University of Brighton

Methods

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Project title: OneHealthWater: Drinking-water under a "One Health" lens – quantifying microbial contamination pathways between livestock and drinking-water

Data set: Sanitary risk observation of hazards at and surrounding rural water sources in Siaya County, Kenya
Version 1.0a, completed Jul 2019

Study site

Fieldwork took place in ten villages in Siaya County, Kenya, a rural site on the shores of Lake Victoria, which hosts a Health and Demographic Surveillance System (Odhiambo et al., 2012) and where residents participate in several ongoing studies of livestock and human health (Thumbi et al., 2015). These studies suggested 43% of households collected domestic water from wells, 32% used rainwater or seasonal streams, whilst most of the remaining households relied on surface water from dams, pans or the lake (Thumbi et al., 2015). Most households (82%) reported having at least one outdoor latrine.

Protocol development and field team recruitment and training

Six observers participated in this exercise and were deliberately chosen to have varying levels of prior experience and education to reflect those likely to use sanitary risk inspection in real-world practice. The 'gold standard' observer (Joseph Okotto-Okotto, JOO; Observer A) had over 20 years' experience of sanitary risk observation, publishing several papers on this topic (Okotto-Okotto et al., 2015, Wright et al., 2013) and managing multiple rural water supply projects (Table 1). A second (Observer E) also had previous experience of sanitary risk observation and some tertiary education, and together with two recent graduates (Observers B and F), were recruited to typify survey team members who might support a regional or national water point mapping exercise. The remaining two (Observers C and D) had a further education qualification and only basic secondary education respectively, and were recruited to typify community-based water user committee members, who might be tasked with ongoing water safety management of rural supplies.

Code	Highest qualification	Field survey experience	WASH experience
Observer A	MSc (****)	****	****
Observer B	BSc (***)	**	**
Observer C	Certificate (further education / college) **	***	**
Observer D	Form 4 (Secondary school) *	*	*
Observer E	HND (***)	***	***
Observer F	BSc (***)	**	**

Table 1: Education levels, field survey experience and WASH sector experience of the six observers (*=lowest; ****=highest)

A 4-day training session inclusive of field trips was organized for observers. During the training, observers were taken through the entire set of questions to familiarize them with the expectations of the questions in the sanitary risk assessment forms in a Comcare environment. The context of each of the questions for each source type was explained to the observers at length to ensure that all them had a common understanding of the questions. Once this was attained, the observers were taken of through a process of identification and recognition of the various source types using the WEDC/UNICEF pictorial guide (Shaw,2005). There were however, difficulties with some source types, for instance the distinction between a hand-drilled or hand-dug Well and a borehole, that required further explanation which could not be gleaned from the pictorial guides. Observers were trained on the techniques of making these distinctions in the field. There were also aspects that required estimates of distances between hazard sources and water sources. The observers were trained on the various techniques of estimating these distances, in particular, using the pace factor. Each observer was trained on how to easily determine own pace factor and use of that to estimate observed distances. Observers were also trained on the use of step-ladders or raised surfaces to observe roof catchments.

Once the theoretical and in-class practical exercises were accomplished and all the observers comfortable with the Risk Assessment protocol and the administration of the protocol, all the observers were then taken to the field for a pre-test or a pilot exercise in three adjacent non-participating villages of Lusi, Kitambo and Ujwang'a. During the 3-day field exercise, the most experienced observer first demonstrated the theoretical concepts leaned during the in-class training for various water source types and hazards and then the rest of the team each took a go in turns until they could competently execute the concepts. The last two days of the pilot field work was spent allowing each observer to independently visit the same water sources in each of the three villages at different times within the same day. At each visit, the observer would use the mobile phone handset to access the Sanitary Risk assessment form and fill it in based on what was observed at each of the sites. The water sources visited included borehole (which was outside the pilot villages), protected and unprotected hand dug wells, Piped water into dwelling and into yard, public stand pipes, unprotected spring, rain water catchment and tanks among others.

