Risk Factors for Leptospirosis in Rural Communities of Bungoma County, Kenya: A Cross Sectional Survey

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ABSTRACT

Leptospirosis is an important re-emerging zoonosis of worldwide public health concern. Leptospirosis is caused by a bacterium of the genus Leptospira. There was an outbreak of leptospirosis in humans in Bungoma County in 2004 with severe consequences. Leptospirosis is enzootic in cattle in Bungoma County. This study was conducted between April and July of 2017 to determine the risk factors for leptospirosis in humans in Bungoma County. The risk factors considered in this study were; rainfall patterns, livestock management practices (grazing and watering system), home slaughter of livestock, consumption of un-inspected meat, rodent infestation in homes, and frequency of contact of livestock keepers with veterinary extension staff. A cross-sectional survey was carried out in Kimilili and Mt Elgon sub-counties of Bungoma County, Kenya. The locations were then sampled and 400 households selected using systematic random sampling technique. Questionnaires were administered to heads of the identified households. Descriptive statistics and the chi-square test were used to analyze the data. Secondary data from medical records in Kimilili and Webuye health facilities were used to show the disease trends in the year 2004. The study reveals the risk factors for leptospirosis in Bungoma County which include the close association of the community and their livestock (87.9%, n=400), rodent infestation in homes (92.3%, n=400), slaughter of animals in non-designated areas (83.8%, n=400), consumption of un-inspected meat (83.0%, n=400) and low contact of the population with veterinary extension staff (63.7%, n=400). The risk factors under consideration in this study were observed in over 80% of the study population. The study recommends that knowledge of leptospirosis and its risk factors be enhanced for effective control and prevention program.

Keywords: Bungoma County, Leptospirosis, Risk Factor

I. INTRODUCTION

Leptospirosis is an ignored and frequently overlooked bacterial zoonosis in Africa (Allan et al., 2015). In humans, leptospirosis causes a variety of symptoms, including headache, high fever, myalgia, chills, jaundice, diarrhea, stomach aches, and rashes (Nakeel et al., 2016). These symptoms are non-pathognomonic and can be mistaken for other infections such as brucellosis, malaria, typhoid, streptococcal infections and rheumatism (Esteves et al., 2018). In livestock, leptospirosis has a substantial impact on reproduction and causes abortion, stillbirth and weak neonates (Simegnew, 2016). Difficult clinical diagnosis and absence of diagnostic laboratory testing results in under-diagnosis and therefore the leptospirosis burden is underestimated (Plank & Dean, 2000; Esteves et al., 2018). Any intervention directed towards the leptospirosis control in humans and livestock strongly depends on surveillance (World Health Organization [WHO]/ Communicable Diseases [CDS], 1999).

In Kenya, there was an outbreak of leptospirosis among humans in Bungoma County in 2004 in the Kimilili Sub-County and Mt Elgon Sub-County's Kaptama Ward. The outbreak is classified as one of Kenya's disaster of public health concern, where 859 cases were confirmed with twelve (12) fatalities (Government of Kenya [GoK], 2018).

It is unclear what risk factors are causing the apparent global resurgence of leptospirosis prevalence (Silvania et al., 2013). However, several factors are considered to have a role in the occurrence of leptospirosis, including the following: - living within urban and peri-urban areas (Raghavan et al., 2011; Raghavan et al., 2012), flooding events (Ward et al., 2004; Raghavan et al., 2012), contact with infected wild and domestic animals (Ward et al., 2004), less than ideal socio-economic conditions in areas where dogs reside (Reis et al., 2008), poor hygiene, the presence of rodents, presence of potential pets as reservoir and history of flooding (Tassinari & Pellegrini, 2008).

The study aimed to determine the risk factors for leptospirosis in humans in Bungoma County, Kenya. The risk factors considered in this study were; rainfall patterns, livestock management methods (grazing and watering system), practice of slaughter of livestock in homes, consumption of un-inspected meat, rodent infestation in residences, and frequency of interaction of farmers with veterinary extension workers.

