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High rate of drinking water contamination due to poor storage in squatter settlements in Mwanza, Tanzania

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Abstract

Background: Drinking water of acceptable quality is supposed to be free from faecal coliform and chemical substances that may be hazardous to human health. Water treatment and safe storage at the household level has been advocated as effective means of ensuring safe drinking water. This study was undertaken to determine the microbiological quality of the drinking water at household level in the squatter settlements in the city of Mwanza, Tanzania.

Methods: A cross-sectional study was conducted between June 2014 and September 2014. A total of 15 randomly selected water sources (tap) and 207 households' drinking water samples from these sources were studied to ascertain level of water contamination using Membrane Filtration Method. Pre-tested questionnaire was used to collect demographic and other data regarding water treatment and storage. Data were entered, cleaned and analysed using STATA Version 11.

Results: All 15 samples from tap used as water sources were found to be free of indicator organism (*Escherichia coli)* while 109 (52.66%) of drinking water samples from 207 households were found to be contaminated with *E. coli.* All contaminated drinking water samples were from containers with no cover and spigot.

Conclusions: There is a significant level of deterioration of water quality from the source to the drinking cup. Efforts to ensure quality storage methods for drinking water should be addressed at household level.

Keywords: *Escherichia coli,* drinking water, water storage, clay pot, squatters, Tanzania

Introduction

Safe drinking water is a powerful environmental determinant of health and a foundation for the prevention and control of waterborne diseases (Bartram *et al*., 2005). Household drinking water of acceptable quality is supposed to be free from total or faecal coliforms and chemical substances which may be hazardous to human health (Kihampa, 2013). According to the World Health Organization (WHO) and Tanzania drinking water guidelines, the microbiological standards for drinking water requires that drinking water should not contain any total or faecal coliform in each 100 ml of water (WHO, 1998; NBS, 2010). The presence of faecal coliform should be considered as an indication of recent faecal contamination (Hörman, 2005). *Escherichia coli* has been used as the best biological indicator of faecal contamination due to the fact that it does not multiply well in the environment but can be found in mammal faeces at concentration of 10 log 9-1 (Edberg *et al.*, 2000). *E. coli* can be detected in the stored drinking water at temperature of 15-18^{o}C within 4-12 weeks after contamination (Edberg *et al*., 2000).

Water, sanitation and hygiene interventions that include increased access to water, improved drinking water quality and hand washing have been shown to be effective in reducing the incidence of diarrheal diseases (Fewtrell *et al*., 2005; Arnold & Colford, 2007; Prüss-Ustün *et al*., 2014). According to WHO, 88% of diarrheal diseases are attributable to consumption of unsafe water, lack of adequate sanitation and poor hygiene (WHO, 2004). Diarrheal diseases are estimated to cause 2.2 million deaths annually and 90% of these deaths occur in children less than five years old (Eisenberg *et al.*, 2007; Clasen *et al.*, 2007). WHO advocates that simple improvements in drinking water quality using point-of-use

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water treatment can lead to a reduction in diarrheal episodes by 25% to 40% (Arnold & Colford, 2007; Bartram *et al.*, 2005).

In 2010, more than half of the population in Tanzania was estimated to have access to an improved water source (pipe water), whereby 79% of urban population and 44% of rural population had access to pipe water (NBS, 2010). In the city of Mwanza, about 78% of the people are estimated to receive piped water from the Mwanza Urban Water Supply and Sewerage Authority, and the rest get water from other sources including deep wells, shallow wells and directly from the Lake Victoria (Lukawe, 2007). However, improved water sources do not guarantee that water is safe enough to be considered as drinking water. Instead, point-of-use treatment of drinking water is of great importance to ensure availability of safe water for drinking at household level (WHO, 2009). Efforts have been made to promote point-of-use treatment of drinking water in order to ensure the availability of safe drinking water at the household level (Bartram *et al*., 2005; Mohamed *et al.*, 2016). But little has been made to measure the microbiological safety of drinking water at the household level. This might indicate that the proportion of the population with sustainable access to safe drinking water is likely to be significantly lower than the reported estimates which use improved drinking water sources as an indicator. This study evaluated the point-of-use treatment methods, storage methods and bacteriological quality of water used for drinking at household level in the squatters of Mwanza City in Tanzania.

