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Microbiological quality and handling practices of street-vended sachet drinking water in Mwanza, Malawi

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Street vending of hand-filled sachet drinking water is common, but not regulated in Malawi. There are concerns that sachet drinking water may be at risk of contamination due to unhygienic handling and/or unsafe sources. From 76 sachet vendors currently operating in Mzanza, 76 interior sachet water samples, 76 exterior bag rinse samples and 70 source water samples were analyzed for Escherichia coli (EC) and total coliforms (TC). All vendors use boreholes and taps for packaging operations and most (74%) do not treat their water. 50% and 20% of source water samples were positive (CFU/100ml≥1) for TC and EC, respectively. At the point-of-sale, most interior water samples contained at least 1 CFU/100ml for both TC (96%) and EC (64%) while 99% and 74% of exterior bag rinse samples were positive (CFU/100ml≥1) for TC and EC, respectively. The results indicate that contamination of sachet water in Mwanza increases from source to point-of-sale, possibly due to unhygienic handling.

Background

The consumption of packaged water in high-income countries has emerged rapidly in recent decades, and low and middle-income countries followed suit more recently (Murthy, 2013; WHO, 2011; Rauf et al., 2015; Fisher et al., 2015). Drinking water may be packaged in plastic or glass bottles, sachets, or bags (Murthy, 2013). Though there are many licensed businesses that follow strict quality assurance programs, informal water vending is common across Africa (Stoler et al., 2012); however, because of the informal nature of the business, data about the extent, quality or profitability of the industry is hard to estimate (Yidana et al., 2014).

The few studies that exist indicate that hand-filled sachet water (i.e. water in a plastic bag) is mostly of poor microbiological quality (Murthy, 2013; Monney et al., 2013; Stoler et al., 2013); 30% of tested sachets in one Nigerian study were contaminated with faecal coliforms above the WHO guideline which recommends that E. coli must not be detectable in any 100 mL sample (Stoler et al., 2012; Nguyen et al., 2014; Dzotsi et al., 2015).

Contamination likely comes from the hands of vendors during collection, transport, hand-filling and hand-tying the sachets. Furthermore, when filling the water into plastic bags, vendors may blow air into the bags to force the bags to open (Oluwafemi & Olumwole, 2012). Even when safe piped water supplies are available, interrupted water supply may force vendors to use unprotected sources (Dzotsi et al., 2015).

Locally hand-filled sachet drinking water is common in Malawi especially among the poor because it is cheaper than factory-bottled water; on average, factory bottled water is sold at K250/500ml while the locally produced sachet water is sold at K50/500ml (750Kwacha is approximately $1USD). This packaged sachet drinking water is mostly sold on the streets and its microbiological safety is questionable.

Our objective then, was to understand the handling practices of water-sachet vendors, to identify the main points of contamination, and to determine whether the water meets the WHO guidelines for drinking water.

Figure 1. Mwanza is a busy transit point into Malawi

Source: USAID

Methods

Study site and population

The study was conducted in Mwanza, which lies to the west of Blantyre in southern Malawi and is a busy trading hub on the Mozambican border (Figure 1). Mwanza has a population of about 10,000 and is the administrative headquarters for Mwanza district. Tete, on the Mozambican side, is a large, industrial city, through which many goods destined for Malawi pass. As such, a considerable service industry that caters to the travellers and business people crossing the border has emerged; packaged water is one popular item that can easily be purchased.

The entire population of 76 water packagers was included in the study after obtaining their informed consent and there were no refusals to participation. Questionnaires were administered to study participants in order to understand water handling practices and the water vending business model. The questionnaire was administered in the local language: Chichewa.

The vendors were interviewed to obtain data about the processing and handling of the water samples. The water sachet was then purchased from the vendor. Data collection took place during the rainy season from January to April 2017.

Microbiological analysis

Once purchased, the sachet was placed into a sterile bag containing 100ml of distilled water and shaken for one minute in order to collect an exterior sample. After shaking, both the exterior sample and the sachet water (an interior sample) were immediately placed in a cooler box containing ice packs then transported to a lab at the district hospital in Mwanza**.** Upon arrival at the lab, the samples were immediately refrigerated and most samples were analyzed within the 6 hour recommended holding time. Source water samples were collected in sampling bags from the point most recently used by the vendor. The water sachets were aseptically opened using a flame-treated pair of scissors. A 100ml water sample was filtered through a 0.45µm Millipore membrane using a Delagua filter device. The membrane filters were then placed on Hyserve Compact Dry Plates and incubated at 37 degrees Celsius for 24 hours. Thereafter, any colonies formed were counted in colony forming units (CFU) per 100ml of the water sample; purple/red colonies were counted as total coliforms (TC) while blue colonies were *Escherichia. coli* (EC).