II. MATERIALS & METHODS

2.1 Study Sites

The investigation was carried out between April and July 2017 in five wards of Kimilili and Mt Elgon Sub-Counties, Bungoma County in Kenya. The study area was selected purposively based on the outbreak of human leptospirosis in Bungoma County in 2004. The county enjoys good weather with heavy rainfall (County Director of Meteorological Services [CDMS], 2016). Rain-fed agriculture is the mainstay of the communities in Bungoma County. The main livestock kept in the county include cattle, sheep, goats, donkeys, pigs, and poultry. Other domestic animals are dogs and cats (County Director of Veterinary Services [CDVS], 2017).

2.2 Study Population

The study focused mainly on the area that was severely affected by the 2004 leptospirosis outbreak in the four wards of Kimilili Sub-County (Kibingei, Kamukuywa, Kimilili, and Maeni) and one ward of Kaptama in Mt. Elgon Sub-County.

2.3 Research Design

A cross-sectional survey was used in this study. The risk factors considered in this study included rainfall patterns, livestock species kept, livestock grazing and watering system, livestock slaughtering practices and inspection, rodent infestation in homes and contact with veterinary extension staff.

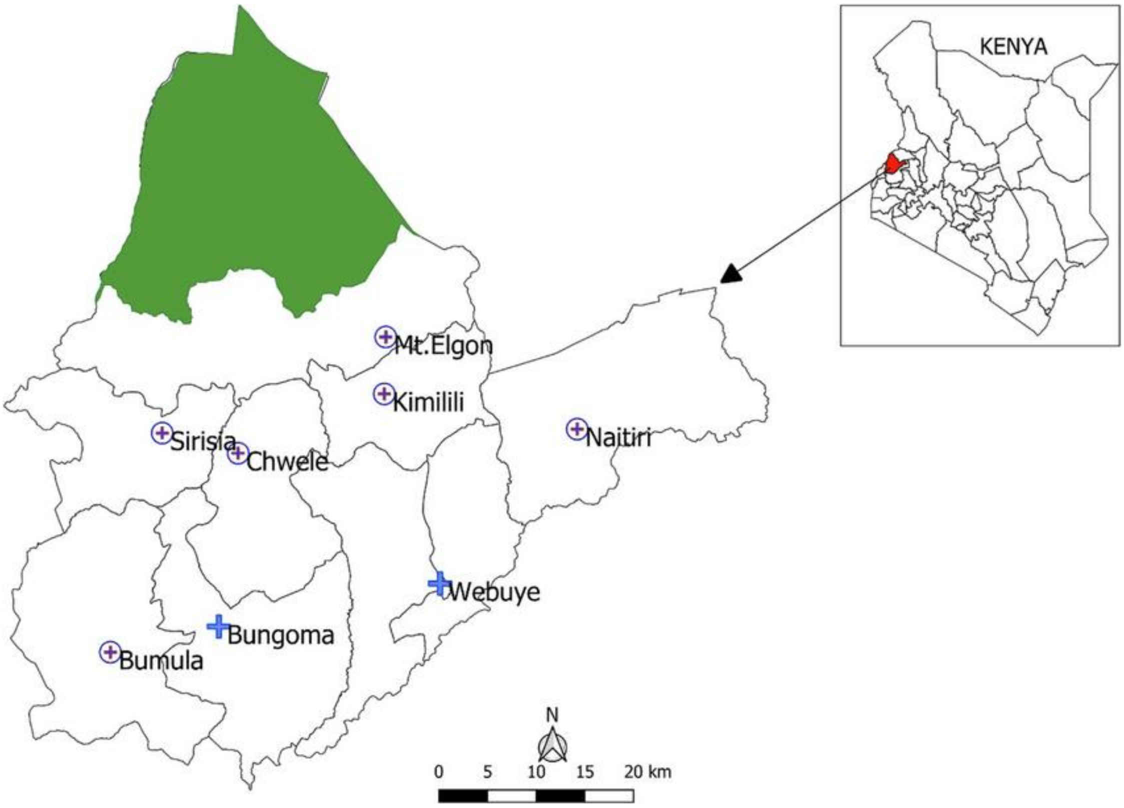

Figure 1
Position of Bungoma County in Kenya (Shaded Red)
Source: KNBS, (2013)

