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

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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 human 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 corliforms 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 reported significant relationship between level of knowledge of respondents on a well being too close to a latrine as a potential route (risk factor), a well located downhill a latrine, an open/uncovered well, surface run-offs into wells, dropping objects in shallow wells, using a dirty drawer, people/animals dropping in wells, doing laundry next to a well, and human/animal feces dropping in the well as potential routes of fecal contamination. 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 human determinants (risk factors) by and large are functions of fecal contamination status of shallow

wells in Dede Division. Households in Dede Division should ensure adequate treatment of water from shallow wells before consumption. hence reduce the rising trends of fecal related diseases in the Division.
Key Words: Human Determinants, Shallow well, Excreta related disease, Water-borne diseases

INTRODUCTION

A water well is a hole dug, bored or drilled into the ground to extract water for domestic consumption. It is considered shallow if less than 50 meters deep (King, 2014). Fecal contamination of water from a health point of view is the pollution of water with pathogens that may inhabit the small and large intestines of human beings. Ingestion of water contaminated with feces is responsible for a variety of diseases important to humans via the fecal-oral route of transmission. In 1998, it was approximated that 2.2 million deaths were connected to diarrhea each year, and a significant percentage of them due to fecal contamination of water, with the vast majority of victims being children in rural areas of the poor countries. It has also been estimated that more than 1 billion people worldwide do not have adequate access to safe drinking water, and more than 2 billion people do not have sufficient access to sanitation facilities (WHO, 2009). The incidence stands at 2.0 cases per 1000 people at risk (Loharika et al., 2013). Diarrheal diseases are the fifth leading cause of morbidity and mortality in children under five years nationally and the third and second leading cause of morbidity and mortality in children under five years at the county levels respectively (DHIS, 2012). This could be largely due to consumption of unsafe water, especially in the rural areas. This is coupled with the high prevalence of HIV/AIDS which renders quite some county residents immune-compromised has significantly increased their vulnerability.

Statement of the Problem

Contamination of underground water sources with fecal matter presents a grave public health threat in developing countries, such as Kenya, where large numbers of households lack access to clean and safe water supplies and rely on untreated surface water sources or shallow unprotected groundwater for domestic utilization (WHO & UNICEF, 2009). A report by the WHO on Global Analysis and Assessment of Sanitation and Drinking water shows that 1 billion people practice open defecation with nine out of ten of them in rural areas, and it is estimated that 1.8 billion people use a source of drinking water that is fecal contaminated (WHO, 2014). Due to high population growth and improper fecal waste disposal, there has been an increase in the prevalence of water-borne diseases, especially diarrheal diseases (WHO, 2009). In Kenya unsafe water, sanitation and hygiene are the second leading risk factor causing morbidity and mortality at the national and county levels respectively (CHSIP, 2013-2017). In addition, 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 March 2015 alone, there were 62 confirmed cases of cholera in Dede Division, which gives an average of 2 new cases per day (DHIS, 2014) in Awendo Sub-county. This study therefore, sought to assess human determinants of fecal contamination status of shallow wells i.e., knowledge, practices and perceptions that influence shallow well water quality in Dede Division, Migori County. If nothing is done to address this problem adequately, it may worsen in the coming decades as rural populations continue to increase, and wells remain a significant source of domestic water consumption.

Specific Objectives

1. To determine fecal contamination status of shallow wells in Dede Division.
2. To assess human determinants of fecal contamination status of shallow wells in Dede division.

Hypothesis

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

MATERIALS AND METHODS

Study Design

The study employed a cross-sectional study design since relevant responses from heads of households and well water samples were collected at one specific point in time and no interventions or follow-ups conducted after completion of the study. Analytical Design was then applied where water samples collected from the sampled shallow wells were transported to a standard government laboratory for bacteriological (fecal coliform) analysis.

Location of the Study

The study was conducted within Dede Division which covers a total of 108.30 square Kilometers. It is divided into West-Sakwa and North-Sakwa Wards respectively, with a total population of about 45,152 people (Census, 2009).

