TECHNICAL DERTERMINANTS OF FECAL CONTAMINATION STATUS OF SHALLOW WELLS IN DEDE DIVISION MIGORI COUNTY, KENYA

Oluoch E.O.[1] and Helmut, K.[2]

[1]Mr. Evance Odiwuor Uluoch
Department of Public Health, University of Eastern Africa, Baraton
E-mail: oluoche@ueab.ac.ke, Tel: +254 729 922 900
[2]Mr. Helmut Khol
Department of Public Health, University of Eastern Africa, Baraton
Email: kholhelmut@yahoo.com, Tel: +254 723 509 098

*Corresponding author
Email: oluoche@ueab.ac.ke

ABSTRACT

A shallow well is a hole dug, bored or drilled less than 50M deep to extract water. Contamination of shallow wells with fecal matter presents a grave public health threat in developing countries, such as Kenya. A report by WHO shows that 1 billion people practice open defecation with nine out of ten of them in rural areas. In Kenya unsafe water, sanitation and hygiene are the 2nd leading risk factors causing morbidity and mortality at the national and county levels respectively. In Dede Division, 65.5% of households depend on shallow wells for domestic needs and there are rising trends of confirmed cases of fecal-related diseases. The study sought to assess technical determinants of fecal contamination status of shallow wells in Dede Division. A cross-sectional study of households using the wells was conducted. Fisher's formula was then used to calculate the sample size of the heads of households, giving a sample size of 386 heads of households. Out of the 180 shallow wells, 54 (30% of 180) were proportionately sampled and grab sampling technique adopted while sampling water from each of the sampled shallow wells. Basic physical parameters like temperature, turbidity and pH were analyzed by a portable turbidity meter and pH meter while H_2S rapid field test was employed for total coliforms analysis of grab samples in the field. Fecal contamination status of each well was determined by Membrane Filter Technique in kisumu government labaratory. Chi-square test was used to measure associations between variables while Multi-variate logistic regression analysis applied to test the hypothesis. The study revealed significant associations between several technical determinants and fecal contamination status of shallow wells e.g. distance (M) from a latrine to a well at (X^2=51.46; df=2; P=0.000), with majority of wells within safe distances of contamination (>10M) but still tested positive for fecal coliforms, distance (M) from the nearest cattle pen if any at (X^2=20.90; df=2; P=0.004) with a significant majority of shallow wells testing positive for fecal coliforms, damage or lack of concrete plinth at (X^2=8.53; df=2; p=0.014), breaks/cracks on the parapet walls if any at (X^2=9.81;df=2; P=0.007), breaks/cracks in the cover/top slab if any at (X^2=9.42; df=2; P=0.024), breaks in the drainage channels at

(X^2=40.94; df=2; P=0.000), shallow well covered while not in use at (X^2=6.37; df=2; P=0.041), shallow well fenced out at (X^2=10.68; df=2; P=0.000,) respectively. Majority of shallow wells (69%) tested positive for *E. Coli*, a strong indicator for presence of fecal matter in water, with only 31% testing negative. Common technical determinants (risk factors) are functions of fecal contamination status of shallow wells in Dede Division. Households in Dede Division. Sufficient treatment of water from shallow wells by households in Dede division before consumption is agent to help reduce the rising trends of fecal related diseases in the Division.
Key Words: Technical Determinants, Shallow well, Excreta related disease, fecal coliforms

INTRODUCTION

A water well is a hole in the earth that is dug, bored, or drilled to obtain water for residential use. If it's less than 50 meters deep, it's termed shallow (King, 2014). From a health standpoint, fecal contamination of water refers to the contamination of water with pathogens that can be found in human small and large intestines. Through the fecal-oral route of transmission, ingesting feces-contaminated water causes a number of diseases that affect people. In 1998, it was estimated that 2.2 million deaths per year were caused by diarrhea, with a considerable number of these deaths attributable to fecal pollution of water, with the vast majority of victims being children in rural parts of poor countries. More than 1 billion people globally are projected to be without adequate access to safe drinking water, while more than 2 billion people are without basic sanitary facilities (WHO, 2009). The rate of occurrence is 2.0 cases per 1000 people at risk (Loharika et al., 2013). Diarrheal diseases are the fifth most prevalent cause of morbidity and mortality in children under the age of five in the United States, and the third and second most common causes in the counties, respectively (DHIS, 2012). This may be largely owing to the use of polluted water, particularly in rural regions. This, combined with the high prevalence of HIV/AIDS, which has rendered many county residents immune-compromised, has raised their vulnerability dramatically.