2.4 Sampling Strategy

Kimilili and Mt Elgon sub-counties were sampled purposively based on the foci of the leptospirosis outbreak of 2004. The two sub-counties were then stratified into the five wards of Kibingei, Kamukuywa, Maeni, Kimilili, and Kaptama and further into the various locations. Twenty six (26) locations were then selected purposively according to the extent of exposure to the leptospirosis outbreak of 2004. Households were selected randomly for interviews and questionnaires administered to the head of the household. The sample size of households was determined using the formula in Thursfield (2005): Z^2 x P x (1-P)/d^2 where Z=1.96 and d =0.05 at a 95% confidence interval. Where n the required sample size, P= 50%, sero-prevalence p=0.5, q=1-p(0.5)d is the precision of the estimate, 5%.
n=1.96^2xo.5x0.5/$(0.05)^2$ =384 households.

The total number of households by location, ward, and sub-county is shown in Table 1.

Table 1
Number of households sampled by Sub-County, Ward, and location

SUB-COUNTY	WARD	LOCATION	No. of HH SAMPLED
Kimilili	Kibingei	Kibingei	6
		Kitayi	4
		Chebukwabi	10
		Kamusinga	16
	Kimilili	Kimilili	22
		Bituyu	10
		Khamulati	12
	Maeni	Kibisi	20
		Sikhendu	22
		Nasusi	29
		Kamasielo	31
	Kamukuywa	Makhonge	16
		Mapera	18
		Mbongi	24
		Nabikoto	18
		Musebe	16
		Kimakwa	16
Mt Elgon	Kaptama	Kaborom	22
		Kaptama	18
		Chesito	13
		Kongit	12
		Kaboiywo	13
		Kaptelelio	10
		Chemoge	10
		Chemuses A	6
		Chemuses B	6
			400

2.5 Data Collection

Both primary and secondary data were used in the investigation. Secondary data was gathered from archival sources, while primary data was collected in the field. Medical reports for the 2004 leptospirosis were obtained from Kimilili and Webuye County Hospitals, these being the main health facilities that handled leptospirosis cases during the outbreak. The data included the number of suspected leptospirosis patients and their residence.

The annual rainfall pattern for Kimilili and Mt. Elgon sub-counties between 2000 and 2010 was obtained from the County Director of Meteorological services-Bungoma County (County Director of Meteorological Services Reports, 2000 to 2010). Then the monthly rainfall distribution in 2004 was tabulated and used to assess the possible association of the disease incidence with rainfall patterns. The data was analyzed using descriptive statistics and chi-square test then presented using tables and graphs.

III. RESULTS & DISCUSSIONS

3.1 Trends of suspected human leptospirosis cases as per hospital records in Bungoma County

Hospital records from Kimilili and Webuye hospitals were used to show the disease trend as reported in the two health facilities. The cases were reported between April and November 2004, when the outbreak occurred (Figures 2 and 3).