Target Population

Heads of households using shallow wells as a source of water for domestic use and shallow wells within Dede Division. There was 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

Grab water sampling technique was adopted. Grab samples were collected from each selected shallow well using a standard 500ml sterilized sample collection bottle following the standard shallow well water sampling procedure as outlined in the World health Organization drinking water quality Standards (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) Households Using Shallow Wells

Fisher et al., (1998) formula was used to calculate the sample size of households to be sampled. Since the number of households using shallow wells was less than 10,000 (4008), the two stages of the formula was adopted as outlined below.

n=Z2pqD/d2

Where:

n= is the desired sample size when the study target population is over 10,000

Z= the standard normal deviate, usually set at =1.96 (@ 95% confidence level).

P=The current proportion of wells fecally contaminated in Kenya (0.5).

q= I–P = 0.5

D=Study design effect (usually 1 when it is not a comparison study)

d = is the Degree of Accuracy required (0.05)

n = Z2pqD/d2 = [1.962 x 0.5x0.5x1]/ [(0.05)2 = 384.16 =384 House Holds.

However,

The target population is less than 10,000, and therefore we use:

Where:

nf=The desired sample size when population is less than 10,000

n = the desired sample size when the population is more than 10,000

N = the estimate of the population size.

nf ={384}/{1+(384/4008)}= 350.559= 351 Household Heads.

Attrition Rate =10% of 351=35Household Heads.

Total Sample Size 351+35 =386 Household Heads.

ii) Shallow Wells

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

Research Instruments

i) Self-administered Questionnaire

A self-administered questionnaire was developed and issued to the respective heads of households for responses on human determinants of fecal contamination of wells.

ii) 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.

iii) 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

A self-administered questionnaire and a checklist was used to collect data from heads of households and personal observation respectively 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

A total of 54 grab water samples were collected from 54 sampled shallow wells out of a total of 180 shallow wells present in Dede Division. These sampled wells served 386 households. As soon as grab water sample were collected, each of the 54 samples were tested for presence of total coliforms using H2S kit. The results indicated that of the 54 water samples collected, 96.3% (n=52) of them tested positive for total coliforms. 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). This is true given the multiple human and technical risk factors significantly associated to fecal contamination status of shallow wells.

Human Determinants of Fecal Contamination Status of Shallow Wells

i) Knowledge on Common Fecal Contamination Routes of Shallow Wells

Most of the respondents 56.58% (n=215) agreed that constructing a shallow well to close (<10m) to a latrine is a potential route for fecal contamination, while 43.68% (n=166) disagreed. As to whether constructing a well downhill a latrine is a route of fecal contamination of shallow wells, 59.26% (n=224) were in agreement while 40.78% (n=154) were not in agreement. Majority of the respondents in Dede Division 58.31% (n=221) are aware that leaving a shallow well uncovered is a potential route of fecal contamination with 41.69% 69% (n=36) 31% (n=16) Present Absent (n=158) not aware. However, the study findings further revealed that a minority of the respondents 48.81% (n=185) agreed that surface runoff is a possible route of fecal contamination of shallow wells while 51.19% (n=194) descented. A substantial majority 50.66% (n=192) of Dede Division residents are aware that Fetching water from a shallow well using a dirty drawer is a potential risk factor of fecal contamination of the well with an equally substantial minority 49.34% (n=187) not aware. A very significant majority 60.69% (n=230) disagreed with the fact that Humans and animal feces droppings in a shallow well is a potential route of fecal contamination with only 39.31% (n=149) in agreement, serious pointer of low knowledge levels in this regard.

Chi-square test Results between Knowledge on Fecal Contamination Routes and Fecal Contamination Status of Shallow Wells

As outlined in table II, there was a significant relationship between level of knowledge of respondents on a well being too close to a latrine as a potential route (risk factor) of fecal contamination and actual fecal contamination status of shallow wells (x2=17.41, p=0.001, df=3). The study further observed very significant relationships between levels of knowledge of respondents on a well located downhill a latrine (x2 =10.32, df=3, p=0.016), an open/uncovered well (x2=22.49, df=3, p<0.01), surface run-offs into wells (x2 =8.86, df=3, p=0.031), using a dirty drawer (x2 =12.13, df=3, p=0.011), people/animals dropping in wells (x2 =14.65, df=3, p=0.004), and human/animal feces dropping in the well (x2 =13.44, df=3, p=0.004) as potential routes (risk factors) of fecal contamination and actual contamination status of shallow wells. However, as outlined in table III, there were no significant relationships between levels of Knowledge on a shallow well being too close to a rubbish pit (x2=8.98, df=3, p=0.062), high rainfall frequency (x2=2.11, df=3, p=0.551), earth dropping from unprotected walls of the well (x2=6.84, df=3, p=0.077) and fecal contamination status of shallow wells respectively.