Statement of the Problem

In underdeveloped nations like Kenya, where significant numbers of households lack access to clean and secure water supplies and rely on untreated surface water sources or shallow unprotected groundwater for domestic use, fecal contamination of underground water sources poses a serious public health issue (WHO & UNICEF, 2009). According to a WHO report on Global Analysis and Assessment of Sanitation and Drinking Water, one billion people perform open defecation, with nine out of ten of them living in rural areas, and 1.8 billion people consume fecal-contaminated water (WHO, 2014). The prevalence of water-borne diseases, particularly diarrheal diseases, has increased as a result of rapid population growth and inefficient fecal waste management (WHO, 2009). Diarrheal diseases are the fifth leading cause of morbidity and mortality in children under five years nationally and the third and 2nd leading cause of morbidity and mortality in children under five years at the county levels respectively (DHIS, 2012). In Dede Division, there have been rising trends of confirmed cases of fecal-related diseases for the last four years (DHIS, 2014), Awendo Sub-county. In Dede Division alone, there were 62 confirmed cases of cholera in March 2015, averaging 2 new cases per day (DHIS, 2014) in Awendo Sub-county (DHIS, 2014). As a result, the goal of this study was to determine the technical factors that influence the fecal contamination status of shallow wells in Dede Division, Migori County.

Specific Objectives

1. To assess Technical determinants of fecal contamination status of shallow wells in Dede division.

Hypothesis

1. Technical determinants are not a function of fecal contamination status of shallow wells within Dede Division.

MATERIALS AND METHODS

Study Design

The study used a cross-sectional study design since relevant responses from heads of households and well water samples were obtained at one specific point in time and no treatments or follow-ups were conducted after the inquiry was concluded. Water samples from the shallow wells were collected and transported to a government laboratory for bacteriological (fecal coliform) analysis using Analytical Design.

Location of the Study

The research was carried out in Dede Division, which spans 108.30 square kilometers. It is divided into two wards, West-Sakwa and North-Sakwa, with a total population of 45,152 people (Census, 2009).

Target Population

A total of 180 shallow (hand dug) wells and approximately 4008 households using wells respectively in Dede Division (MOH, 2014), Awendo Sub-county.

Sampling Techniques

Households and Shallow Wells

Cluster sampling was employed to divide the Sub-County into two wards namely: North-Sakwa and West-Sakwa respectively. The wards were then further Clustered into sub-locations namely; South-Kanyamgony, North-Kanyamgony, Rabondo, Kamresi, Kadera-Kwoyo, Kadera-Lwala, East-Kakmesia, Kanyasrega, and West Kakmesia respectively (see table I).

Shallow Well Water Sampling Technique

The method of obtaining water samples was employed. As specified by the World Health Organization's drinking water quality criteria, grab samples were taken from each shallow well using a standard 500ml sterile sample collecting vial (1997).

Transportation of Grab Samples

Although recommendations vary, the time between sample collection and analysis should, in general, not exceed 6 hours and 24 hours is considered the absolute maximum (WHO, 2010). The grab samples were therefore transported within 6 hours, in a light-proof insulated box with melting ice or ice parks with water to ensure rapid cooling to KIWASCO government laboratory in Kisumu for further bacteriological (fecal coliforms) analysis.

Sample Size Determination

i) Shallow Wells

Out of the 180 shallow wells, 54 (30% of 180) were proportionately sampled for water sampling (see table I).

Research Instruments

i) A Checklist

A checklist was developed to help assess technical determinants i.e, observable sanitary risks around the wells, well protection status by checking different construction elements e.g., Siting/location and topography in relation to sanitary facilities e.g. latrines was examined by checking the positioning of shallow wells whether uphill, downhill or relatively on a flat ground visa-vi latrines and animal waste sites-cattle pens. Finally, the distance between shallow wells and the nearest latrines and cattle pens was determined by a tape measure and the results noted.

ii) Water Sample Collection Form

A model water sample collection form (WHO, 1997) was adopted and used to record collected grab samples results both physical (temperature and turbidity) in the field and bacteriological (E. coli) at the laboratory. Some details included, sample collection time, well number, date of collection, sub-location of collection, date of analysis, and time of analysis.