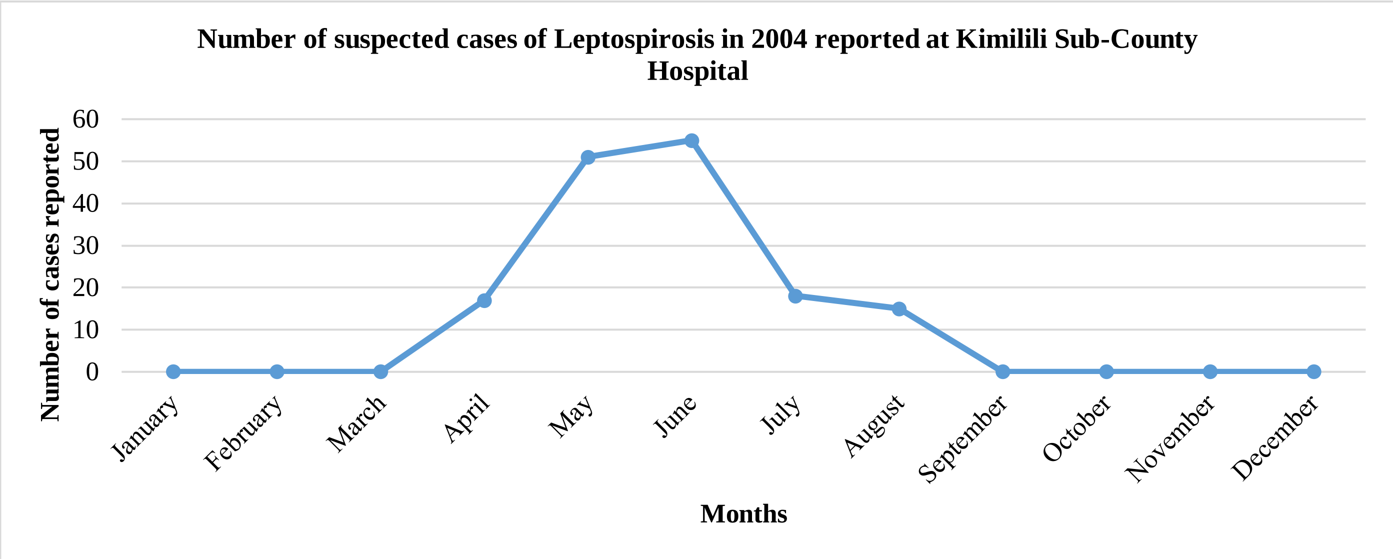

Figure 2
Number of Suspected Cases of Leptospirosis Treated at Kimilili Sub-County Hospital in 2004