Discussion on Knowledge on Common Fecal Contamination Routes of Shallow Wells

Various knowledge levels of respondents on possible fecal contamination routes of shallow wells were evaluated for their likelihood of causing contamination. A shallow well dug too close to a latrine, a well downhill a latrine, an open/uncovered well, presence of a faulty septic tank, surface runoffs, dropping objects in wells, using dirty drawers, laundering next to the well and human and animal feces dropping inside the well were found to be highly significant predictors of fecal contamination of shallow wells (see table II). These concur with a study by Dighton which revealed that fecal contamination can reach ground water sources, including drinking water wells, from failed septic systems, leaking sewer lines, by passing through the soil and large cracks in the ground. Domestic pets, especially dogs, and cats can contribute to fecal contamination of well waters. Runoff from roads, parking lots, and yards can carry animal wastes to unprotected wells through erosion (Dighton, 2010). A study by Donderski and Wilk (2008), further concurs with these findings revealing that the major culprit of well water fecal contamination emanates from poor positioning of pit latrines particularly in rural areas and slums. They further report that most infrastructural investors do not adhere to the regulations by authorities on the distance hence they end up constructing latrines at close (less than 30 meters apart) proximity to the wells. However, having a well too close to rubbish pit, and high rainfall frequency respectively, were not significant predictors of routes of fecal contamination of shallow wells (see table II). This may be attributed to the fact that rubbish pits are not primarily filled with human/animal waste and fecally contaminated wastes which are potential sources of contamination.

ii) Human Hygiene Practices

The study findings revealed that a significant 76% (n=288) of respondents in Dede Division wash their hands at the shallow wells after handling farmyard manure with only 24% (n=91) not washing at the shallow well, a practice that increases susceptibility of the well to fecal contamination. Majority of the study respondents 60.9% (n=231) wash baby nappies next to the shallow wells while 39.1% (148) do not. This is very significant given the potential risk this practice creates in as far as fecal contamination of shallow wells is concerned. Most respondents 93.1% (n=353) reported treating their shallow wells with only 6.9% (n=26) not treating/disinfecting their shallow wells. The findings revealed that the most common method of shallow well treatment is pouring Liquid chlorine at 40.4 % (n=153). Other methods include removal of mud at 28.8% (n=109), and lastly dewatering the well at 15% (n=57) respectively.

Results on the relationships between Human Hygiene Practices and Fecal Contamination Status of Shallow Wells

The study findings as shown in Table IV revealed a significant association between washing hands after visiting latrines as a human hygiene practice (x2 =10.08, df=1, p=0.001) and fecal contamination status of shallow wells with a significant majority of respondents 86.5% (n=328) reporting washing their hands after visiting toilets. However, 48.5% (n=96) of those who wash their hands either do so on top of the well or a distance less than 5M from the draw point. The results further revealed a very significant association between hand washing after handling manure (x2 =15.44, df =1, p<0.001) and fecal contamination status of shallow wells. However, 76% (n=288) of them wash their hands at the well, with 56.6% (n=204) either washing on top of the well or a distance less than 5M from the draw point. There were no significant associations between cleaning of baby nappies (x2=df =1p=0.540), treatment/disinfection of wells (x2 =1.71, df=1, p=0.191), well treatment method (x2 =8.87, df=1, p=0.067,) and fecal contamination status of shallow wells respectively. Figure 4.2 shows that 93.1% (n=353) of respondents treat/disinfect their wells.

Discussions on human Hygiene Practices

As shown in table IV, washing hands after visiting toilets and after handling manure at the well were highly significant predictors of fecal contamination status of shallow wells respectively. In as much as it's a good practice, a significant majority (48.5%), of those who wash their hands after visiting toilets do so on top of the well. This may either contaminate the drawers or wash off traces of fecal matter back into the well hence contamination. However, cleaning baby nappies next to a shallow well was not necessarily a predictor of fecal contamination (p=0.54). It was noted however, that 60.9% of the respondents still clean baby nappies next to the well, as a result exposing the shallow wells to fecal contamination. This may be as a result of lack of access to modern disposable diapers in rural settings or very low income levels by households. This concurs with a study by Conboy and Goss (2009), which affirms that people who handle fecal wastes particularly from children and the disabled around water sources for convenience end up contaminating the water with feces, as a result exposing themselves to fecal related diseases. In spite of 93.1% of respondents reporting treating their wells, well treatment was not a significant predictor of fecal contamination (p=0.191). This may be attributed to inefficient methods of treatment.

