PREDICTORS OF *E. COLI* CONTAMINATION AT RURAL WATER POINTS IN KENYA, MALAWI, MOZAMBIQUE, UGANDA, AND ZAMBIA

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ABSTRACT

Julian T. Oliver: Predictors of *E. coli* contamination at rural water points in Kenya, Malawi, Mozambique, Uganda, and Zambia
(Under the direction of Jackie MacDonald Gibson)

Little quantitative information is available on how institutional factors affect drinking water quality in rural sub-Saharan Africa. Data were collected on *E. coli* concentrations and management practices at 549 rural water points in Kenya, Malawi, Mozambique, Uganda, and Zambia. Water piped on the premises of the home had much lower odds of contamination than public taps, boreholes, dug wells, and springs. The presence of a trained technician marginally decreased the odds of contamination (OR=0.28, p=0.07). Among water points testing positive for *E. coli*, nearby technical support and fee collection systems were associated with significantly lower concentrations. The sanitary inspection score, previously recommended as a surrogate for water quality analysis, was uncorrelated with *E. coli* concentrations (Kendall's tau =-0.063, p=0.11). These results provide further evidence of the need for financial and institutional support to maintain water points and to aim for piped water as the gold standard.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADP	Area Development Program
JMP	WHO/UNICEF Joint Monitoring Programme for Water Supply Sanitation
MDG	Millennium Development Goals
O&M	Operation and Maintenance
PPS-WOR	Probability Proportionate to Size Without Replacement
PSU	Primary Sampling Unit
SSU	Secondary Sampling Unit
WaSH	Water, Sanitation, and Hygiene
WHO	World Health Organization

CHAPTER 1: INTRODUCTION

In 2010, the Millennium Development Goal (MDG) of halving the proportion of the global population without sustainable access to drinking water between 1990 and 2015 was met. However, in 2014, the World Health Organization (WHO) reported that 11% of people in the world still do not have sustainable access to safe drinking water (WHO/UNICEF 2014). The lowest levels of drinking water coverage are in sub-Saharan Africa (WHO/UNICEF 2014).

People who have sustainable access to drinking water use water from what the WHO/UNICEF Joint Monitoring Programme for Water Supply Sanitation (JMP) calls an improved source[1] (WHO/UNICEF 2014). However, due to the presence of microbial and chemical contamination, improved sources do not always supply safe water (Bain et al. 2014a). Bain et al. (2014b) estimated that "1.8 billion people globally use a drinking water source that suffers from fecal contamination." Fecal contamination is considered by the WHO as the greatest threat to public health (WHO/UNICEF 2010).

Many studies have assessed the effectiveness of interventions for contamination of global water supplies. Kayser et al. (2014) found that post-construction support of small piped water systems improved water quality in El Salvador. Studies in South Africa and Nigeria found point-of-use interventions to be successful in improving water quality and lowering incidence of diarrhea (Abebe et al. 2014, Barzilay et al. 2011).

[1] An improved drinking water source is one that, "by the nature of its construction and when properly used, protects the source from outside contamination, particularly fecal matter." (JMP 2014)

Foster et al. (2013) studied the management of rural water systems in Liberia, Sierra Leone, and Uganda to identify predictors of functionality. Factors associated with water system functionality included presence of a fee collection system, spare parts proximity, availability of a handpump mechanic, and women in key water committee positions. However, little quantitative information is available on how these institutional factors affect drinking water quality in rural sub-Saharan Africa.

This study evaluated associations between water system management practices and *E. coli* concentrations at rural drinking water points in Kenya, Malawi, Mozambique, Uganda, and Zambia. Factors assessed included the presence of local water committees, the gender composition of those committees, the availability of spare parts, the presence of staff responsible for operating and maintaining the system and whether or not the staff were trained, the collection of fees for water use, and the type of water point (piped water, public tap, borehole, dug well, and others). In addition, this study evaluated whether a measure known as the sanitary inspection score, which was developed by the World Health Organization and others to predict drinking water contamination risk, is correlated with *E. coli* concentration. The sanitary inspection score is based on ten yes/no questions intended to determine the "possible hygiene risks that could affect the current and future quality of water supplies (WHO/UNICEF 2011)." The results of this study can inform community leaders, local public health organizations and government agencies, and international development organizations on strategies for improving the management and monitoring of drinking water systems, in order to improve the microbiological quality of the water these systems provide.

CHAPTER 2: METHODS

2.1 Study Population

The data used in this study were collected as part of an evaluation of water, sanitation and hygiene (WaSH) programs led by World Vision. The programs are being carried-out in rural communities in ten countries[2] in sub-Saharan Africa. World Vision has several area development programs (ADP) in each country. In addition to the data collected in these ADPs, data from adjacent or nearby "comparison areas" where World Vision is not operating were collected to assess the progress of World Vision-supported areas in comparison to these comparison areas. The data from water points in both of these subgroups were used in this study. The water points used in this study were identified in interviews with heads of households, who were asked to identify the primary functioning water point that they use and last used nonfunctioning water point.

2.2 Study Design

A population-based field study design was used for the World Vision evaluation in which interviews were conducted to gather data about water points in addition to households, schools, and health facilities. Water samples were also collected at each of these locations. This study used data collected from Kenya, Malawi, Mozambique, Uganda, and Zambia. The independent variables used in the model were selected based on our interest in their relationship with water quality at rural water points. The dependent variable, *E. coli*/100 ml, was chosen because it is a commonly used indicator of fecal contamination.

[2] Ethiopia, Ghana, Kenya, Malawi, Mali, Mozambique, Niger, Rwanda, Uganda, Zambia

2.3 Cluster Selection

A multi-stage geographically clustered sample design was used to select households. A probability proportionate to size without replacement (PPS-WOR) sampling method (Stevens, 1958) was used to select clusters of households based upon well-delineated geopolitical area units. These clusters were the primary sampling units (PSU) and varied in size depending on the country in which they were located. In smaller countries, these clusters were selected in a single stage. In larger countries, clusters exceeding 200 households were selected using the first stage with a subsampling of smaller geographical units (segments) conducted in a second stage yielding secondary sampling units (SSU). Clusters of 100-200 households were ultimately selected. Consultants in each country were asked to select World Vision areas for study by overlaying area maps of PSUs on maps of the World Vision ADP boundary maps. Comparison areas were then selected from the enumeration districts outside of the ADPs. Ultimately, 56 clusters (PSUs) in World Vision areas and 56 clusters in the comparison areas were selected.