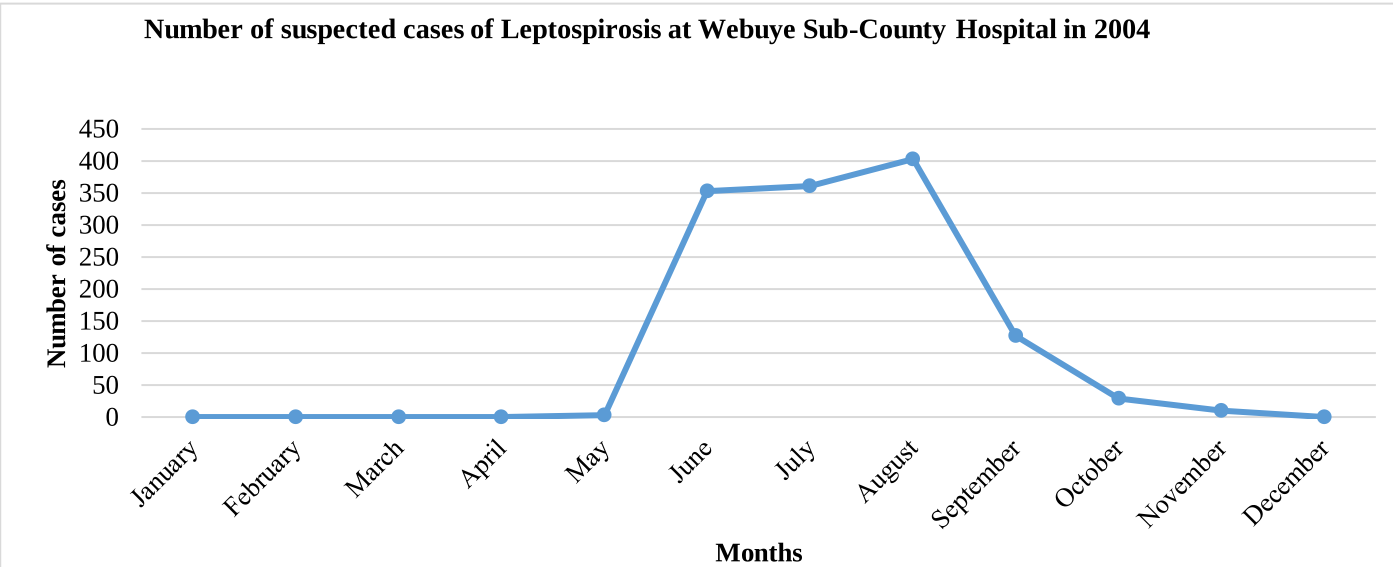

Figure 3
Number of Suspected Cases of Leptospirosis Treated at Webuye Sub-County Hospital in 2004

Hospital records reveal that at Kimilili Sub-County Hospital, the initial cases were reported in April 2004, with 17 cases, all from Chesamisi village. The cases then increased gradually, reaching a peak of 55 in June 2004 and subsiding to 15 cases in August 2004. There were no cases in September and subsequent months of 2004. On the other hand, in Webuye Sub-County Hospital, the first case was reported on 22nd May 2004, followed by more reports on 24th and 25th May 2004, respectively. These cases were from Chesamisi and Wabukhonyi areas of Kamukuywa Ward, Kimilili Sub-County. Table 2 below shows the residences of the patients treated in the two health facilities.

Table 2
The Origin of the Cases Encountered At Kimilili and Webuye Health Facilities in 2004, Bungoma County, Kenya

VILLAGE	SUB-COUNTY	TOTAL
Kamukuywa	Kimilili	6
Makhonge	Kimilili	7
Chesamisi	Kimilili	79
Kimilili	Kimilili	41
Mutukuyu	Kanduyi	1
Nandolia	Kanduyi	2
Teremi	Kabuchai	1
Namangofulo	Sirisia	1
Kaptama	Mt Elgon	1
Misikhu	Webuye West	1
Matulo	Webuye West	10
Mbakalo	Tongaren	35
Wabukhonyi	Tongaren	5
Maliki	Tongaren	1
Not recorded	Not recorded	518
TOTAL		714

Of all the cases with residence recorded, most (18.6%, n=714) were from Kimilili Sub-County and Chesamisi area contributing a high proportion of the cases. However, majority of the cases (72.5%, n=714) did not indicate the patients' residence.

3.2 Rainfall Patterns

The annual rainfall in Bungoma County ranges between 400mm (lowest) and 1,800mm (highest). Figures 3 and 4 indicate that the annual rainfall for the year 2004 falls within this range in the two sub-counties of Kimilili and Mt. Elgon. Analysis of the annual rainfall patterns shows that the highest rainfall in Kimilili Sub-County was recorded in 2006 (1,849mm), followed by 2010 (1,774mm), then 2007 (1,691mm). The amount of rainfall recorded in 2004, when the leptospirosis outbreak occurred is 1,272mm.

