water container.

Table 5 | Reasons behind choice of drinking water outside the home (multiple responses)

Reasons	Frequency ($N = 105$)	Percentage
Cleanliness	66	63
Colour	64	61
Safety	6	5.7
Smell	2	2
Water container	2	2

FGD showed that cleanliness of water was judged by naked eye and simply implied that the water was clear and not muddy. Probing revealed that there was no clear-cut difference between what the informants meant by cleanliness and clear colour. It appears that clear water was considered as clean. Clear water interpreted as clean water could also be the respondents' justification for taking river water outside the home since it is clear most of the time except during the rainy season.

Although the respondents mentioned safety as a reason behind their choice of drinking water outside of the home it is not clear how they assessed safety of the water before deciding to drink water or not. It seems that safety of the water was based on the perceived cleanliness and colour of water.

Semi-structured interviews revealed a more mundane reason behind choice of drinking water outside of the home in the study area. Informants reported that accessibility was the single most important reason. Informants stated that given the circumstances under which they perform their daily chores (under the scorching sun) they often have no choice but to quench their thirst in the nearby water sources irrespective of the condition of the water. Hence both adults and schoolchildren fetching firewood or looking after cattle would resort to the river as the source of drinking water, as it is the most accessible at that point in time. The same would apply to those working on farms or making bricks. Schoolchildren would also opt for boreholes situated in schools for drinking water during the school hours.

The cleanliness of the water container (e.g. mug) was mentioned to be an important reason behind their choice when residents sought drinking water from other peoples' homes either on their way to church, market or when visiting relatives. It is customarily acceptable to request drinking water from the homes of others in the study area. Under such circumstances the condition of the water container in which drinking water is provided becomes an issue for consideration. Some individuals reported that they would refuse to take the water if the container was dirty.

DISCUSSION

The finding that the respondents in this study consumed drinking water outside of the home has implications for HWTS treatment technologies (CDC 2000; Makutsa *et al*. 2001; Sobsey 2002; Gundry *et al*. 2004). The focus of HWTS technologies has been on improving the microbiological quality of drinking water at the household level leaving away-from-home drinking water consumption unaddressed. Yet according to our findings the practice of drinking water away from home is common and reflects a significant proportion of daily water consumption. The demand for drinking water away from home is necessitated by daily activity patterns, which keep people out of their residences for long hours. The practice observed in the study area is typical of most rural settings in Africa where local populations engage in subsistence agriculture, pastoralism and gathering economy as means of livelihoods. Very often in such settings access to safe drinking water from protected sources is limited (Makutsa *et al*. 2001) and populations have to rely on unprotected sources such as ponds, rivers, springs and wells.

The assumption in HWTS technologies is that people in areas with limited access to safe drinking water would ferry water from the source to the household for storage and use; hence the need to treat water and store it in appropriate containers that guarantee safety. While there is no doubt that this strategy improves the quality of drinking water (Gundry *et al*. 2004; Clasen *et al*. 2006; Freeman *et al*. 2009) and is accessible to many people, the findings of this study suggest that there is need to also focus on away-from-home drinking water consumption. It is clear that local populations in resource-poor settings, which are the target of HWTS initiatives, consume drinking water outside the home as dictated by daily activity patterns.

The volume/quantity of water a person consumes in a day is essential in estimating the risk of exposure to waterborne pathogens (Pintar *et al*. 2009). Although our study relied on questionnaire recall and personal diaries to estimate the quantity of water consumed it is clear that the quantities of water (125–250 ml) reported to be consumed outside the home are not negligible. It is possible that the quantities are higher than those reported and capturing this may require more rigorous methods as shown by Pintar *et al*. (2009). Nevertheless, the findings are a clear indication that consumption of drinking water outside the home is common and occurs to a level at which we need to be concerned about the microbiological quality of water that is consumed (Clasen *et al*. 2006; Elsanousi *et al*. 2009).

In the study area it is evident that the drinking water consumed by people away from their homes is of poorer microbiological quality. As shown in the water quality assessment results (Table 4), all sources of drinking water outside the home in the area (protected or not) are contaminated. None of the water sources measures up to the Kenyan (KEBS 1996) and WHO (2008) standards of water quality for human consumption. Even the boreholes in schools used by schoolchildren and the households in the villages surrounding the schools are not safe for consumption as widely believed by the residents.

Although the microbiological quality of the water sources was found to be poor, the study population on their part thought the water was safe for drinking without any form of treatment or purification. Water safety (quality) was assessed on the basis of colour and since most water sources in the area are clear, respondents concluded that the water was safe for drinking without any further treatment. This is concurrent with the turbidity measures (Table 4). Judging water on the basis of colour could explain why residents of the area drink water from sources such as rivers and springs while away from home. The clarity of the water from such sources seemed to have blurred the respondents' assessment of the microbial quality of the water. Water from boreholes (with pumps) and protected springs were considered to be safe because the sources were protected. Respondents argued that since the sources were protected the water was likely to be safer for consumption. The study population did not appear to be aware of the risks of such sources especially the fact that protection did not imply that the water was safe for drinking.

These findings draw our attention to a new dimension of drinking water consumption that has received little attention in the literature. So far attention has been on point-of-use water treatment with a number of water treatment technologies directed at improving the quality of drinking water at the household level (Sobsey 2002; Tiwari & Jenkins 2008; Freeman *et al*. 2009). However, in the light of the findings of this study HWTS approaches are potentially likely to fail in resource-poor settings where local populations routinely consume drinking water from contaminated sources outside the home. There is therefore need for new innovative approaches that would address out-of-home drinking water consumption in order to complement and maximize the benefits of HWTS.

The LifeStraw™ (Elsanousi *et al*. 2009) is such an innovative approach, which can potentially be used to purify/filter water both at home and outside the home. Its advantage over the HWTS approaches lies in the fact that it is easy to transport and use outside the home. One can easily insert it into a water source such as a river or spring and drink water directly as it is purified without necessarily using another container to draw water. The product is designed for resource-poor settings and is affordable.

The study design was exploratory and sought to explore away-from-home drinking water consumption practices using qualitative methods supplemented by a short questionnaire survey. This has implications for the level of analysis. Although the study was exploratory it did include quantitative assessments of the microbiological quality of sources of water consumed in the study area. Triangulation of data allowed us to show that the drinking water consumed outside the home in the study area is of poor microbiological quality. Thus despite the limitation of the design, this study makes a significant contribution by documenting the away-from-home drinking water consumption practices and the quality of the water consumed.

CONCLUSIONS

The findings of this study have a number of implications for practice and research:

- Away-from-home drinking water consumption is a common practice in resource-poor settings. The amount of water consumed is not negligible and is a significant proportion of daily drinking water consumption.
- The microbiological quality of the water consumed outside the home is poor and therefore exposes populations in resource-poor settings to the risk of infection from waterborne diseases. Although the microbiological quality of the water is poor, local populations perceive the water to be safe for drinking and are sometimes forced by circumstances to take it without any form of treatment or purification/filtration.
- There is need to focus attention on away-from-home drinking water consumption in terms of water treatment technologies and behaviour change in order to minimize the risk of infection from contaminated water. A multiple barrier approach that addresses both point-of-use water treatment at the household level (HWTS) and away-from-home drinking water consumption is required to improve water quality in resource-poor settings.

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