2.4 Household Selection

Consultants in each country created the household sampling frame by creating a map of every occupied housing unit in each selected cluster. Systematic sampling was then used to select a random sample of 25 households in each cluster to be interviewed. Systematic sampling entails sampling every Kth household on the list after a random starting point, in which the sampling interval (K) for each segment is based on the ratio of the total number of households in the segment and the designated number of selected households for the segment.

2.5 Water Point Selection

Enumerators went to the preselected households to request interviews. During the interviews questions were asked to determine the primary water point that was functioning and the last used nonfunctioning water point. The enumerators were responsible for locating the functioning and non-functioning water points mentioned in the interview so that the water at the water points could be sampled. GPS coordinates were taken at both the households and the water points.

2.6 Data Collection

The water or WaSH committees of identified water points were asked questions about the water point(s) they were responsible for. If a committee was not present, a community leader was interviewed. Enumerators recorded interviewee responses on a questionnaire form (Appendix 1) or on a mobile device if it was available (this varied by country). The questions asked that provided information for the independent variables used in this study were mostly asked in a "Yes," "No," or "Don't Know" response format. When questions were asked about distance, a set of ranges was provided (e.g. 0-5 km, 5-10 km, etc.).

2.6.1 Water sampling

Enumerators used sterile Whirlpak® bags to collect water samples. Water samples were either tested immediately or stored according to protocol (Appendix 2) and tested off-site.

2.7 Data Analysis

A negative binomial logit hurdle model was used to perform regression analysis using Stata version 13.0 to identify relationships between a range of explanatory variables and *E. coli* presence or count in a 100 ml sample. This model accounts for Poisson overdispersion and an unexpected number of zero responses in the sample. Poisson overdispersion occurs when the variance is larger than the mean (Hilbe, 2014). P values were calculated using robust standard errors to account for clustering in the data due to some communities having multiple water points represented in the sample. The logistic component of the model provides the odds of detecting or not detecting *E. coli* in a 100 ml sample. The negative binomial component of the model provides the expected number of *E. coli* in a 100 ml sample.

2.7.1 Model Development

A manual stepwise method was used to select the final model used in the analysis. A full model with all considered independent variables (Table 1) was run and the p values of both components of the model were observed. If any independent variable had a p value above 0.2 it was removed from the model. The final model includes only independent variables that had a p value below 0.2 in at least one component of the model.

Table 1. Independent variables considered for analysis

Explanatory Variables
Presence of water committee
Distance to capital
Number of households using water point
Age of water point
Presence of O&M plan
Presence of sufficient funds for O&M
Distance of technical support
Distance to materials for repairs
Presence of person responsible for O&M
Sufficient amount of water
Presence of fee collection system
Water point type
Country

2.7.2 Sanitary Inspection Analysis

A separate analysis was conducted to determine the relationship between sanitary inspection scores of boreholes and *E. coli* concentration. A sanitary inspection score questionnaire was adapted from the *WHO/United Nations Children's Fund guide Rapid Assessment of Drinking-water Quality: A Handbook for Implementation* (Table 2). The questionnaire includes ten yes/no questions that aim to identify sources of contamination and other possible causes of contamination at water points (e.g. broken hand pumps and damaged drainage channels). "Yes" answers indicate higher risk and are scored as "1," while "no" answers are assigned a score of zero. Therefore, a score of 10 indicates the highest possible risk, and a score of zero represents the lowest possible risk. The total score out of ten was calculated for each borehole. The Kendall's rank correlation between *E. coli* concentration and sanitary inspection score was then determined, and the significance of the correlation was assessed with the Kendall's rank correlation test.

Table 2. Sanitary inspection questionnaire

Item	Question	Answer		
1	Is there a latrine within 10 m of the water point?	Yes	No	Don't know
2	Is there a latrine uphill of the water point?	Yes	No	Don't know
3	Are there any other sources of pollution within 10 m of the water point (ex. waste from animal breeding, cultivation, roads, industry, etc.)?	Yes	No	Don't know
4	At the water point, is drainage allowing ponding within 2 m of the borehole?	Yes	No	Don't know
5	At the water point, is the drainage channel cracked, broken or unclean?	Yes	No	Don't know
6	Is the fence around the water point missing or faulty?	Yes	No	Don't know
7	At the water point, is the cement floor slab (cement floor surrounding the water point) less than 1m in radius?	Yes	No	Don't know
8	At the water point, does spilt water collect on the cement floor area?	Yes	No	Don't know
9	At the water point, is the cement floor slab cracked or damaged?	Yes	No	Don't know
10	At the water point, is the hand pump loose at the point of attachment to the cement floor slab?	Yes	No	Don't know

CHAPTER 3: RESULTS

3.1 Descriptive Analysis

3.1.1 Water Point Type and Sufficiency of Supply

The majority of the water points in the study sample were boreholes (71.4%) (Figure 1). Public taps were the second-most represented water point type in the sample, making up 6.74% of the sample. The remaining water point types present made up less than 6% of the sample each. Notably, 24.5% of the water points lacked sufficient water to provide year-round service..