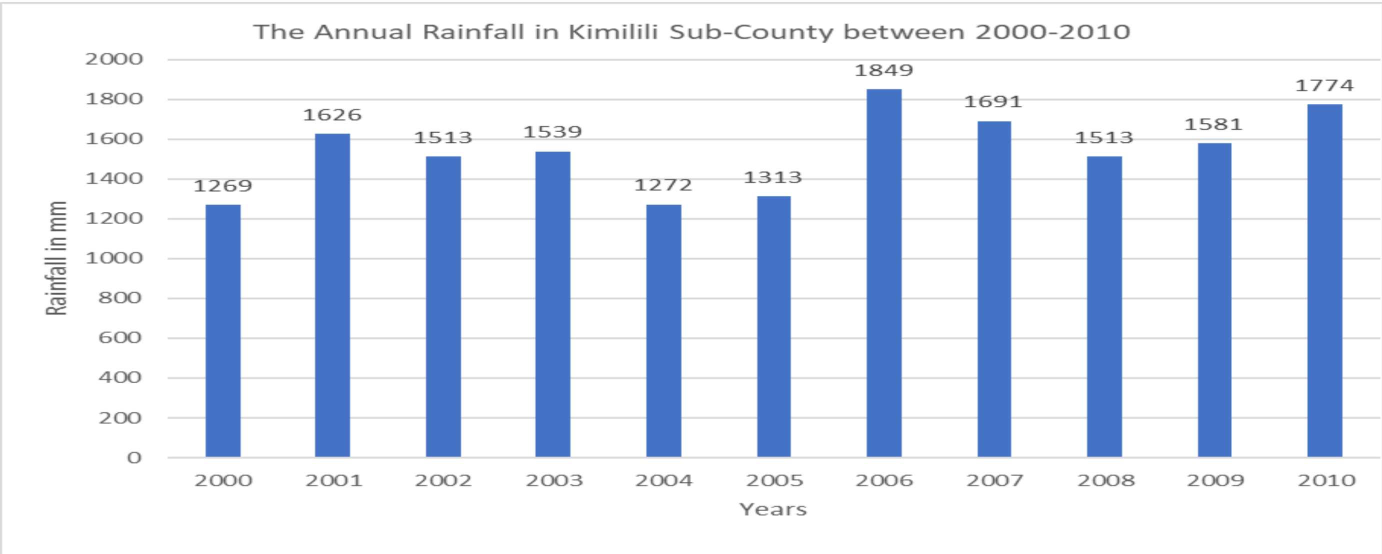

Figure 3
The Annual Rainfall in Kimilili Sub-County between 2000 And 2010

A similar pattern is observed in the amount of rainfall recorded in Mt Elgon Sub-County, where the highest amount of rainfall is recorded in 2006, followed by 2010 and 2007, respectively.