Each of the observers uploaded the data real-time into the database through the Comcare Software using mobile handsets. At the end of the day, the observers make a record of the water sources they visited and this record is compared with what is uploaded in the database to ensure that they all matched each other. The pre-test data was analysed and adjustments were made in the form to capture some unique situations that were discovered and could not be addressed by the existing questions in the form. A 2-day refresher training session was held before the second fieldwork period.

Following initial piloting, sanitary risk inspection protocols were adapted from those promoted by WHO (World Health Organization, 1997). Adaptations involved checking for the presence of water system components (e.g. filter boxes on rainwater systems; parapets surrounding wells), additional observations concerning livestock hazards (e.g. footprints or animal faeces at a source), and additional observations of a hazard's underlying causes (e.g. branches overhanging a roof catchment for rainwater harvesting, leading to bird droppings). Protocols were selected based on six source types: springs, surface waters, unprotected wells, protected wells, boreholes, and rainwater harvesting systems. Following piloting, the JMP core question concerning the main source of drinking-water (WHO / UNICEF, 2006) was adapted to include an addition response category for water kiosks. Following a team review and follow-up site visits after wet season fieldwork, it emerged that some households were fetching water from broken pipes. Others had adapted their water supplies to cope with intermittent supplies by storing piped and rainwater in the same tank. Specific response categories were introduced for such sources in the dry season.

Sample design and water source selection

To estimate the minimum required sample size for our study, we used the published method for approximating the variance of the estimated limits of agreement (Bland and Altman, 1999), and the standard deviation of differences between percentage sanitary risk scores recorded by two observers of wells and boreholes in Greater Accra, Ghana (Yentumi et al., 2018). We estimated that observations of at least 92 water sources would give 95% confidence limits of 19.91% for the limits of agreement.

Chosen water sources were drawn from those used by 234 households participating in the OneHealthWater study (http://www.onehealthwater.org/). After seeking their informed consent to participate in the study, households were asked to identify the main drinking-water source that they used in an initial visit. These sources were visited by the survey team between 9th April 2018 and 4th June 2018, the season of long rains. Households were then revisited in the dry season and asked to identify the source used to obtain drinking-water stored in the home at the time of the visit. These sources were then visited between 21st November 2018 and 2nd March 2019, alongside those previously reported as used by households in the first visit.

Fieldwork

During wet season fieldwork, the six observers visited each of these sources independently at different times to reduce the potential for collusion or one observer's behaviour influencing a second observer. In the dry season, only five observers were available to conduct fieldwork. Because of the logistical difficulties in organising visits in this rural area, this sometimes led to a lag of several days between successive visits to the same source, particularly in the wet season. Each observer first identified the appropriate source class based on the adapted version of the JMP's standard classification (WHO / UNICEF, 2006) and an accompanying pictorial guide. Observer B additionally collected a water sample and took in situ measurements of turbidity and electro-conductivity. If the source type was rainwater, a well, borehole, spring or surface water, each observer undertook a sanitary risk inspection to identify contamination hazards at or surrounding each source, based on the observation protocol for that source type. Piped water sources and water vended from kiosks were thus excluded from sanitary risk inspections. Where a hazard such as a latrine was identified close to a source, the observers estimated the distance to the hazard by pacing. All observations were recorded via the CommCare cell phone-based data collection system (Dimagi Inc, 2019). Unless the field team was explicitly asked by bystanders, no feedback was provided on the hazards present during the visit.

Physico-chemical water testing methods

Free residual chlorine: This was tested in situ using SenSafe free chlorine Water Check test strips, capable of detecting 0, 0.05 0.1, 0.2, 0.4, 0.6, 0.8, 1.2, 1.5, 2.0, 2.6, 4.0, and >6.0 ppm (mg/L) of free chlorine. The method is approved by the US Environmental Protection Agency (ITS Method 99-003), as published in the 2007 Federal Register. No calibration is necessary for these strips.

pH of water samples was measured using a Hanna Instruments HI-98128 Pocket pHep5 Water Resistant pH Tester calibrated with the appropriate standard solutions (see calibration steps and standards). The pH meter was calibrated every morning using freshly prepared standard pH buffers at pH 4.0, 7.01 and 10.0. All standard solutions used were certified traceable to N.I.S.T. The pH meter included an integrated digital thermometer that was used to measure water *temperature*. The thermometer was not calibrated.