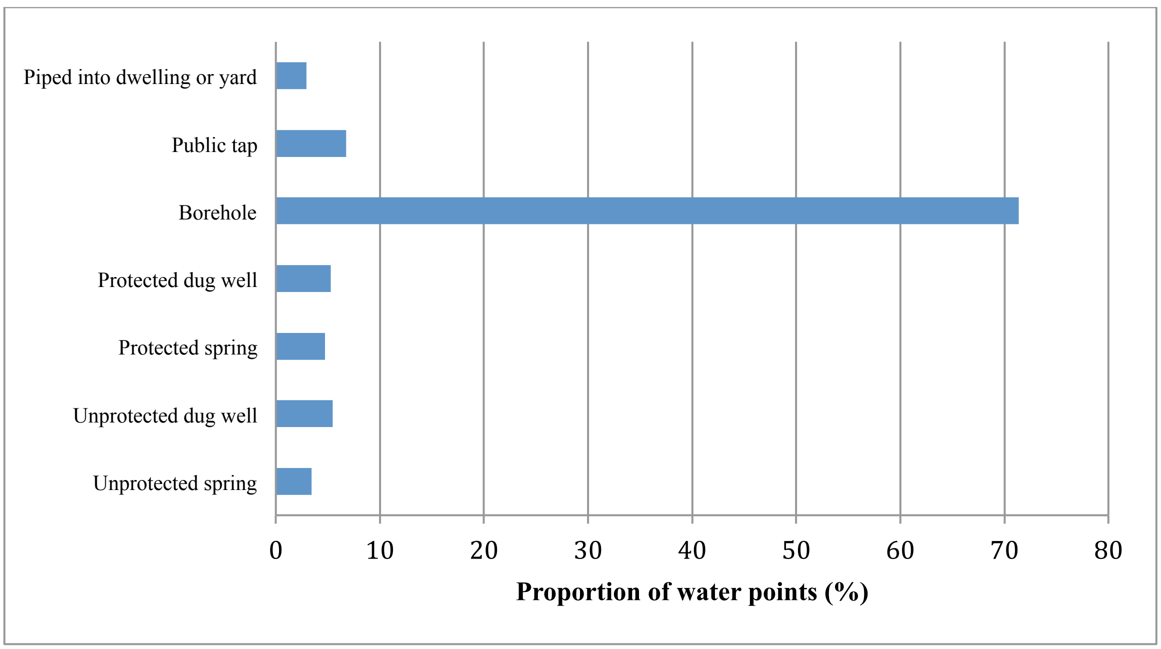

Figure 1. Water point types included in study sample (n=549)

3.1.2 *E. coli* Concentrations

The World Health Organization classifies the presence of *E. coli* /100 ml in four groups representing the degree of fecal contamination and potential risk to human health: low risk, intermediate risk, high risk and very high risk. The majority of water points in each country were classified as low (Figure 2). Zambia had the highest percentage of water points classified as low risk (89.6%) and Kenya had the lowest percentage of water points classified as low risk (51.9%). Uganda had the lowest percentage of water points classified as very high risk (0.0%) and Kenya had the highest percentage of water points classified as very high risk (16.98%).

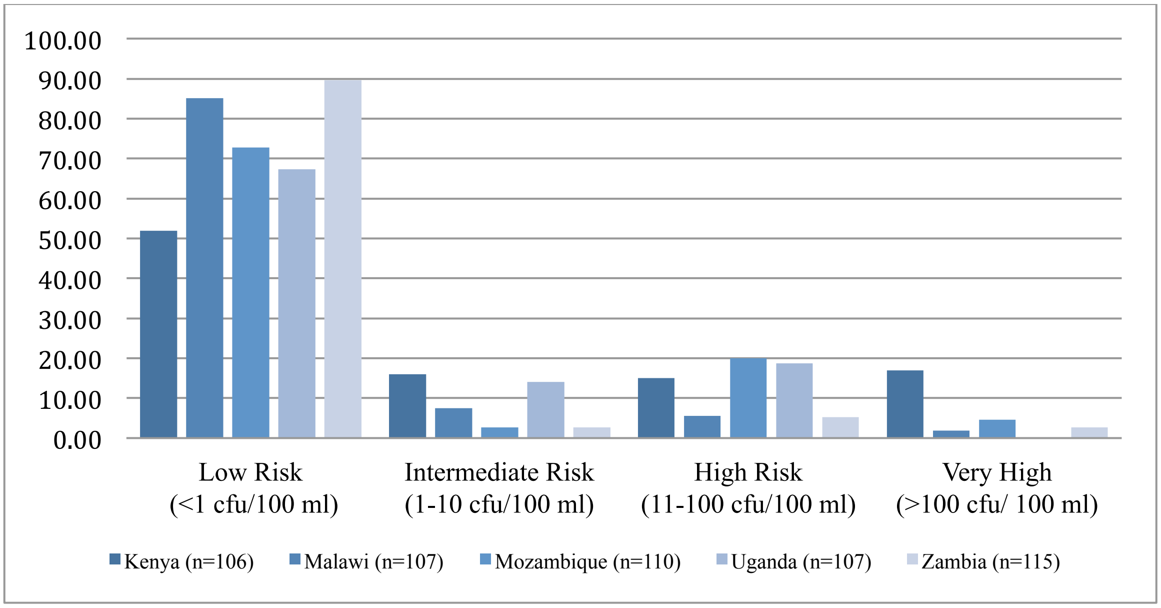

Figure 2. WHO *E. coli* risk categories by country in percentage of water points

3.1.3 Management Practices

To understand the degree to which different management structures are in place at water points in the five countries, descriptive statistics of questionnaire responses were analyzed. Most water points in the study sample were managed by a water committee (84.9%), and most of these committees (92.8%) had at least one woman member (Figure 3). A large proportion of water points had a caretaker or operator (63.6%), but most water points did not have a paid caretaker or operator (82.4%). The majority of water points in the study sample also had a person responsible for repairing and maintaining the water point (68.3%) and most water points had a person who had received training in operation and maintenance (O&M) of the water point (54.7%). Water points in the study sample generally had a fee collection system in place (72.3%) and had a plan for O&M (73.5%). However, fees for water point use were not generally collected on a regular schedule (57.7%) and did not have sufficient funds for O&M (63.9%).