Materials and Methods

Study area and design

A cross-sectional study was conducted between June 2014 and September 2014. This study was conducted in the squatter settlements (Kirumba, Igogo and Mbugani) of Mwanza city in north-western Tanzania. In the current study squatters were defined according to United Nations Human Settlements Programme (UN-HABITAT) as areas that have inadequate access to safe water and sanitation, poor structural quality of housing, overcrowding, insecure residential status and missing good infrastructure (UNCHS, 1996).

Sample size and sampling techniques

Using Kish Leslie formula for cross sectional study the minimum sample size of 207 households were obtained when prevalence of 16% faecal contamination of the stored drinking water from a study in Sierra Leone was used (Clasen & Bastable, 2003a). A total of 15 main water sources used by these households were conveniently sampled.

Purposive sampling was used to obtain three wards (Igogo, Kirumba, and Mbugani) with squatters out of 21 wards in Mwanza city. Streets within these wards with characteristics of squatter settlements were purposively selected and they included: South Mabatini (Mbugani), North Mabatini (Mbugani), Igogo A, Igogo B, Ibanda (Kirumba) and Kabuholo (Kirumba). These wards had a total of 3,144 households with almost equal distribution. Simple random sampling was used to select 207 households which were involved in the study. The current number of households in each street was obtained from the household registers at the street office of Executive Officer. By using a random number generator, the households to be involved in the study were obtained.

Data collection

Pre-tested questionnaire was used to collect demographic, water treatment and storage data. About 200 ml of drinking water were collected from each household by using the same cup the house holds member use to obtain water from the storage container. Water was directly poured to the sterile universal bottle and caped. In addition, 200 ml of water was collected from 15 sources (tap). All water samples were stored in a cooler with ice packs and were processed within 6 hours of collection for isolation and enumeration of *E. coli* using Membrane Filtration Method (Boisson *et al*., 2013).

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Laboratory procedures

A total of 100 ml of each sample was passed through a 0.45 micron filter (Parker Hannifin Corporation-USA) on a metal apparatus and placed on Petri dish coated with Endo Agar (Oxoid, UK) and incubated for 24-48 hours at 35°C (Eckner, 1998). For any growth further identification to confirm *Escherichia coli* as the indicator organism was done using in house biochemical test (Mshana *et al.*, 2009). Water with no *Escherichia coli* in 100mL of water tested was regarded as free from contamination (Ainsworth & WHO, 2004).

Data analysis

The data was entered, cleaned and analysed by using STATA Version 11. Age of a person responsible to prepare drinking water and number of people in each household were summarized using median and inter-quartile range (IQR). Categorical variables including sex, education, water treatment and water storage method were summarized in proportions. Univariate and multivariate logistic regression analysis were performed to determine factors associated with contamination of drinking water. P-value of less than 0.05 at 95% confidence interval was considered statistically significant.

Ethical considerations

The ethical approval to conduct this study was obtained from the joint CUHAS/BMC Research and Ethical Review Committee with certificate number CREC/030/2014. All interviewed participants were asked to sign a written informed consent.

Results

Demographic characteristics

This study involved 207 households with the median household size of 5 (IQR 4-7) people. The median age of people who were responsible of preparing drinking water was 30 (IQR 24-38) years. The majority 192 (92.75%), of respondents had a primary school education level while 14 (6.76%) were illiterate.

Table 1: Water treatment methods and reasons for not treating (n=207)

Variable	Response	Frequency	Percentage
Water treatment method	None	50	24.15
	Boiling	119	57.49
	Letting it stand and settle	23	11.11
	Straining through cloth	13	6.28
	Bleaching/use of chlorine	2	0.97
Reasons for not treating	Water already safe from source	32	64
	Cost	11	22
	Bad taste	7	14

Source of drinking water in the squatters of Mwanza city

All households used tap water as the source of their drinking water. A total of 157 (75.84%) respondents, reported treating their water for drinking using boiling, 119 (57.49%) leaving the water to stand and settle, 23 (11.11%) used chlorination and 15 (9.6%) strain through cloth (Table1). The majority of households 202 (97.58%) stored their drinking water; of these 200 (98.55%) used a clay pot. Only 2 (1%) used buckets with cover and spigot as storage container of drinking water.