Human Sanitary Practices

The study findings revealed that majority of the pit latrines 79.7% (n=302) are constructed more than 10M away from the shallow wells with 20.3% (n=77) constructed within 10M from the shallow well. However, 66.5% (n=253) of pit latrines nearest to the shallow wells are erected on lower ground (in terms of gradient) with only 33.5% (n=127) erected on higher ground in Dede Division. Minority of the shallow wells 39.3% (n=21) had faulty drainage channels potentially capable of permitting ponding around the shallow wells with a significant majority 60.9% (n=33) having proper drainage channels. In addition, 85% (n=46) of shallow wells in Dede Division had their concrete floors more than 1M wide, a significant majority 62.5% (n=33) having proper drainage channels. In addition, 85% (n=46) of shallow wells in Dede Division had their concrete floors more than 1M wide, a significant pointer to proper sanitary maintenance while 15% (n=8) only had their floors less than 1M wide. Study findings further revealed that majority walls of shallow wells 85.2% (n=323) were adequately sealed at any point 3M below the ground with only 14.8% (n=56) not adequately sealed. In addition, 65.2% (n=147) had visible cracks on on the cover wall around the respective shallow wells, with only 34.8% (n=132) without cracks. A significant majority of shallow wells 60.7% (n= 230) had their drawers (ropes and buckets) left in positions of possible contaminations e.g. next to animal droppings with the rest 39.3% (n=149) well placed. Over 82.1% (n=311) of shallow wells required a cover with only 17.9% (n=68) of them covered.

The findings revealed that 96.3% (n= 365) had human feces absent within 10M of the shallow wells while 3.7% (n=14) had human feces present. However, 69.9% (n=264) had animal droppings present within 10M while 30.4% (n=115) did not have them.

Association between Human Sanitary Practices and Fecal contamination Status of Shallow Wells

The study found out that there were significant associations between latrines located on higher ground in relation to shallow well (x2 =24.38, df=1, p<0.001), shallow wells with concrete floors less than 1M around the well (x2=15.94, df=1, p=0.009), walls inadequately sealed 3M below the ground (x2 =9.34, df=1, p=0.002), cracks in concrete walls around the shallow wells (x2 =6.83, df=1, p=0.003), human feces present within 10M from the shallow well (x2 =7.61, df=1, p=0.006), animal droppings present within 10M from the shallow well (x2=10.84, df=2, p=0.004) and fecal contamination status of corresponding shallow wells respectively. In all the categories listed above, majority of shallow wells tested positive for fecal coliforms. However, other categories of sanitary practices had no significant association with fecal coliform status of shallow wells. These included latrines located within 10M of the well (x2=4.27, df=1, p=0.187), presence of other sources of pollution like animal excreta and rubbish (x2 =0.19, df=1, p=0.784), faulty draining channels permitting ponding at (x2=3.32, df=1, p=0.068), ropes and buckets left in positions of possible contamination (x2 =4.21, df=1, p=0.648) respectively.

Multinomial Logistic Regression Analysis of Human Determinants as a Function of Fecal Contamination Status of Shallow Wells

As outlined in table VI, the study established that human determinants in general are a function of fecal contamination status of shallow wells at (p<0.001). This therefore means that human determinants are predictors (pointers) of fecal contamination status of shallow wells in Dede Division.

Discussion of Human Sanitary Practices

Much as there are many influences on microbiological contamination of shallow wells reflecting several different mechanisms by which microbes derived from feces may enter the water in the well, study findings show that latrines constructed on higher ground than wells were significantly associated with fecal contamination status of corresponding shallow wells (p=0.000). This enhances movement of fecal coliforms within the soil through leaching and filtration to the near shallow well water sources. The findings further revealed that concrete floors <1M wide around the well (p=0.000), walls of wells inadequately sealed at any point 3M below the ground (p=0.000), cracks in the concrete wall around the well (p=0.003), human feces present within 10M of the well (p=0.006), and animal droppings present within 10M of the well (p=0.004), were human sanitary practices significantly associated with fecal contamination status of shallow wells. These concur with a study conducted in Conakry, Guinea, which showed that there was widespread contamination of shallow dug wells and suggested that microbiological contamination was associated with poor maintenance (human sanitary practices) of the wells rather than sub-surface leaching of fecal material (Howard et. al, 2003). However, sanitary risk factors such as a well requiring a cover (p=0.820), ropes and buckets left in positions of possible contamination (p=0.648), well installation requiring fencing (p=0.661), were not significantly associated with fecal contamination of shallow wells. This is contrary to a study by (Rojas et. al, 2004) which found that factors such as the presence of uncapped wells and poor sanitary completion were as important as sub-surface leaching of microbiological contaminants. The total sanitary risks scores showed a significant association with fecal contamination status of shallow wells.