Pilot Study

The pilot study was conducted in Kabuoro Ward outside the actual study area. In addition, 10% (n=17) of the sample size of the heads of households was used in the pilot.

i) Validity

Validity of the questionnaire was ensured through asking relevant questions that helped answer the specific objectives of the study. The researcher also discussed the contents of the questionnaire and the checklist with experts (supervisors) before collecting data in order to enhance content validity. Research assistants were adequately trained before being allowed to participate in data collection in the study.

ii) Reliability

The study maintained a high level of reliability by ensuring that questions outlined in the self-administered questionnaire were constructed using simple language that was easy to understand by all potential respondents. Cronbach's alpha analysis was run on the piloted questionnaires with the aim of attaining an alpha level of 0.75 and above.

Data Collection Techniques

An observational checklist was used to collect technical data from shallow wells and their environs in the study. In addition, water samples were collected on standard 1000ml sterilized laboratory bottles and immediately placed in a light proof Insulated box containing melting ice or ice-packs with water to ensure rapid cooling.

Data Analysis

i) In Situ Measurement of Microbial Parameters

Hydrogen sulfide (H2S) rapid field test was used to test for presence or absence of total coliforms in the grab samples, after which grab samples positive for total coliforms were safely transported to the laboratory for fecal coliform analysis.

ii) Laboratory Analysis of Grab Samples

Membrane Filter Technique was adopted to test for E. coli presence in the grab samples initially identified as positive for total coliforms. Aseptic technique was applied as per WHO standards (WHO, 1997).

Data Management and Analysis

Data was managed by Statistical Package for Social Sciences (SPSS) version 20 and Microsoft Excel 2013 soft wares. This involved data coding, data entry, data cleaning, data summarization and data organization. Descriptive statistics were employed in organizing and summarizing data sets of collected variables. Chi-square was used to test associations between variables while multiple linear logistic regression analysis used to test the hypotheses (Kothari, 2004).

Logistical and Ethical Considerations

Permission was obtained from the National Commission for Science Technology and Innovation (NACOSTI) to conduct the study. Ethical clearance was sought from Kenyatta University Research Ethics Committee for any ethical issues which may have risen during the study.

Thereafter, the County Government of Migori, Awendo sub-county public health office, and the chiefs in charge of Dede Division were informed of the intention of the study. Informed consent was then sought from the selected respondents (heads of house-holds) and the purpose of the study explained to them to encourage voluntary participation. Confidentiality of participants was ensured through coding of questionnaires.

RESULTS AND DISCUSSIONS

Fecal Contamination Status of Shallow Wells

In Dede Division, a total of 54 grab water samples were collected from 54 shallow wells out of a total of 180 shallow wells. The wells that were sampled served these 386 dwellings. As soon as the grab water samples were acquired, each of the 54 samples was tested for total coliforms using an H2S assay. The results revealed that total coliforms were found in 96.3 percent (n=52) of the 54 water samples analyzed. The positive samples were then safely transported in light proof insulated box with melting ice-packs to the laboratory for fecal coliform analysis. Using the filter membrane technique, majority of the water samples from shallow wells in Dede Division tested positive for Escherichia coli 69% (n=36) showing presence of fecal matter (figure 4.1). As shown in figure 4.1, a significant majority of shallow wells (69%) tested positive for Escherichia Coli, a strong indicator for presence of fecal coliforms in water, with only 31% testing negative showing absence of fecal matter. This concurs with a study conducted in Conakry, Guinea, which showed widespread contamination of shallow dug wells (Howard et al. 2003). Given the numerous technical risk variables that are strongly linked to fecal contamination status, this is accurate.