Drinking water contamination

Out of 207 drinking water samples, 109 (52.66%) were found to be contaminated with *Escherichia coli.* All contaminated water was from water samples from clay pot (perfect predictor of contamination). Moreover, 15 water samples from 15 points of water supply (stand pipes) were free from *Escherichia coli*.

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On multivariate logistic regression analysis, as age of the person responsible for preparation of drinking water increased the odds of the contamination was found to decrease (OR=0.93, 95% CI: 0.91-0.97, p< 0.001). Though not statistical significant, as number of households members increased the odds of contaminating drinking water was also found to increase by 7.5% (OR=1.075, 95% CI (0.91-1.27, p=0.405).

Table 2: Factors associated with contaminated drinking water

		Univariate		Multivariate	
Variables	**Water contamination**	**OR(95%CI)**	**P-value**	**OR(95% CI)**	**P-value**
Age(years)	26 (23-31)	0.937(0.907-0.967)	0.001	0.93 (0.91-0.97)	0.001
Education					
Primary (150)	72(48.00%)	1			
No education(14)	9(64.29%)	1.95(0.624-6.092)	0.251		
Secondary (43)	28(65.12%)	2.022222(1-4.089)	0.05	0.855(0.47-1.54)	0.605
Number of people	5(4-7)	1.012(0.87-1.17)	0.877	1.075(0.91-1.27)	0.405
Water source					
Public tap (159)	76(47.8%)	1			
Private tap (148)	33(68.7%)	2.402(1.211-4.767)	0.012	1.71(0.82-3.54)	0.148
Water treatment					
No (86)	42(48.84e)	1			
Yes (121)	67(55.37%)	1.299(0.746-2.262)	0.354	1.377(0.72-2.64)	0.335
Storage					
No storage (5)	0	1			
Store with CS (2)	0(0.0%)				
Store without CS (200)	109(54.5%)	Perfect predictor	-	Perfect predictor	-

Key: CS= cover and spigot

Discussion

All households from squatters were found to use tap as source of drinking water signifying the high coverage of tap water in the city. This is in contrast with the study done in a slum in Kenya which reported only 9% of households were using tap water as a main source of drinking water (Kimani-Murage & Ngindu, 2007). This could be explained by the fact that in 2014 the coverage of pipe water in Mwanza City was about 78% compared to estimated 60% coverage in urban areas in Kenya by 2007 which is estimated to drop by 20% in urban poor population (MoWI, 2007). The high coverage of pipe water in Mwanza, might be driven by Tanzania national policy (Postel, 2000) and Millennium Development Goals which promote the sustainability of improved water sources.

This study found that proper storage of drinking water is essential to ensure quality of safe drinking water. This has also been observed in other studies elsewhere (Mintz et al., 1995, Clasen and Bastable, 2003b). This could be explained by the possibility of contaminations during daily use with poor hygiene. The majority of households used clay pot to store drinking water. All contaminated water samples in the current study were stored in clay pots. The clay pots used in the study settings did not have cover and spigot for drawing water. Most of households had one common cup that was used by each family member to draw water from the clay pots. As reported previously (Sobsey, 2002; Gundry *et al*., 2003; Clasen *et al.*, 2007; TDHS, 2011), drinking water contamination observed in this study might be contributed by the frequencies of drawing water from the drinking water container.

Similar to the study conducted in slums in Kenya (Chemuliti *et al.*, 2002; Kimani-Murage & Ngindu, 2007) and in Bagamoyo, Tanzania (Mohamed *et al.*, 2016) the current study found all samples of water supply (stand pipes) to be free from indicator pathogen (*E. coli)*. This confirms what has been observed in Kenya (Chemuliti *et al.*, 2002) and Mali (Gadgil, 1998) that there is high rate of water quality deterioration from source to drinking cup. However, these results contradict the previous findings from Dar es Salaam and Morogoro Tanzania where contamination was also reported in the tap water (Jiwa *et al*., 1991; Kihupi *et al*., 2016).

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In conclusion, a significant level of deterioration of water quality from the source to the drinking cup was observed in the current study. This study underscores the needs of health promotion programs on proper handling of safe drinking.

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Conflict of interest

Authors declare that they have no competing interests.

Author's contributions

OEM, MFM, LM, HDM and SEM designed the study. OEM supervised data collection. MFM, NM, MMM and SEM analysed the data. MFM, LM, MMM and SEM drafted the first manuscript, and all authors reviewed, revised and approved the final version of the manuscript.

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