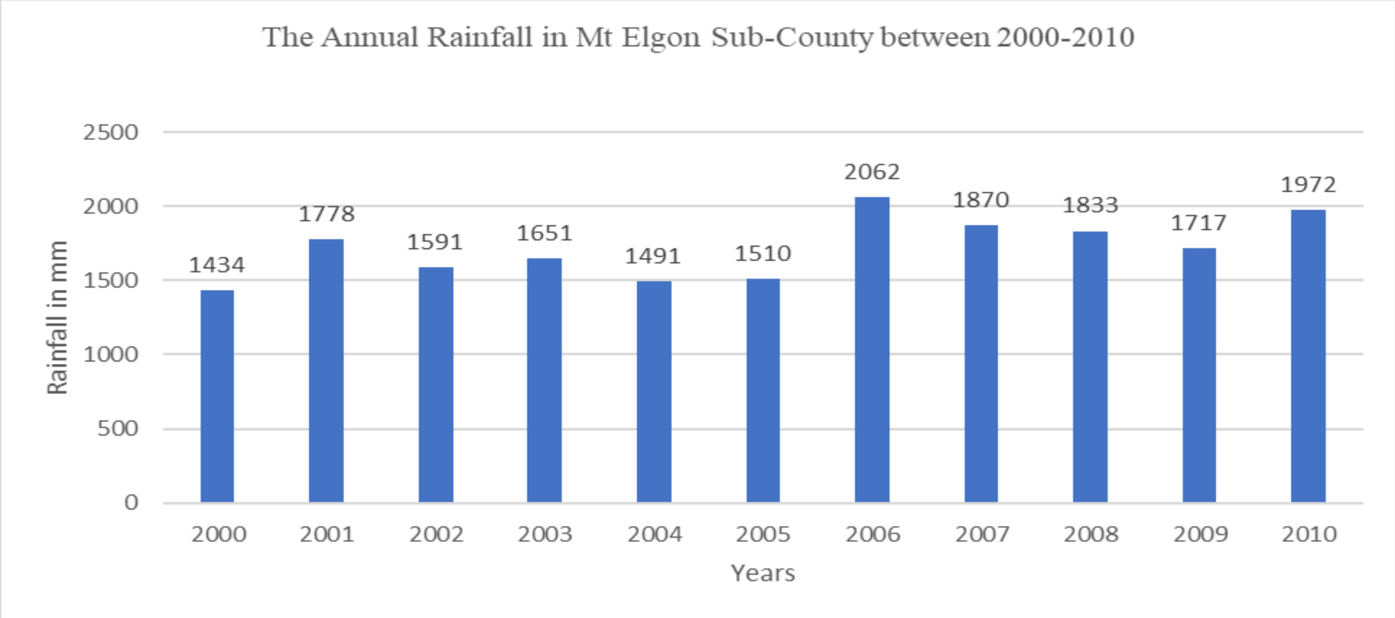

Figure 4
The Annual Rainfall in Mt. Elgon Sub-County between 2000 and 2010

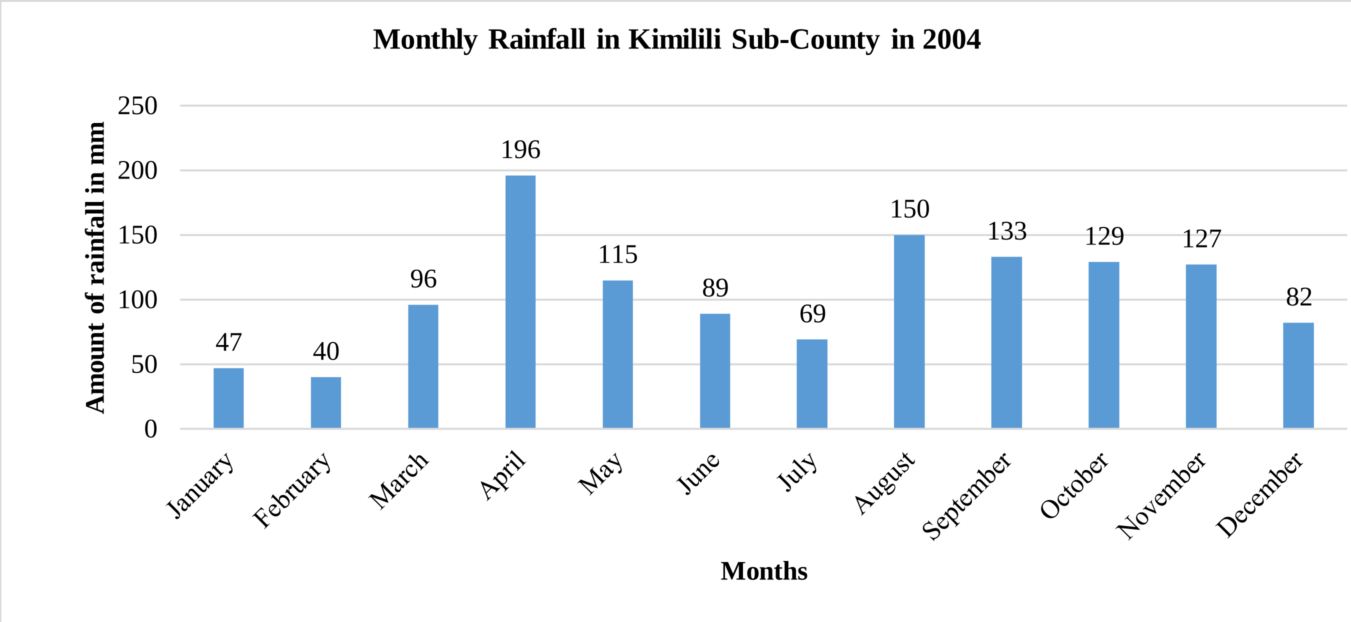

Figure 5
Monthly Rainfall Pattern for Kimilili Sub-County In 2004

The monthly rainfall in both Kimilili and Mt Elgon Sub-Counties shows that the highest rainfall was recorded in April 2004, which went down to July before increasing again (Figures 4 and 5).

