**Methods**

**Grant number:** ES/T008121

**Sponsor:** UKRI

**Project title:** Water & Waste: Expanding safe water and waste management services access to off-grid urban populations in Africa

# Data set: Questionnaire and water quality data for post hoc evaluation of the water safety impacts of Kisumu’s Delegated Management Model of water service delivery

**Version 1**, completed Jan 2024

## Objectives

The main objective of this study was to compare water safety (measured by thermotolerant coliform counts in piped or kiosk and household stored drinking-water) in areas of Kisumu under delegated management versus comparable control areas through a post-hoc impact evaluation exercise.

## Studysite

Fieldwork took place in the City of Kisumu in Kenya. Kisumu is Kenya's third largest city, with a population of over 500,000 people and is located on the shores of Lake Victoria. Over 60% of the population of the City’s population lives in informal settlements, typically densely populated and lacking adequate access to electricity, water and sanitation services (Sibanda et al. 2017). The City Authorities have been exploring various technical and management approaches for providing safe and affordable water to these informal or of-grid populations. One such approach is known as the Delegated Management Model (DMM), in which a utility delegates management of infrastructure and water service delivery to slum residents. In Kisumu, the main water service provider in the City, known as Kisumu Water and Sanitation Company (KIWASCO), works in partnership with individual or groups, termed ‘Master Operators’ (MOs). KIWASCO offers the MOs water at a bulk supply tariff, who then sell it to households or kiosk vendors. The MOs are also in turn responsible for minor maintenance, such as the repair of small leaks, and the management of customer interfaces assuring the quality of water supplied (Anand 2003, Schwartz and Sanga 2010). Kisumu was one of the first cities to implement, on a large-scale, a water intervention initiative that targets informal settlements using a DMM approach in this part of the world (Nzengya 2015).

This form of outsourcing of distribution and customer care to private operators or community-based organizations is meant to allow the utility to focus on supplying high quality potable water as its core business, and thus improve the technical and financial performance of water utility (World Bank 2009). For informal settlement residents where there are difficulties in the laying out of water supply infrastructure, the key benefit of this approach is to bring quality water closer to their homes or households and make it more affordable (World Bank 2009).

## Study and sample design

Kisumu city is administratively divided into Locations and Sub locations. Within the sub locations, there are further subdivisions into villages and Area Enumeration Units (EAs). The EAs are areal delineations for population census purposes, normally carried out by the Kenya National Bureau of Statistics (KNBS). These areal Units (EAs) were used as initial stage sampling units. Eligible EAS constituted those classified as urban by national statistical Agency, KNBS. EAs dominated by communal establishments were excluded. Specifically, most households in eligible EAs lived in over-crowded or non-durable housing, lacked improved sanitation or water sources, secure tenure, or waste services.

The characteristics of urban EAs (including whether or not water was delivered via DMM; metered water connections per household; kiosks per capita; population density; proximity to sewerage lines; and probability of built-up land cover measured via Sentinel-2 satellite imagery) were collated within a GIS. To minimize differences between EAs under delegated management and control EAs, a balanced sample of EAs was selected using coarsened exact matching based on these characteristics. This enabled the selection of a set of DMM and matched control non-DMM EAs with comparable characteristics. Given that EA boundaries were delineated a decade or more before planned fieldwork, to allow for the replacement of EAs that no longer met the inclusion criteria, 50 EAs in Kisumu were selected at random from the eligible EAs.

Project field teams carried out an intensive one-month reconnaissance exercise in all selected EAs, firstly to verify whether they still met one or more of the slum criteria described above, and secondly to enable the teams to overcome the navigational difficulties of identifying EA boundaries in the field. During this exercise, the survey team was accompanied by community guides in each EA. After the introductions, the field teams with the assistance of these community guides visited the community to conduct the reconnaissance visit. Following field reconnaissance, six EAs in Kisumu were excluded as lacking slum characteristics and random replacements were selected. Field work started on 21st February 2022 and ended on 13th September 2022. Data curation and processing was completed in November, 2023.