In total, 222 water samples were analyzed, of which 76 samples were interior point-of-sale (sachet water), another 76 were exterior point-of-sale (bag rinse) and 70 were source water samples. Due to budget constraints, every tenth sample was analyzed in duplicate: blanks and positive controls were done on each day of the analysis to determine the validity and reliability of the test. Distilled water was used to prepare blanks while chicken faeces were used to prepare positive controls.

Results and discussion

Collection and storage

Piped water and boreholes were the only two sources of water used for packaging operations. 63% of the vendors mentioned private piped water as their primary source used for packaging while 37% mentioned a borehole as their primary source. However, on the day of the interviews and water sample analysis, 52% of the vendors used piped water for the sample collected, 47% used borehole and 1% did not know the source of the water they used for packaging (Table 1). 51% of the vendors reported that water was not always available from their primary source they use for packaging. Therefore, they either use secondary sources or store the water they fetch from the primary sources. 58 respondents reported that their source of water is located away from their homes. Of these, 62% spend more than 30 minutes round trip of collecting water.

83% of the respondents reported that they use a container with a lid to store the water before packaging it, 4% do not use a lid to cover the water when stored before packaging and 13% reported that they package the water directly from collection container without storage. Furthermore, 41 vendors (62%) reported that they also use a jerry can to store their water before packaging. 27% reported that they package the water on the same day it is collected, 42% store it for one day, 21% store it for 2 days and 7% store it for 3-4 days before packaging.

Treatment, packaging and sales

Nearly three-quarters of vendors reported that they do not treat their water, whereas others used a combination of chlorine, cloth filtration and boiling (Table 2). For the two people who boil their water, one reported boiling the water until it comes to a rolling boil while the other one didn't know for how long the water is boiled. For those who treat their water, 72% store their water in a container with a lid after treating it, 6% package it directly after treating it and then store it while 22% do not store it. Furthermore, 71% store the water for a day or less after treating it while the rest (29%) store it for 2 to 3 days after treatment. At the point-of-sale, untreated interior water samples had higher mean EC concentration than treated interior samples: 30CFU/100ml and 6CFU/100ml, respectively. These differences are statistically significant ($p=0.02$).

The mean time taken to package the water is 55 minutes, and it ranges from 15 minutes to 2 hours. All vendors reported that they press fingers on the mouth of the sachets and force them open in order to fill them with water. The mean number of sachets filled with water per day is 84 and it ranges from 20 to 250 sachets per day. The sachets are filled with water and are sealed by tying the sachets manually. All vendors refrigerate the water after packaging it. 3% of the vendors sell it direct from the refrigerator while 97% of the vendors sell the sachet water from cooler boxes. Only 19% of those who sell from cooler boxes add ice blocks (frozen by themselves) while the rest, 81%, do not.

Table 1. Collection and storage

Variable	N	%
Primary water source		
Tap	48	63%
Borehole	28	37%
Water availability (primary source)		
Always available	38	50%
Not always available	38	50%
Alternative water source		
Borehole	33	83%
Stored for unavailable days	5	12%
Water source on interview day		
Tap	39	52%
Borehole	36	47%
Time to collect water/day (hrs)	55	1.8*
Pre-treatment water storage means		
Container with lid	63	83%
Container without lid	3	4%
No storage	10	13%

Water contamination

Quality control samples

No TC or EC was detected from any of the 12 blank samples (negative controls). All 12 positive control samples for TC and EC were too numerous to count. In terms of TC, 10 of the 12 duplicate samples contained the same number of colonies while one duplicate sample differed by one colony and one other duplicate sample differed by 3 colonies. Similarly in terms of EC, 10 of the 12 duplicate samples contained the same number of colonies while one duplicate sample differed by 8 colonies and one pair differed by 12 colonies.

Source water samples

Two different sources (38 public boreholes and 32 private taps) were tested. 50% and 20% of source water samples were positive (CFU/100ml≥1) for TC and EC, respectively. The mean TC concentration of tap water samples was higher than that of borehole water, 18CFU/100ml and 9CFU/100ml, respectively. Similarly, the mean EC concentration of tap water samples was higher than that of borehole water, 5CFU/100ml and 2CFU/100ml, respectively.

Interior samples

At the point-of-sale, most of the interior samples contained at least 1 CFU/100ml for both TC (96%) and EC (64%). Interior samples from the point-of-sale had significantly higher mean concentrations of TC than source water samples, 585 CFU/100ml and 13 CFU/100ml, respectively ($p=0.013$). Similarly, interior samples from the point-of-sale had a higher mean concentration of EC than source water samples, 24 CFU/100ml and 3 CFU/100ml, respectively, and the difference is also statistically significant ($p=0.000$).