Table 4.7 shows that 44 percent (n=24) of pit latrines in Dede Sub-county are more than 15 meters away from shallow wells, whereas 28 percent (n=15) are 6-10 meters and 11-15 meters away, respectively. Majority 51.2% (n=28) of cattle pens (if any) within homesteads are located more than 15M away from the respective shallow wells, 40.6% (n=22) located 6-10M away, 4.2% (n=2) located between 11-15M away and the rest 4% (n=2) located between 1-5M away from the nearest shallow well. Most shallow wells 59.9% (n=32) are located uphill in relation to the nearest cattle pen (if any), with 35.6% (n=19) located downhill and only 4.5% (n=2) located on a relatively flat ground in relation to the nearest cattle pens. A significant majority 70.1% (n=37) of shallow wells had no damage to or lack of a concrete plinth with only 29.8% (n=16) having damaged/cracked plinths. Most shallow wells 54.6% (n=29) had no significant cracks/breaks on their parapet walls with about 45.4% (n=25) having the same. The study further observed that a significant majority 51.2% (n=28) of shallow wells in Dede Sub-county had breaks/cracks in the cover/top slab with about 48.8% (n=26) with no cracks on the top slab. A minority 44.1% (n=24) had breaks in their drainage channels with the majority 65.9% (n=30) having no breaks on their drainage channels. Very few wells 21.9% (n=12) are covered while not in use while over 71.8% (n=42) are not covered while in use. Finally, it was observed that a significant majority 61.2% (n=33) of shallow well areas in Dede Sub-county are not fenced with only 38.6% (n=21) of them fenced out.

As outlined in table 4.8, Study findings revealed very significant associations between several technical determinants and fecal contamination status of shallow wells. Distance in meters from a latrine to a well had a significant association with fecal coliform presence in wells at (X^2 =51.46, df=2, $p<0.001$), with majority of wells within safe distances of contamination (>10M) but still tested positive for fecal coliforms. In addition, Distance in meters from the nearest cattle pen if any had a significant association with fecal contamination status of the wells at (X^2 =22.97, df=2, $p<0.001$) with a significant majority of shallow wells testing positive for fecal coliforms. The study further revealed significant associations between damage or lack of concrete plinth (X^2 =8.53**,** df=2, p=0.014), breaks/cracks on the parapet walls if any (X^2 =9.81**,** df=2, p=0.007), breaks/cracks in the cover/top slab if any (X^2 =7.24,df=2, p=0.024), breaks in the drainage channels (X^2 =40.29df=2,$p<0.001$), shallow well covered while not in use (X^2 =6.37**,** df=2, p=0.041), shallow well fenced out (X^2 =15.29,$p<0.001$, df=2) and fecal contamination status of the wells respectively.

As shown in table in table 4.8, the chi square analysis run further revealed no association between location of the well in relation to the nearest latrine at (X^2 =5.29,df=2, p=0.071), well protection status at (X^2 =1.45, df=1, p=0.228,) and fecal contamination status of shallow wells respectively.
The analysis affirmed that technical determinants in general are a function of fecal contamination status of shallow wells at ($p<0.001$) there by rejecting the null hypothesis, "Technical determinants are not functions of fecal contaminations status of shallow wells," and failing to reject the alternative. This therefore means that technical determinats generally are predictors (point to) of fecal contamination status of shallow wells in Dede Sub-County, Migori county, Kenya.

Conclusion

Technical determinants are a function of fecal contamination status of shallow wells in Dede division. Most of shallow wells in the study area are fecal contaminated.

Recommendations

• Households in Dede Division should ensure that shallow wells are properly treated for fecal contamination before using water from these sources.
• The relevant authorities should inform households in Dede Division on prevalent routes of fecal contamination of shallow well water, as well as proper hygiene and sanitation practices around shallow wells, in order to prevent fecal contamination of the wells.

Acknowledgement

Gratitude to God for wisdom and good health till completion of the study. NRF for the Award of Kshs. 396000.00 in grant for the study. I thank Dr. Daniel Akunga, Dr. Jackim Nyamari and Mr. Helmut Khol for their professional contributions towards the success of this study. Much

appreciation to the heads of households in Dede Division for their time and participation. May God richly bless you.