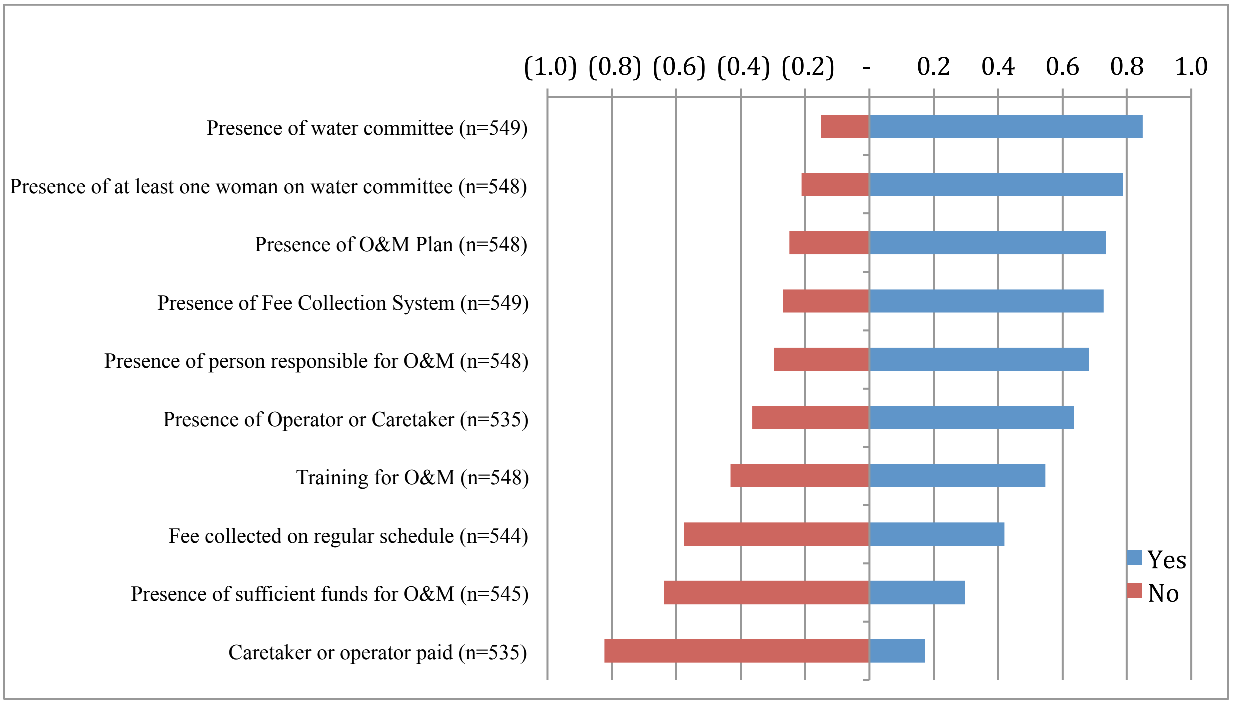

Figure 3. Fraction of water points with and without specified characteristics

A majority of water points in the study sample were located between 0 and 20 km away from water point support for technical problems (70.6%) (Figure 4). However, a large proportion of water points in the study sample were located further than 20 km away from a place to obtain materials for water point repairs (46.9%).

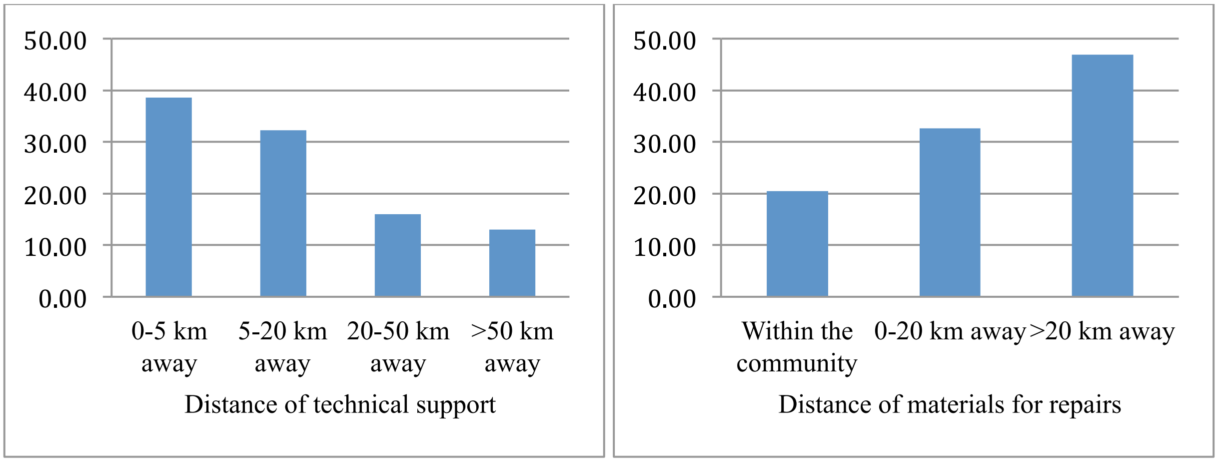

Figure 4. Distance of technical support (n=523) and distance of materials for repairs (n=549) in percentage of water points

3.2 Negative Binomial Logit Hurdle Model Analysis

A negative binomial logit hurdle model was used to perform a regression analysis to find the association between *E. coli* detection and concentration, the management factors shown in Table 1, and demographic variables that may affect water quality.. Two management-related variables— presence of an O&M plan, and presence of sufficient funds for O&M—were excluded from the final model, because their *p* values were above the inclusion criterion ($p < .2$).

3.2.1 Logistic Regression Component of Hurdle Model Analysis

Results from the logistic regression component (Table 3, columns 2-3) indicate factors influencing whether or not a water point is likely to be contaminated with *E. coli*. The type of water point had the largest influence on the potential for contamination: in comparison to water piped on the premises of a household, public taps and protected dug dwells and springs had the highest odds of contamination (OR=2240, p<.001), public taps the second-highest odds (OR=536, p=.003), unprotected dug wells and springs the third-highest odds (OR=262, p=.003), and boreholes the fourth-highest odds (OR=67, p=.002). In general, water points that are closer to technical support had higher odds of contamination than those that are more distant from technical support. However, this relationship is statically significant only for water points that are >20 km from technical support, which had odds of contamination 10 (=1/0.10) times lower than water points within 5 km of technical support (p=.026). Notably, water points that were older were significantly less likely to be contaminated (OR=0.95, p=0.027). Among the five countries, water points are most likely to be contaminated in Kenya and least likely to be contaminated in Zambia.