***Sample Size Estimation and Sampling***

We powered our sample to detect (alpha=0.05; power=0.8) a hypothesised 1 log reduction in point-of-use thermotolerant coliforms (cfu/100ml) from a median contamination level of 1024cfu/100ml in Kisumu’s slums with 1 log standard deviation reported in a previous study (Okotto 2010). We randomly sampled 22 MOs from the selected EAs with DMM, 91 kiosk owners (58 from DMM and 33 from non DMM, and 11 water hand-cart operators (2 from DMM, 9 Non DMM). We further sampled adult household customers for the MOs and Kiosks (131 DMM and 120 Non DMM). With permission from participants, we sampled and tested piped water from master operator lines/tap, kiosks and handcart vended and point-of-use water ‘along the chain’ for thermotolerant coliforms using standard water quality sampling and analysis procedures. The intended analysis from the study was to examine the effect of delegated management on household stored water contamination using logistic regression, controlling for risk factors related to the vendor (e.g. vessel cleaning and handwashing), the household (e.g. household hygiene and sanitation facilities), and the piped supply (e.g. adequate residual chlorine).

## Ethical approval

The study was approved by the Faculty of Environmental and Life Sciences Ethical Review Committee, University of Southampton, UK (reference: 55755; approval date 19th August 2020) and by the Ethics Review Office of Jaramogi Oginga Odinga University of Science and Technology, Kenya (REF: ERC/23/6/20-4; approval date 19th August 2020).

Field team recruitment, training, and organization

This section summarizes the characteristics of the team members to facilitate data interpretation.

A team of 8 surveyors, an assistant field supervisor, a field supervisor and a Data Manager and a water quality technologist were recruited, giving the project a 14-member strong team, besides the 2 Co-PIs and the other project support staff (Table 1).

**Table 1:** *Characteristics of RAs and Field Staff in the Kenyan team*

|  |  |  |  |
| --- | --- | --- | --- |
| **TEAM** | **CODE in SurveyCTO** | **QUALIFICATION** | **EXPERIENCE IN FIELD DATA COLLECTION IN RELATED FIELDS** |
| **Water Quality and Lab. Technologist** | (6) | Higher National Diploma (food Science, Microbiology) | 29 years |
| **Data Manager** | Master Access | Bsc. (Applied Statistics with IT), | 5 Years |
| **Field Supervisor** | 6 | Diploma (community Mobilization and Animal health) | 20 yrs |
| **Asst. Field Supervisor** | 2 | Diploma (Environment and Community Development) | 15 yr |
| **TEAM 1** | 1 | Form 4 (Certificate - Training in Community Development) | 4yrs |
| 9 | BSc. (Spatial Planning -JOOUST Student) | 2yrs |
| **TEAM 2** | 11 | Bsc. (Environmental Science) | 6yrs |
| 8 | BED.(Arts) | 1yrs |
| **TEAM 3** | 3 | BSc ( Applied Statistics) | 5yrs |
| 4 | Bachelor of Arts (urban and Regional Planning) | 3yrs |
| TEAM 4 | 9 | BSc. (Environmental Science – environmental Biology and health) | 4yrs |
| 7 | Form 4 (Certificate) | 1yr |

The off-grid areas where the RAs were to work in are prone to several security challenges and so they were paired up in teams of two for each team. An introductory presentation was made to the participants introducing them to the overall project objectives, design of the study and the study area overlain with google maps and the Enumeration Areas (EAs) maps, which were the smallest units in which they would operate during the study. They were also trained on techniques and processes of successful consenting, best field practices, and how to use google map navigation to locate the boundaries of the EAs. The final protocols, which had been refined by the project researchers, Co-Principal Investigators (Co-PI) and the Principal Investigators (PI) and loaded onto the SurveyCTO software platform, were downloaded onto the tablets (Samsung TabA 2019 (T585)) that were acquired and issued to RAs for fieldwork. Hardcopy prints of the questionnaires were also made for use during the training. The Data Managers and project Investigators conducted the training. The entire team was taken through all the questionnaires which were projected on a wall screen from the SurveyCTO platform. This was to train them to gain competence in using SurveyCTO software during questionnaire administration. In addition, exhaustive discussions were also held on the various questionnaires checking for the logical flow, ambiguity and practicality of implementing the questions in a field situation to ensure uniformity in understanding and how to interpret them for clarity and consistency of observations. Adjustments were then made to the observation protocols in areas which were found wanting.

Team members were trained on Water Quality sampling techniques so that they could successful take water samples from the households and deliver to the laboratory within the prescribed time lines for further analysis. The use of 481026 SenSafe free Chlorine Water Check Test Strips and how to make other observational insitu parameters were thoroughly explained to the team members. These included the hygiene and sanitary conditions in the households and water source environments that could impact on the quality of water. Others included how to record measurements and observations in the specially designed data sheets and tracking sheets with barcoded information. These aspects of the training were conducted by the Laboratory Technologist, the data manger and project investigators.