TABLES

Table I: Sampling Frame of Shallow Wells and Households in Dede Division

Sub-Location	No. of Wells	Sample Size of wells in @ Sub-location	N/n	No. of H/holds using wells	Sample Size of H/holds in @ Sub-location	N/n
South Kanyamgony	25	{25/180}*54=**8**	3	544	{544/4008}*386=**52**	10
Rabondo	20	{20/180}*54=**6**	3	381	{381/4008}*386=**37**	10
North Kanyamgony	31	{31/180}*54=**9**	3	596	{596/4008}*386=**57**	10
Kamresi	21	{21/180}*54=**6**	4	543	{543/4008}*386=**52**	10
KaderaKwoyo	25	{25/180}*54=**8**	3	472	{472/4008}*386=**45**	10
KaderaLwala	25	{25/180}*54=**8**	3	475	{475/4008}*386=**46**	10
East Kakmesia	10	{10/180}*54=**3**	3	379	{379/4008}*386=**37**	10
West Kakmesia	7	{7/180}*54 =**2**	4	319	{319/4008}*386=**31**	10
Kanyasrega	16	{16/180}*54=**5**	3	299	{299/4008}*386=**29**	10
Totals	**180**	**---**		**4008**	**---**	
Sample Size	**54**	**54**		**386**	**386**	

Table 4.7: Technical Determinants results as observed in the Study Area

Technical Determinants	**Categories**	**n**	**%**
Distance in Meters from the nearest latrine to the well	6-10	15	28%
	11-15	15	28%
	>15	24	44%

Distance in Meters from the nearest cattle pen (if any) to the well	1-5	2	4%
	6-10	22	40.6%
	11-15	2	4.2%
	>15	28	51.2%
Well location in relation to the nearest cattle pen (if any)	Down hill	19	35.6%
	Uphill	32	59.9%
	Relatively flat Ground	2	4.5%
Damage to or lack of concrete plinth	Yes	16	29.8%
	No	37	70.1%
Breaks/cracks on the parapet wall	Yes	25	45.4%
	No	29	54.6%
Breaks/cracks in the cover/top slab	Yes	28	51.2%
	No	26	48.8%
Breaks in the Drainage channel	Yes	24	44.1%
	No	30	65.9%
Well covered while not in use	Yes	12	21.9%
	No	42	78.1%
Well Area fenced out	Yes	21	38.6%
	No	33	61.2%

Table 4.8: Chi-Square Test Results on Relationships between Technical Determinants and Fecal Contamination Status of Shallow Wells

Technical Determinants		**Fecal Contamination Status**		
Risk Factor	**Categories**	**Present**	**Absent**	**Chi-square**

Distance (M) from nearest latrine to the well	6-10	45	61	
	11-15	90	16	X^2 =51.46; df=2; P<0.001*
	>15	127	40	
Distance (M) from nearest cattle pen (if any) to the well	1-5	10	5	
	6-10	88	66	X^2 =20.90; df=4; P<0.001*
	11-15	10	6	
	>15	132	32	
Location of the well in relation to the nearest cattle pen (if any)	Downhill	145	50	
	Uphill	35	39	X^2 =22.97; df=3; P<0.001*
	Relatively flat ground	35	7	
Damage to or lack of concrete plinth	Yes	88	25	
	No	149	85	X^2 =8.53; df=2; P=0.014*
Breaks/cracks on the parapet wall	Yes	75	19	
	No	142	65	X^2 =9.81; df=2; P=0.007*
Breaks/cracks in the cover/top slab	Yes	79	37	
	No	138	47	X^2 =7.42; df=2; P=0.024*
Breaks in the Drainage channel	Yes	19	32	
	No	198	52	X^2 =40.94; df=2; P<0.001*
Well covered while not in use	Yes	3	2	
	No	214	82	X^2 =6.37; df=2; P=0.041*
Well Area fenced out	Yes	60	9	
	No	157	75	X^2 =15.29; df=2; P<0.001*

Significant at 0.05

Table 4.9: Showing further Chi Square Test Results on Relationships between Technical Determinants and Fecal Contamination Status of Shallow Wells

Technical Determinants		**Fecal Contamination Status**		
Risk Factor	**Categories**	**Present**	**Absent**	**Chi-square**

Location of the well in relation to the nearest Latrine	Downhill Uphill Relatively flat ground	103 147 12	32 80 5	X^2 =5.29; df=1; P=0.071
Well protection status	Protected Unprotected	82 180	44 73	X^2 =1.45; df=1; P=0.228