Conclusion

Majority of shallow wells in Dede Division are fecally contaminated. Human determinants are a function of fecal contamination status of shallow wells in Dede division.

Recommendations

- Households in Dede Division should ensure adequate treatment of shallow wells for fecal contamination before utilization of water from these sources.

- Households in Dede Division should be sensitized by the relevant authorities on common routes of fecal contamination of shallow well water and safe hygiene and sanitation practices around shallow wells to prevent fecal contamination of the wells.

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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 II: Chi-square test Results between Knowledge on Fecal Contamination Routes and Fecal Contamination Status of Shallow Wells

	Fecal Contamination Status

Common knowledge on Fecal Cont. Routes	**Scale**	**Present**	**Absent**	**Chi Square Test**
Well too close (<10M) to latrine	SA	25.9%	7.4%	
	A	17.9%	5.5%	
	D	13.2%	7.4%	
	SD	12.1%	10.6%	x^2 = 17.41; df=3; P=0.001*
Well downhill a Latrine (in terms of Gradient)	SA	19.8%	7.4%	
	A	23.5%	8.5%	
	D	19.1%	8.5%	
	SD	6.6%	6.6%	x^2 =10.32; df=3; P=0.016*
Open/uncovered well (unprotected)	SA	18.5%	22%	
	A	26.6%	7.4%	
	D	15.3%	8.2%	
	SD	8.7%	9.5%	x^2 =22.49; df=3; P<0.001*
Surface Runoffs	SA	13.2%	2.6%	
	A	23.2%	9.8%	
	D	21.6%	13.2%	
	SD	11.1%	5.3%	x^2 =8.86; df=3; P=0.031*

Using Dirty Drawer	SA	13.2%	4%	
	A	25.6%	7.9%	
	D	17.4%	9.5%	
	SD	12.9%	9.5%	x^2 =12.13; df=3; P=0.011*
Human/Animal feces Droping in the well	SA	11.1%	1.8%	
	A	18.5%	7.9%	
	D	29%	12.4%	
	SD	10.6%	8.7%	x^2 =13.44; df=3; P=0.004*

***Significant at p<0.05**

Table III: Chi-square test Results on further Relationships between knowledge on Fecal Contamination Routes and Fecal Contamination Status of Shallow Wells

Common knowledge on Fecal Cont. Route	Scale	Fecal Contamination Status: Present	Fecal Contamination Status: Absent	Chi-Square Test
Well close to rubbish pit	SA	14.2%	4.5%	
	A	23.2%	7.4%	
	D	19.5%	7.9%	
				x^2 =8.98; df=4; P=0.062
	SD	11.9%	11.3%	
High Rainfall Frequency	SA	7.9%	2.9%	
	A	28%	10.6%	
	D	20.9%	5.8%	
				x^2 =2.11; df=3; P=0.551
	SD	12.4	11.4%	
Earth dropping from	SA	11.9%	5%	
unprotected well wall	A	23%	6.9%	
	D	21.4%	10.3%	x^2 =6.84; df=3; P=0.077
	SD	12.9%	8.7%	

Table IV: Results on the relationships between Human Hygiene Practices and Fecal Contamination Status of Shallow Wells

Human Hygiene Practice	Fecal Contamination Status			
Risk Factor	**Scale**	**Present**	**Absent**	**Chi Square Test**
Washing hands after handling manure at well	Yes	57.3%	29.3%	
	No	11.9%	1.6%	x^2 =15.44; df=1; P<0.001*
Washing hands after visitig Toilets/latrines	Yes	57.3%	29.3%	x^2 =15.44, df=1, p<0.001*
	No	11.9%	1.6%	
Cleaning baby nappies next to the well	Yes	48.5%	27.4%	x^2 =0.38; df=1; P=0.54
	No	20.6%	3.4%	
Treating & disinfecting well	Yes	41.4%	19.5%	x^2 =1.71; df=1; P=1.911
	No	27.7%	11.3%	
Well treatment Method	Yes	65.2%	28%	x^2 =8.87; df=1; P=0.067
	No	4%	2.9%	