Day two of the training was spent on practicing and role-playing within the office to ensure that the surveyors and the water quality Technologist had gained the requisite competence to operate on their own in the field.

## Community entry and sensitisation in the study area

Initially, a stakeholder workshop was planned to mobilize community leaders and government officers for the impending project activities. However, the onset of COVID-19 prevented such face-to-face physical meetings in the country, and stakeholders lacked the technology to attend an equivalent online meeting. Consequently, the project team met smaller groups of stakeholders in open spaces or community halls. The team held four meetings with the policy-level stakeholders, which included those in the environment (3 persons), water (4 persons), public health (2 persons), and administration sectors (10 persons) of the County and National Government of Kenya in their respective offices.

With the policy and administration level stakeholders' consent, the team then moved on to the project sites. At these locations, the team held sensitization/mobilization meetings with the local chiefs and assistant chiefs, who then extended invitations to the various community leaders, including the village elders. On average, each of the meetings had between 5-10 participants. For each EA, a community guide deemed knowledgeable of the EAs and also known to residents was nominated to work with the RAs in their respective EAs. In many instances, project teams found community guides who also worked with the Kenya National Bureau of Statistics (KNBS) staff during the population census enumeration exercise, making it easy to identify the limits and boundaries of the EAs. In addition, some Community-Based Organizations/ NGOs operating in the waste management area in all the projects' sub locations were also met and sensitized.

Additional sensitization was also carried out through presentations at public meetings of stakeholders such as Kisumu WASH Network (KIWASH), other development partners and the Kisumu County Government. In summary, the sensitization, mobilization and engagement exercise successfully reached more stakeholders (approximately 80 participants) than was initially targeted (60) for the initial workshop.

## Pre-testing of methodology

Pre-testing of the survey methodology took place in two (2) EAs which were replacement EAs (one in DMM and the other in non-DMM areas) and also not selected for the main survey. In each EA, four households (2 DMM and 2 Non-DMM), two Kiosks (one DMM and one Non-DMM) and one handcart were visited, interviewed and water samples taken to pre-test the questionnaire. Alongside refinements to survey instruments, problems encountered during pre-testing were discussed, the instruments adjusted in readiness for the actual Survey.

## Field data management

All the finalized forms or questionnaires were uploaded on to the SurveyCTO platform and downloaded into the Samsung TabA 2019 (T585) by the survey team. Each surveyor was given a unique Identity Code to access and download the forms from the SurveyCTO platform and deploy for use in recording observations and short interviews with households, MOs and Kiosk and hand cart venders as guided by the protocols. Barcodes were attached to all water sample bottles, with hand-held scanners used to ensure full linkage of water sample characteristics recorded in the field with water quality test results from the laboratory.

## Laboratory Measurements

Laboratory preparations were done a day before samples were collected from the field. Preparation involved the calibration of field meters, for Conductivity, PH., Temperature, and Turbidity which were done once a week. Other tasks included sterilization of samples bottles and standard Aluminum Petri Dishes (code 422-560) by autoclaving, ensuring that Sample tracking sheets, Sample bar codes, Ice packs, Cooler boxes, Autoclavable bags, permanent marker pens, other pens and pencils and the sample transport means were all available in time. For microbiological samples, strong, autoclavable PPE white plastic bottles with a minimum capacity of 300 - 500 ml were used. These had screw caps that maintained an effective seal, even after they were sterilized many times in an autoclave. Sample bottles were washed with a non-ionic detergent and rinsed at least three times with distilled, deionized water. Water samples were tested for microbiological indicator organisms by use of a portable field-testing incubator (DelAqua Kits DWT: 10098), for both total coliforms and thermotolerant (faecal) coliforms.

The membrane filtration method which gives a direct count of total coliforms and thermotolerant coliforms present in a given sample of water was used in the laboratory. 100ml volume of water was filtered, under vacuum pumping, through a gridded cellulose acetate membrane of uniform pore diameter, 0.45 μm. One (1) ml volume of sterile ¼ strength ringer’s solution diluent was added across the surface of the filter membrane to aid in cell isotonicity. The water filtered for analysis were from KIWASCO water supply utilities for domestic use, and therefore the standard volumes were used. The results were recorded in excel sheets, coded and uploaded into the SurveyCTO platform for integration with the other study databases.