Table 3. Negative binomial logit hurdle model for water points

	Logistic		Negative Binomial	
Explanatory Variables	OR (95% CI)	P Value	OR (95% CI)	P value
Distance to Capital	0.97 (0.94-1.01)	0.157	1.00 (0.98-1.02)	0.720
Number of households per water point	2.11 (0.96-4.60)	0.062	1.05 (0.78-1.41)	0.738
Distance of technical support				
0-5 km away	1			
5-20 km away	1.16 (0.20-6.71)	0.871	**3.95 (1.10-14.13)**	**0.035**
>20 km away	**0.10 (0.01-0.76)**	**0.026**	**19.93 (4.80-82.76)**	**p<.001**
Distance to materials for repairs				
Accessible within community	1			
0-20 km away	4.77 (0.11-211.51)	0.419	0.46 (0.08-2.77)	0.398
>20 km away	2.84 (0.08-103.99)	0.570	0.53 (0.17-1.65)	0.271
Sufficient Water	3.57 (0.52-24.48)	0.196	**19.10 (5.74-63.55)**	**p<.001**
Water Committee				
No Committee	1			
Committee with no women	0.68 (0.01-36.92)	0.850	**67.77 (5.92-775.85)**	**0.001**
Committee with at least one woman	0.20 (0.01-3.77)	0.285	**4.46 (1.51-13.17)**	**0.007**
Water Point Age	**0.95 (0.91-1.00)**	**0.031**	**0.94 (0.90-0.98)**	**0.004**
Fee Collection				
No fee collected	1			
Fee collected not on a schedule	15.53 (0.30-797.78)	0.172	**0.24 (0.06-0.92)**	**0.038**
Fee collected on a regular schedule	14.40 (0.32-650.64)	0.170	**0.07 (0.02-0.20)**	**p<.001**
Person Responsible for O&M				
No person responsible for O&M	1			
Untrained person responsible for O&M	1.42 (0.23-8.90)	0.709	**2.06 (1.12-3.76)**	**0.019**
Trained person responsible for O&M	0.28 (0.07-1.12)	0.071	1.17 (0.46-2.96)	0.744
Country				
Zambia	1			
Uganda	**12.77 (2.55-63.94)**	**0.002**	**0.002 (0.00-0.03)**	**p<.001**
Mozambique	**59.64 (3.33-1067.38)**	**0.005**	**0.0004 (0.00-0.01)**	**p<.001**
Malawi	5.65 (1.00-32.01)	0.051	**0.005 (0.00-0.11)**	**0.001**
Kenya	**72.16 (7.12-731.33)**	**p<.001**	**0.04 (0.00-0.73)**	**0.029**
Water Point Type				
Piped into dwelling or yard	1			
Protected dug well or spring	**2239.73 (90.61-55362.07)**	**p<.001**	**0.02 (0.00-0.28)**	**0.005**
Public Tap	**536.16 (8.55-33637.94)**	**0.003**	0.14 (0.01-2.43)	0.176
Borehole	**66.68 (4.80-926.87)**	**0.002**	**0.02 (0.00-0.30)**	**0.004**
Unprotected dug well or spring	**262.37 (6.41-10744.89)**	**0.003**	0.09 (0.01-1.54)	0.096

* indicates statistical significance < .05
** indicates statistical significance < .01

3.2.2 Negative Binomial Component of Hurdle Model Analysis

Results from the negative binomial component (Table 3, columns 4-5) indicate factors influencing the expected *E. coli* concentration at water points where contamination was found. In general, water points that are located further from technical support had higher expected *E. coli* concentrations than those that are closer to technical support. This relationship is significant for both water points that are located 5-20 km away from technical support (OR=3.95, p=.035) and those located >20 km away from technical support (OR=19.93 p<.001). The type of water point also influences expected *E. coli* concentrations. Boreholes had expected *E. coli* concentrations 50 (=1/.02) times lower than piped water (p=.004) and protected dug wells and springs had expected *E. coli* concentrations 50 times lower than piped water (p=.005), although these former sources are at much higher risk of contamination than piped water, as shown in the logistic component of the hurdle model. In comparison to water points where no fee for water is collected, expected *E. coli* concentrations were 4 (=1/0.24) times lower when a fee is collected irregularly and 14 (=1/.07) times lower when a fee is collected on a regular schedule. Expected *E. coli* concentrations were also significantly higher when there was an untrained person responsible for repairs, in comparison to when no person was responsible for repairs. Unexpectedly, *E. coli* concentrations were significantly higher when there was a committee present with or without at least one woman serving as a member. Among the five countries, water points in Zambia had the highest expected *E. coli* concentrations and water points in Mozambique had the lowest.

3.3 Sanitary Inspection Score Correlation Analysis

A correlation analysis was performed to determine the relationship between borehole sanitary inspection scores and *E. coli* concentrations (Figure 3). Sanitary inspection score for boreholes and *E. coli* concentration were found to be uncorrelated (Kendall's tau=-0.063, p=0.11).

Figure 5. Sanitary inspection score vs. log10 of *E. coli* concentration

CHAPTER 4: DISCUSSION

Our results suggest that the presence of certain management characteristics at rural water points influences the odds of detecting *E. coli* and the expected *E. coli* concentration at these water points. Many of the characteristics indicated as factors of interest were found to be predictors of *E. coli* presence and concentration. These characteristics included the type of water point, distance from technical support, having a fee collected on a regular schedule, having a person responsible for O&M, having a sufficient amount of water supplied by the water point, water point age, and the presence of a water committee. Country was also a significant factor.

Water sources piped on the premises of a household were significantly less likely to have *E. coli* present when compared to boreholes, public taps, protected dug wells and springs, and unprotected dug wells and springs. This finding is consistent with a study that found that on-plot piped water was able to provide safer water to connected households over other available sources, including those sources meeting the definition of improved (Brown 2013).

Access to effective technical support, both within and outside of the community also significantly influences detection of *E. coli* and expected *E. coli* concentrations at water points. Water points that are closer to technical support have lower expected *E. coli* concentrations and *E. coli* was less likely to be detected at water points that have a person present who has been trained in O&M. This finding is consistent with studies that have found that post-construction support, which typically includes technical training, has been found to be associated with system performance and improved water quality at rural water points. (Whittington 2008, Kayser 2014).

Cost recovery for water systems is also an important contributor to improved water quality. Water points that had a fee collected had significantly lower expected *E. coli* concentrations than those that had no fee collection system in place. This finding is consistent with studies that have determined that cost recovery is necessary for effective O&M of rural water supplies to take place (Carter 1999, Harvey 2007, Carter 2010, Foster 2013). Water points that are effectively maintained experience improved water quality.