Exterior samples

At the point-of-sale, 99% and 74% of exterior samples were positive (CFU/100ml≥1) for TC and EC, respectively. At the point-of-sale, exterior samples had higher mean EC counts than interior samples: 44CFU/100ml and 24CFU/100ml, respectively. These EC mean differences were not statistically significant ($p=0.08$). However, in terms of TC the opposite was observed: at the point-of-sale, exterior samples had lower mean TC counts than interior samples: 474CFU/100ml and 585CFU/100ml, respectively. Similarly, these mean TC concentrations were not statistically significant ($p=0.68$). Contamination of the exterior part of the sachet may put the consumer at risk of contamination due to the consumption method, i.e. ripping the bag open with teeth and drinking the water directly from the sachet. In terms of EC, 80% of source water samples conformed to WHO guidelines for drinking water and none of the source water samples was in the high risk category (>100CFU/100ml). At the point-of-sale, only 36% of interior samples and 26% of exterior samples conformed to WHO guidelines. Results are shown in Figure 2.

Table 2. Treatment and packaging

Variable	N	%
Water treatment		
Chlorination	12	16%
Boiling	2	3%
Pass through	3	4%
Settling	1	1%
No treatment	56	74%
Don't know	2	2%
Post-treatment storage		
Container with lid	13	72%
No storage	4	22%
Stored while	1	6%
Post-treatment storage duration (days)	15	1*
Time to package (minutes)	71	55*
Number sachets filled/day	76	93*
Ice blocks		
Use	14	18%
Don't use	62	82%
Number sachets sold/day	76	81*

Conclusion and recommendations

Based on the findings from this study, it appears that there are unhygienic practices that increase the risk of water contamination along the supply chain from the source to the point-of-sale. While not all water is unsafe, the storage and packaging practices that currently occur put the consumers at considerable health risk. Health authorities should consider monitoring and testing sachet water as well as raising awareness on water, sanitation and hygiene practices among the vendors. Much of the source water was found to be safe and of good quality, but further testing of the boreholes that were found to exceed WHO guidelines should be further investigated.

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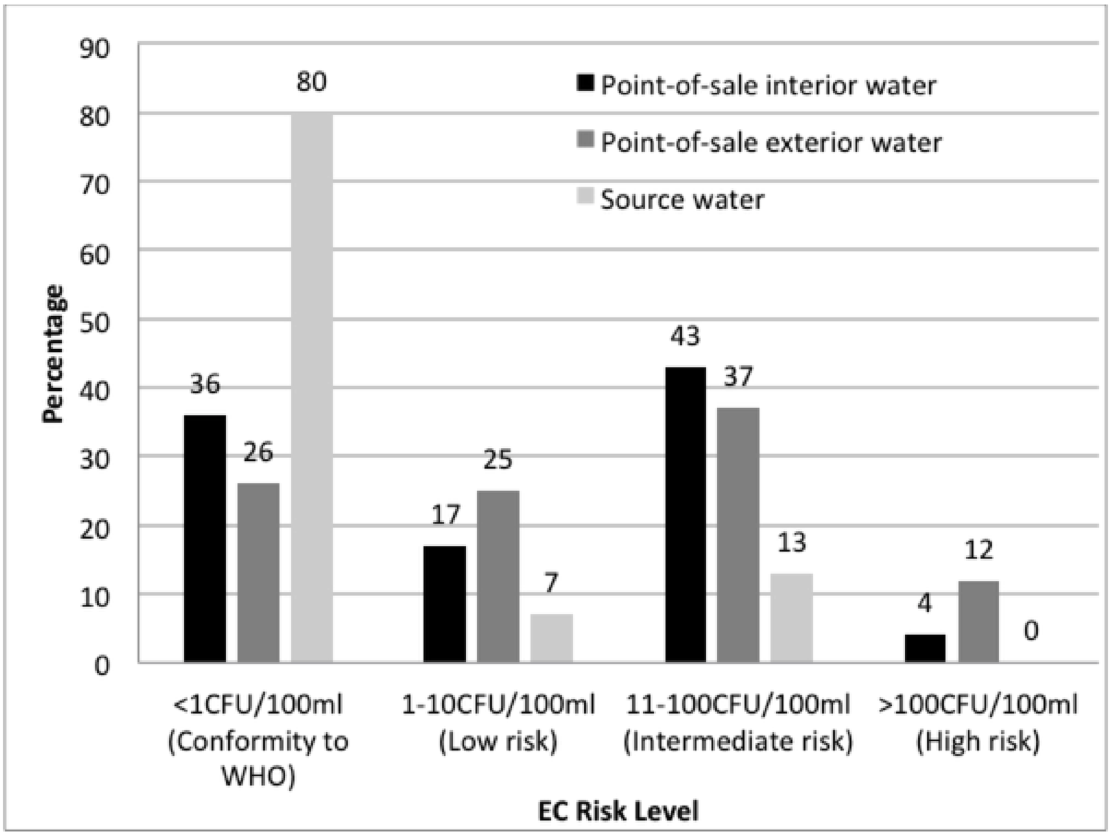

Figure 2. E.Coli concentrations for water sachets and source water

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