## Data management, processing, quality control, linkage and anonymization

***Data management****:* Finalized forms or protocols were uploaded onto SurveyCTO platforms and downloaded into the Samsung TabA 2019 (T585) by the surveyors. Filled forms were then uploaded into a common SurveyCTO server from where the data manager would download them for processing.

***Quality control****:* Quality control measures undertaken during and following data collection included the following:

* Range checks were coded into SurveyCTO data entry forms, e.g., preventing negative counts of items.
* Coordinate data were mapped and checked.
* Checks and skip patterns were coded in SurveyCTO forms to ensure all required information was filled appropriately.
* Constraints were coded into SurveyCTO forms to restrict entry of future dates for date variables.
* Restrictions were placed on the number of characters entered for text field e.g IDs to ensure consistency.
* Enumeration Area ID (EA ID) and Retail Outlet ID were entered twice, at the beginning and end of the questionnaire as a control check for accuracy.
* Field supervisors and Project Investigators routinely made random checks on the data collection process by following surveyors to the field and observing the process.
* Field supervisors reviewed data queries and error logs working hand in hand with the data manager and surveyors.
* Where relevant, duplicate records were flagged and removed from the data using unique IDs
* All obsolete test data, e.g pre-test data, was omitted from the final dataset.

***Calculated fields****:* To aid analysis, the following fields have been automatically calculated:

* Survey start / end time, upload time, and interview / observation duration: Automatically captured via tablets used for data capture.

***Anonymization****:* Field team member names and fields containing personal data have been removed, and comments or other free text fields in the data file have been screened for inadvertent disclosure of personal data. Coordinates (latitudes and longitudes) have also been removed from data files to avoid disclosing participating kiosk or household locations.

***Identifier format, data structure, linkage & related data resources:***

*Identifier format*: Identifiers take the following format:

* *Households*: 4 characters for EA (EA01, EA02, etc), followed in some DMM areas only by 4 characters for the Master Operator (MO01, MO02, etc), followed by 5 characters for household (HH001, HH002, etc), followed by ‘Y’ for areas under DMM or ‘B’ for control areas. Note that the MO was not incorporated into the household ID for all households in DMM areas because of uncertainty over local pipeline management arrangements.
* *Water samples*: Water sample identifiers were scanned from barcodes and take the format “WW-B” followed by 6 digits.
* *Water vendors (kiosk and hand*-*cart operators)*: 4 characters for EA (EA01, EA02, etc), followed in DMM areas only by 4 characters for the Master Operator (MO01, MO02, etc), followed by ‘WK’ for kiosk operators or ‘WV’ for hand-cart vendors, followed by a unique 3-digit code for the vendor (001, 002, etc), followed by ‘Y’ for areas under DMM or ‘B’ for control areas.

*Data structure and linkage:* The data comprise three tables, namely one for water vendor questionnaires (kiosk and hand-cart operators), one for household questionnaires, and a third for water samples that contains laboratory-based water quality test results. The unique water sample identifier field *barcode\_number* can be used to link both the vendor and household tables to the laboratory results. Note that there are four water sample records from kiosks in the water sample table which will remain unlinked via this strategy. This is because these four samples were collected at a later date, because piped water was unavailable at the time of interview owing to supply interruptions. The field *serving\_vendor\_id* can also be used to link the vendor table to the household table.

Protocol deviations

Unfortunately, a skip pattern coding error on computer entry forms between pilot and final survey implementation meant that one block of household questions was not collected. These questions related to household water treatment and storage. As documented in the relevant data dictionary, these fields are therefore null for all records.

**References:**

Anand, P.B. (2003) From conflict to co-operation: some design issues for local collective action institutions in cities. Journal of International Development 15(2), 231-243.

Nzengya, D.M. (2015) Exploring the challenges and opportunities for master operators and water kiosks under Delegated Management Model (DMM): A study in Lake Victoria region, Kenya. Cities 46, 35-43.

Okotto, L.G.O. (2010) Independent and small scale urban water providers in Kenya and Ethiopia.

Schwartz, K. and Sanga, A. (2010) Partnerships between utilities and small-scale providers: Delegated management in Kisumu, Kenya. Physics and Chemistry of the Earth 35(13-14), 765-771.

Sibanda, L.K., Obange, N. and Awuor, F.O. (2017) Challenges of Solid Waste Management in Kisumu, Kenya. Urban Forum 28(4), 387-402.

World Bank (2009) Improving water utility services through delegated management: lessons from the utility and small-scale providers in Kisumu, Kenya, p. 16, Nairobi.