Some of our water point characteristics of interest were found to not significantly influence detection of *E. coli* and expected *E. coli* concentration. Proximity of water points to spare parts was found to be a significant predictor of handpump functionality in Sierra Leone (Sara 1998, Foster 2013). However, we did not find that distance to spare parts was a significant predictor of contamination.

Additionally, we did not find that sanitary inspection scores were correlated with *E. coli* concentrations. This finding suggests that sanitary inspections cannot be used to predict water quality and should not be used alone in assessing water safety. Several previous studies have supported the use of sanitary inspections and microbiological analysis together to assess water safety and move forward with interventions due to the overall similarities in the results found when both methods are used (Lloyd and Bartram 1991, Etang 2001, Cronin 2006, Rawat 2007, Patrick 2011). However, other studies (for example, a study by Luby et al. in Bangladesh) also have found hat the sanitary inspection score is uncorrelated with measured water quality.

We also found that at water points where *E. coli* was detected, boreholes and protected dug wells and springs had significantly lower expected *E. coli* concentrations than piped water systems, even though the non-piped sources were at substantially higher risk of contamination (that is, of having nonzero *E. coli* concentrations). This may be caused by intermittent service, which has been linked to piped systems. When systems operate intermittently, they are at risk for microbial contamination due to loss of positive pressure causing back siphonage and infiltration (Basualdo 2000, Cotruvo 2000, Agard 2002, Lee 2005, Shaheed 2014). Brown et al. (2013) found that 100 percent of respondents whose household was connected to a piped water supply reported that intermittent service occurred regularly.

Water points located closer to technical support were also more likely to have *E. coli* present. A possible explanation for this observation is that increasing distance of support may mean fewer local sources of fecal contamination due to decreased population density. Haque et al. (2013) found that increased population density was associated with groundwater pollution.

Finally, water points that had a committee present, with or without at least one woman serving as a member, were found to have significantly higher *E. coli* concentrations. This finding is inconsistent with studies that have suggested that having women in key positions on water committees contributes to higher rates of functionality for water points (Gross 2001, Foster 2013).

The results and interpretations of this study are subject to some limitations. First, due to the cross-sectional design of this study, no causal relationships can be determined between the predictor variables and the outcome variable. Second, water samples were only taken at one point in time. Consequently, the model does not account for the seasonal variations in water quality that are likely to occur. Additionally, the predictor variables included in the model are not an exhaustive list of possible predictors of water quality at rural water points in the five countries represented. Therefore, the effects of some of the variables included in the model may be related to other factors that are not present in the model or discussed in this paper.

CHAPTER 5: CONCLUSIONS

The objective of this study was to study the factors associated with improved microbiological water quality in Kenya, Malawi, Mozambique, Uganda, and Zambia. Our results suggest that the critical management factors that can help reduce the risk of contamination and, where contamination occurs, the exposure concentrations, are the presence of a trained operator, a regular fee collection system, and the presence of nearby technical support for repairs. In addition, piped water supplies have orders of magnitude lower risks of contamination than non-piped supplies, but among non-piped supplies boreholes are at lower risk than dug wells and springs. In addition, we found that the sanitary inspection score was uncorrelated with E. coli concentrations, with very high concentrations (>1,000 cfu/100 ml) occurring in some water points that had perfect sanitary inspection scores. These results provide further evidence of the need for financial and institutional support to maintain water points, to aim for piped water as the gold standard, and to only use sanitary inspections in conjunction with other methods of water safety analysis.

APPENDIX 1: WATER POINT QUESTIONNAIRE FOR WORLD VISION EVALUATION

WV-UNC Water Point Evaluation Form

Instructions: A sample of functioning and non-functioning water points in the communities will be selected and questions asked to the water/WaSH committee president. Each water point within a community should be assigned a gps point.

FIELD			**OFFICE**
Interviewer's code & name ☐☐ …………… ……………………	**Team Leader 's code & name** ☐ …… …………………………	**General Supervisor** …………………………	**Data Entry Supervisor** ……………………………
Completed Date: dd/mm ☐☐☐☐	**Checked Date: dd/mm** ☐☐☐☐	**Checked Date: dd/mm** ☐☐☐☐	**Entry Date: dd/mm** ☐☐☐☐

SECTION 1: IDENTIFICATION	
1.01: SURVEY ZONE 1=WaSH ADP; 2=Non-WaSH ADP; 3=Control zone	
1.02: COUNTRY	
1.03: REGION 1=Northern Region; 2=Upper East Region (This is an example for **Ghana**. Alter these choices for each country.)	
1.04: PROVINCE, STATE, OR ZONE	
1.05: DISTRICT	
1.06: AREA DEVELOPMENT PROGRAM (ADP)	
1.07: COMMUNITY	
1.08: GPS NUMBER	
1.09: LANGUAGE 1=Dagbanli 2=Mampruli; 3=Kusal; 4=Frafra/Kasim 5=Likpakpaln/Basare; 6=Talen; 7=Nabt; 8=Other (specify) (This is an example for **Ghana**. Alter these choices for each country.)	

*Water point number*______________ *(list the number water point surveyed in the community)*

*Name of the interviewee*____

*Position of the interviewee*____

Who financed the construction of this water point (list organizations)?-
______________________________-____ -
____