Table 4.11: Showing a Multinomial Logistic Regression Analysis of Technical Determinants as functions of Fecal Contamination Status of shallow Wells

Model Fitting Information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	**Sig.**
Intercept Only	389.198			
Final	147.382	241.816	20	**<0.001***

Significant at 0.05

REFERENCES

1. Adams, J., Bartram, J., Chartier, Y., Sims, J. (2009).Water, Sanitation and Hygiene StandardsforSchools in Low-costSettings; *WHO Library Cataloguing-in-Publication Data.*
2. Afubwa, O., Mwathi, A. (2014). EnvironmentalHealth and OccupationalHealth and safety; Acrodile Publishing Limited.
3. Conner, M. and Norman, P., (2010).*Predicting Health Behavior*. Search and Practice with Social Cognition Models. Open University Press: Baltimore.
4. Kenya National Demographic Health Information Survey (2012).
5. Kenya National Demographic Health Information Survey (2014).
6. Loharika, A., Langat D.,Ope ,M., Njeru, I., Gathigi, L., Mokayotto, L., Abde, A. (2013). A National Cholera Epidemic with high case fatality Rates- Kenya.*The Journal of Infectious Diseases*; 208(1); page 569-577.

7. Mark, (2007): Managing Water in the Home: Accelerated Health Gains from Improved Water Supply; Water, Sanitation and Health Department of Protection of the Human Environment World Health Organization Geneva.
8. Migori County Health Strategic Information Plan (2013-2017).
9. Mohamud, A., Ahmed, J., Nyoka, R., Auko, E., Kahi, V., Ndirangu, J., Nguhi, M., Burton, J., Muhindo, B., Breiman, R., Eidex, R. (2012) Epidemic cholera refugee camp, Kenya 2009; the importance of sanitation &soap.*Journal of Infections in DevelopingCountries*; 6(3l); page 234-241.
10. Nordberg, E. (2007). Communicable diseases; a manual forhealthworkers in sub-Saharan Africa. Nairobi. AMREF
11. Nyamogoba, H., Obala, A., Kakai, R. (2010) Combating cholera epidemicsby targetingreservoirs of infection and transmissionroutes: A review. East African Medical Journal; Volume 79(3); page 150-155.
12. Onyango, D., Karambu, S., Abade, A., Amwayi, S., Omwolo, J. (2013) High case-fatality cholera outbreak in western KenyaAug 2010. *Pan African Medical Journal;* 109(15); page 88-94.
13. Tambekar D.H., Hirulkar, N.B., Gulhane, S.R., Rajankar P.N., and Deshmukh S.S. (2007): Evaluation of hydrogen sulphide test for detection of fecal coliform contamination in drinking water from various sources: *African Journal of Biotechnology* Vol. 6 (6), pp. 713-717, 19.
14. Townsend. S.A, (2009).The relationships between salmonellas and fecal indicator bacteria concentrations in two pools in the Australia wet/dry tropics.*Journal Applied Bacteriology.* 73:182-188.
15. WHO, (1997). GuidelinesforDrinkingWaterQuality;FirstAddendumto 3rd Edition Vol. 1 Recommendations.
16. WHO, (2007). ManagingWater in the Home: AcceleratedHealthGainsfromImproved WaterSupply;Water, Sanitation and Health Department of Protection of the Human Environment World Health Organization Geneva.
17. WHO, (2008). Evaluation of the H2S Method for Detection of Fecal Contamination of Drinking Water; *Water, Sanitation and Health Department of Protection and the Human Environment World Health Organization Geneva.*
18. WHO, (2009).Guidelines for Drinking-water Quality 3rd Edition.Volume 1.*World Health Organization. Geneva.*
19. WHO, (2010). Indicators (draft document). OECD*, World Health Organization, Geneva.*
20. WHO, (2010). WeeklyBulletingonMajorEpidemic-Pronediseases;*A bulletin of the Sub-County of Prevention & Control of Communicable Diseases (DDC)Epidemic and Pandemic Alert and Response (EPR) Programme.*

21. WHO, (2014).Investing In Water and Sanitation: Increasing Access, ReducingInequalities; UN-Water Global Analysis and Assessment of Sanitation and Drinking- WaterReport.