Significant at p<0.05

Table V: Association between Human Sanitary Practices and Fecal contamination Status of Shallow Wells

Human Sanitary Practices		Fecal Contamination Status		
Risk Factor	**Categories**	**Present**	**Absent**	**Chi-square**
Latrine within 10M of the Well	Yes	53.8%	5%	
	No	15.3%	25.9%	x^2 =4.27; df=1; p=0.187
Latrine on higher ground than the	Yes	29.3%	4.2%	
well	No	39.8%	26.6%	x^2 =24.38; df=1; P<0.001*
Faulty drainage channel permitting	Yes	22.4%	10%	
ponding	No	46.7%	20.8%	x^2 =3.32; df=1; P=0.68
Concrete floor <1M wide around the	Yes	8.2%	6.9%	
well	No	60.9%	24%	x^2 =6.83; df=1; P=0.009*
Walls of well inadequately sealed at	Yes	13.2%	1.6%	
any point 3M below the ground	No	55.9%	29%	x^2 =9.34; df=1; P=0.002*
Cracks in the concrete wall around	Yes	30.1%	7.4%	
the well	No	41.7%	23.5%	x^2 =6.83; df=1; P=0.003*

Ropes and buckets left in position of	Yes	42.5%	18.2%	
possible contamination	No	26.6%	12.7%	x^2 =0.21; df=1; P=0.648
Well require a cover	Yes	58.3%	23.7%	
	No	10.8%	7.1%	x^2 =3.03; df=1; P=0.820
Installation require fencing	Yes	48.8%	21.1%	
	No	20.3%	9.8%	x^2 = 0.19; df=1; P=0.661
Human feces present within 10M of	Yes	1.3%	2.4%	
the well	No	67.8%	28.5%	x^2 =7.61; df=1; P=0.006*
Animal droppings present within	Yes	24.3%	5.8%	
10M of the well	No	44.7%	25.1%	x^2 =10.84; df=2; P=0.004*

***Significant at p<0.05**

Table VI: Multinomial Logistic Regression Analysis of Human Determinants as a Function 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	465.400			
Final	273.513	191.887	65	**<0.001***

Significant at 0.05*

REFERENCES

Adams, J., Bartram, J., Chartier, Y., Sims, J. (2009).Water, Sanitation and Hygiene StandardsforSchools in Low-costSettings; *WHO Library Cataloguing-in-Publication Data.*

Afubwa, O., Mwathi, A. (2014). EnvironmentalHealth and OccupationalHealth and safety; Acrodile Publishing Limited.

Conner, M. and Norman, P., (2010).*Predicting Health Behavior*. Search and Practice with Social Cognition Models. Open University Press: Baltimore.

Kenya National Demographic Health Information Survey (2012).

Kenya National Demographic Health Information Survey (2014).

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.

Mark, (2007): ManagingWater in the Home: AcceleratedHealthGainsfromImproved WaterSupply;Water, Sanitation and HealthDepartment of Protection of the Human EnvironmentWorldHealthOrganization Geneva.

Migori County Health Strategic Information Plan (2013-2017).

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.

Nordberg, E. (2007). Communicable diseases; a manual forhealthworkers in sub-Saharan Africa. Nairobi. AMREF

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.

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.

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.

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.

WHO, (1997). GuidelinesforDrinkingWaterQuality;FirstAddendumto 3rd Edition Vol. 1 Recommendations.

WHO, (2007). ManagingWater in the Home: AcceleratedHealthGainsfromImproved WaterSupply;Water, Sanitation and HealthDepartment of Protection of the Human Environment World Health Organization Geneva.

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.*

WHO, (2009).Guidelines for Drinking-water Quality 3rd Edition.Volume 1.*World Health Organization. Geneva.*

WHO, (2010). Indicators (draft document). OECD, *World Health Organization, Geneva.*

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.*

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

Rojas R, Howard G, Bartram J, (2004). Groundwaterquality and watersupply in Lima.

In: Nash H, McCall GJH, editors. Groundwaterquality, AGID Report No. 16.

London: Chapman& Hall; p. 159–167.