Electro-conductivity of water samples was measured using a COND3110 handheld meter calibrated with appropriate standard solutions (see calibration steps and values). The conductivity meter was calibrated before each sampling campaign using a 1413µS standard solution, and then checked for consistency each morning with the same standard. The meter was recalibrated when readings varied from the standard.

Turbidity was measured using a Hanna Instruments HI 93703 Portable Turbidity Meter. The sample cell was rinsed with distilled water between samples, and then rinsed three times with the sample before taking the reading. The turbidity meter was calibrated each morning against a formazin standard supplied by the manufacturer of the meter.

Other measurements:

The *depth to water below ground level* (bgl) was measured at each well with an accessible point for the dipper probe. The probe was gently lowered into the well until the audible alarm sounded to indicate that it had reached the water surface. The depth bgl was measured from the calibrated tape and adjusted, where necessary, to account for the depth of the plinth above ground level. After recording the depth to water, the probe was then lowered until it reached the bottom of the well. The depth of water in the well was calculated as the difference between the two readings.

References:

BLAND, J. M. & ALTMAN, D. G. 1999. Measuring agreement in method comparison studies. *Statistical Methods in Medical Research,* 8**,** 135-160.

DIMAGI INC. 2019. *Commcare: the world's most powerful mobile data collection platform* [Online]. Cambridge, Massachussetts: Dimagi Inc. Available: https://www.dimagi.com/commcare/ [Accessed 30/07/2019.

ODHIAMBO, F. O., LASERSON, K. F., SEWE, M., HAMEL, M. J., FEIKIN, D. R., ADAZU, K., OGWANG, S., OBOR, D., AMEK, N., BAYOH, N., OMBOK, M., LINDBLADE, K., DESAI, M., TER KUILE, F., PHILLIPS-HOWARD, P., VAN EIJK, A. M., ROSEN, D., HIGHTOWER, A., OFWARE, P., MUTTAI, H., NAHLEN, B., DECOCK, K., SLUTSKER, L., BREIMAN, R. F. & VULULE, J. M. 2012. Profile: The KEMRI/CDC Health and Demographic Surveillance System-Western Kenya. *International Journal of Epidemiology,* 41**,** 977-987.

OKOTTO-OKOTTO, J., OKOTTO, L., PRICE, H., PEDLEY, S. & WRIGHT, J. 2015. A Longitudinal Study of Long-Term Change in Contamination Hazards and Shallow Well Quality in Two Neighbourhoods of Kisumu, Kenya. *International Journal of Environmental Research and Public Health,* 12**,** 4275-4291.

THUMBI, S. M., NJENGA, M. K., MARSH, T. L., NOH, S., OTIANG, E., MUNYUA, P., OCHIENG, L., OGOLA, E., YODER, J., AUDI, A., MONTGOMERY, J. M., BIGOGO, G., BREIMAN, R. F., PALMER, G. H. & MCELWAIN, T. F. 2015. Linking Human Health and Livestock Health: A "One-Health" Platform for Integrated Analysis of Human Health, Livestock Health, and Economic Welfare in Livestock Dependent Communities. *Plos One,* 10.

WHO / UNICEF 2006. Core questions on drinking-water and sanitation for household surveys. Geneva.

WORLD HEALTH ORGANIZATION 1997. Guidelines for drinking-water quality. Vol. 3: surveillance and control of community supplies. 2nd ed. Geneva: World Health Organization.

WRIGHT, J. A., CRONIN, A., OKOTTO-OKOTTO, J., YANG, H., PEDLEY, S. & GUNDRY, S. W. 2013. A spatial analysis of pit latrine density and groundwater source contamination. *Environmental Monitoring and Assessment,* 185**,** 4261-4272.

YENTUMI, W., DZODZOMENYO, M., SESHIE-DOE, K. & WRIGHT, J. 2018. An assessment of the replicability of a standard and modified sanitary risk protocol for groundwater sources in Greater Accra. *Environmental Monitoring and Assessment*.