3. ACCESS TO SAFE WATER					
3.01	What is drinking water point of drinking water? (Check box next to the appropriate category.)		Piped water into dwelling		
			Piped water into yard		
			Public tap		
			Borehole (with handpump/pump)		
			Protected dug well (closed)		
			Unprotected dug well (open)		
			Protected spring (closed)		
			Unprotected spring (open)		
			Rainwater		
			Water-selling cart or truck		
			Surface water		
			Bottled water or sachet		
			Other: __________________		
3.02	Has this water point had its water quality tested for *E. coli* levels (microbiological water quality)?	Yes	No	Don't know	
3.03	Has this water point had its water quality tested for arsenic levels?	Yes	No	Don't know	
3.04	Has this water point had its water quality tested for fluoride levels?	Yes	No	Don't know	
3.08	Does the water point have continuous water service?	Yes	No	Don't know	
3.09	Does the water point have a scheduled water service?	Yes	No	Don't know	
3.10	Is the water point functioning?	Yes	No	Don't know	
3.11.	*If no to 3.10*, what are the main reasons why the water point is non-functional?		Financial		
			Fee Collection		
			Technical		
			Administrative		
			Other: ________________________		
3.12	*If no to 3.10*, how long has the water point been non-functional?	______-_____ [days]			
3.13	For what length of time was the water point nonfunctional during its last breakdown?	_____________[days]			
3.14	Has the water point broken down in the past year?	Yes	No	Don't know	
3.15	*If yes to 3.14*, has your community water point had a breakdown in the past two weeks?	Yes	No	Don't know	
3.17	Are there people in your community who do not have access	Yes	No	Don't	

	to or cannot afford to use this water point?			know
3.18	*If yes to 3.17,* what do these people do to get water? (Check box next to the appropriate category.)		Get water from a neighbor	
			Use an unimproved water source	
			Other: ____________________	

4.	**WATER SYSTEM SUSTAINABILITY**			
4.01	What is the age of the water point?			
4.02	What is the distance from your community to the district capital?	[____________] km		
4.03	How many households use (d) this water point? (If not functioning , questions are in parentheses for this and subsequent quesitions)	[____________] households		
4.04	How many households are (were) registered users of the drinking water point ?	[____________] households		
4.05	What type of hand pump is present? (Check box next to the appropriate category.)		Afridev	
			India Mark II	
			Kardia	
			Inkar	
			Other: ________________________	
4.06	Does (did) the water point have a water committee?	Yes	No	
4.07	*If yes to 4.06,* does (did) the water/WaSH committee contain at least one woman?	Yes	No	Don't know
4.08	*If yes to 4.06*, how many meetings does (did) the committee hold each month?	[____________] meetings		
4.09	Does (did) the water point have a fee collection system?	Yes	No	Don't Know
4.10	How many households in the community paid a water fee the last time it was collected?	[____________] households	Don't know	
4.11	What is (was) the price of water? (ex. USD per jerrycan, USD per liter, USD per month, etc.)	____________USD	per liter	
		____________USD	per month	
		____________USD	Other: __________	
4.12	If there is (was) a technical problem that cannot be fixed on this water point, how far away is the support for the water system? (Check box next to the appropriate category.)		0-5 km away	
			5-20 km away	
			20-50 km away	
			>50 km away	
4.13	Does (did) your community have a plan for operation and maintenance of the water system?	Yes	No	Don't know
4.14	Does (did) your community have sufficient funds to support operation and maintenance or upgrades and replacement materials for the water system in the future?	Yes	No	Don't know
4.15	How far away are (were) the materials you use for water point repairs (ex. spare parts, tools, etc.)? (Check box next to the appropriate category.)		Accessible within the community	
			0-20 km away	
			>20 km away	

4.16	Does (did) your water point have at least one person responsible for repairing and maintaining the water point and distribution system?	Yes	No	Don't know
4.17	Does (did) your water point include at least one person who has been trained in operation and maintenance of the water point and distribution system?	Yes	No	Don't know
4.19	Is (was) there a sufficient amount of water from the water point available to your community throughout the entire year?	Yes	No	Don't know
4.29a	Were water or WaSH committee members (as indicated in 3.01) elected or appointed?	Elected	Apointed	No Committ ee
4.30a	Is (was) there an operator or caretaker of the water point?	Yes	No	Don't Know
4.31a	*If yes to 4.30a*, is (was) the operator/caretaker paid?	Yes	No	Don't Know
4.32a	*If yes to 4.31a,* how much is (was) she/he paid per month?	[__________] USD		
4.33a	*If yes to 4.30a,* how many hours does (did) the operator or caretaker work each month?	[___________] hours		
4.34a	What is (was)the minimum monthly wage in the country?	[__________] USD		
4.35a	What are (were) the responsibilities of the water or WaSH committee ? (Do not prompt. Check boxes next to all categories mentioned by respondent.)	☐ Financial ☐ Fee Collection ☐ Technical ☐ Administrative ☐ Other: ____________________		
4.36a	Is (was)the water fee collected on a regular schedule?	Yes	No	Don't know

DIRECT OBSERVATION FOR SUBSEQUENT QUESTIONS (see diagram below)				
4.37a	Is there a latrine within 10 m of the water point?	Yes	No	Don't know
4.38a	Is there a latrine uphill of the water point?	Yes	No	Don't know
4.39a	Are there any other sources of pollution within 10 m of the water point (ex. waste from animal breeding, cultivation, roads, industry, etc.)?	Yes	No	Don't know
4.40a	At the water point, is drainage allowing ponding within 2 m of the borehole?	Yes	No	Don't know
4.41a	At the water point, is the drainage channel cracked, broken or unclean?	Yes	No	Don't know
4.42a	Is the fence around the water point missing or faulty?	Yes	No	Don't know
4.43a	At the water point, is the cement floor slab (cement floor surrounding the water point) less than 1m in radius?	Yes	No	Don't know

4.44a	At the water point, does spilt water collect in the cement floor area?	Yes	No	Don't know
4.45a	At the water point, is the cement floor slab cracked or damaged?	Yes	No	Don't know
4.46a	At the water point, is the hand pump loose at the point of attachment to the cement floor slab?	Yes	No	Don't know

LAST WATER QUESTION				
4.23	Are there any other water points (hand pumps) in your community? (If surveys have not been facilitated around these water points, move to these water points when the interview is over).	Yes	No	Don't Know

5. WATER SAMPLE		
INSTRUCTIONS: Ask if you may obtain a water sample from the water point. Refer to the Water Testing Quality Protocol sheet for more information on methods for collection, labeling, etc.		
5.01	What is the GPS waypoint for the primary community water point?	Lat: N ________ ° ________________' *(degrees,)* Long: E ________ ° ________________' *(degrees,!)* Altitude: [____________________] meters
5.02	Take a sample of the water from the water point. What is the concentration of *E. coli* in a 100 mL water sample?	[_____________] cfu / 100 mL
5.03	What is the arsenic level in the water sample?	[____________] mg/L
5.04	What is the fluoride level in the water sample?	[____________] mg/L

Now, ask the water/WaSH committee respondent if they would be willing to answer a few questions about sanitation in their community?. . . .

6. ACCESS TO SANITATION			
	How are children's feces disposed of in this community? (check all that apply)		Child used toilet/latrine ____
			_______ Put/rinsed into toilet or latrine______
			Put/rinsed into drain or ditch______
			Thrown into garbage bin or pile______
			Buried______

			Left in the open______	
			Not applicable______	
			Don't know	
			Decline to state.__	
6.01	On what date was the first community-led total sanitation (CLTS) trigger activity performed here?	|___|___|/|___|___|/|___|___|___|___|		
6.02	Who performed the first CLTS activity here? (Check box next to the appropriate category.)		Government	
			World Vision	
			Other NGO	
			Other: ____________________	
6.03	Has your community been declared open defecation free (ODF)?	Yes	No	
6.04	*If yes to 6.03*, on what day was the community declared ODF? *(dd/mm/yyyy)*	|___|___|/|___|___|/|___|___|___|___|		

THE BELOW QUESTIONS ARE FOR THE ENUMERATOR.

10.01. Did the person answering the questions seem irritated or nervous during the interview?

Yes No

10.02. Did you feel that the respondent was being truthful?

Yes No

10.03. How would you rate the quality of this interview?

Good Fair Poor

10.04. How many people were present when you conducted this interview?

Number of family members: ________________________________

Number of non-family members: ________________________________

Total number: ________________________________

10.06. Other comments:

____

____

____

____

APPENDIX 2: PROTOCOL FOR WATER SAMPLE COLLECTION

NOTE: The following protocol is taken from the Water Institute's "Draft WaSH MEL Water Quality Testing Protocol" (Fisher, 2013).

5.1 Materials

Be sure you have the following materials for water sample collection before carrying out your surveys.

- Sterile Whirlpak® bags (or sterilized autoclavable bottles)
- Cooler with ice packs
- Permanent markers
- Latex or nitrile gloves
- Alcohol-based hand sanitizer
- Sterile distilled water (at least one fresh bottle per sample collector per day)
- Cold chain indicator strips such as 3M Monitor Mark® or similar

5.2 Procedure for Collection of Samples

1. Label each collected sample or field blank with sample ID, date and time using permanent marker.
2. For water point samples: use Water point ID as sample ID and add S for source water sample. For household water samples, use community ID + H + Household number. When more than one sample of the same type is collected from a given source or household, label them using sequential letters. Thus, the 2rd source water sample collected from source #1 in the community of Makalondi in Niger on July 1, 2013 at 1:15 PM would be labeled as follows: MAK.N12.833.E001.686-001-S-B / 01.07.2013 / 13:15. The first household sample collected from household # 5 in the same community on July 1, 2013 at 1:15 PM would be labeled as follows: MAK.N12.833.E001.686-H-005-B / 01.07.2013 / 13:15.
3. Apply a fresh pair of gloves and sterilize hands with hand sanitizer.
4. For water samples for microbiological analysis:
    a. Open labeled sterile 500-mL Whirlpak® bag (or other sterile sampling container) without touching the lip or the inside of the bag/container.
    b. For source samples: take sample directly from pipe, hose, or other source outlet; for household samples, ask the female head of household to bring you a glass of water just as she would normally drink or serve it, and collect the sample in the sterile sample container.
    c. Fill container with sample without touching anything to the lip or the inside of the container (no hands, pipes, glasses, or other objects of any kind).
    d. If using a Whirlpak bag:
        i. Whirl the bag quickly three times and pinch the sides closed.
        ii. Twist the yellow tabs together to seal the bag shut.
    e. Place sample container upright in cooler with ice.
5. For physical or chemical analysis of samples (ex. arsenic and fluoride testing):
    a. For on-site analysis: collect as described above and test immediately.
    b. For off-site analysis: collect samples not requiring acidification (fluoride, etc.) as described above.
    c. For samples needing to be acidified (arsenic, etc. if not to be tested immediately on-site), add the requisite amount of acid to the containers either before or immediately after sample collection. Typically, this will be 1 mL of 1 N HCl for every 100 mL of sample collected.

   d. Seal the containers.
   e. Place upright in cooler with ice.
6. After collecting the last sample of the day, collect a field blank as follows:
   a. Label sample container with Community or Household ID, BL for blank, and the date and time using a permanent marker.
   b. Open a fresh bottle of sterile distilled water without touching the mouth of the bottle.
   c. Fill the sample container with sterile distilled water using the same procedure as rest of samples.

5.3 Sample Storage and Transport *(For off-site analysis only)*

1. All samples should be analyzed immediately or stored inside secondary containers (clean and sterile plastic bags) in a cooler with ice packs within 15 minutes of collection. The cooler temperature should not exceed 5 degrees C. Cooler temperature should be monitored with cold chain indicator strips such as 3M Monitor Mark® or similar.
2. Transport samples in cooler to laboratory for analysis within 12 hours.
3. The cold chain must remain unbroken during transport to the laboratory. If the temperature of a batch of samples exceeds 5˚ C for a cumulative total of one hour or more, discard the batch of samples.

5.4 Chain of Custody (For central laboratory analysis only)

1. Every day, each field team transporting samples to a central laboratory for testing must obtain a fresh chain of custody (COC) form when they check out their cooler.
2. The top portion of the COC form must be completed by the field team and transported with all samples to the lab.
3. Any transfer of samples between field teams or between a field team and other workers must be documented on the COC form.
4. No samples can be processed until the lab technicians verify that the cold chain has not been broken and that the contents of the cooler match the COC form. Once these details have been verified, the lab technicians can sign off on the COC form to accept custody of the samples.
5. Once received by the laboratory, samples and cold chain indicators must be immediately transferred to a refrigerator and must not exceed 5 degrees C. All samples must be processed within 12 hours of the time they are received by the laboratory.
6. If the total time between collection and analysis exceeds 24 hours, or the temperature of the samples exceeds 5 degrees C for a cumulative total of one hour or more, all samples in the batch must be discarded, along with all analytical results for those samples.

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