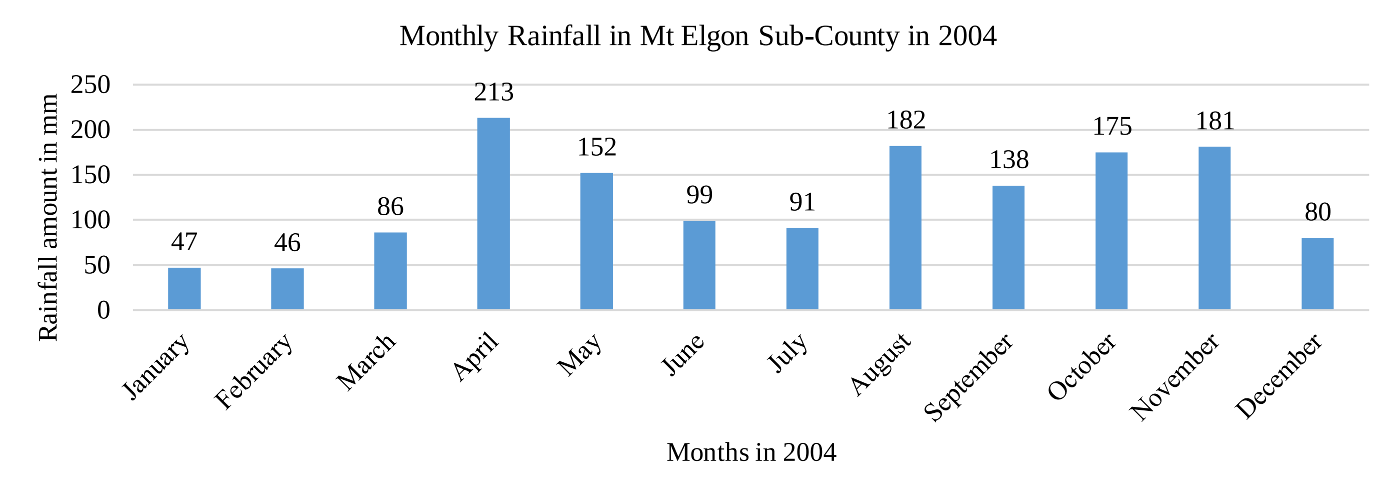

Figure 6
Monthly rainfall pattern for Mt.Elgon Sub-County in 2004

The first suspected case of leptospirosis was reported in Kimilili in April 2004, which also coincided with the onset of the rainy season. In both Kimilili and Mt.Elgon Sub-Counties, the highest rainfall occurred in April 2004.
A Pearson Correlation analysis was done to determine the relationship between monthly rainfall and the corresponding number of cases and results in Table 3 below.

Table 3
Pearson Correlation between Monthly Rainfall and the Corresponding Number of Suspected Leptospirosis Cases at Kimilili Hospital

Correlations			
		CASES	RAINFALL
CASES	Pearson Correlation	1	.043
	Sig. (2-tailed)		.894
	N	12	12
RAINFALL	Pearson Correlation	.043	1
	Sig. (2-tailed)	.894	
	N	12	12

The Pearson Correlation of 0.043 shows that a strong correlation exists between the pattern of rainfall and number of leptospirosis cases. The Key Informant Interviews revealed that relatively heavier rainfall resulted in flooding of many parts of the study area, especially in the surrounding swampy villages. Key Informant Interviews revealed that the high rainfall resulted in flooding, poor sanitation thereby compromising hygienic standards and therefore resulting in outbreaks of waterborne diseases. Leptospirosis is strongly associated with heavy rain (Gaynor et al., 2007; Kawaguchi et al., 2008; Sophia et al., 2014). Flooding assists in the spread of the disease (Wasinski & Dutkiewcz, 2013; Sophia et al., 2014). Studies have demonstrated that leptospirosis outbreaks are associated with elevated rainfall patterns and that there was a 0.55% increase in leptospirosis infections in Brazil for every millimeter daily rainfall above the study area's average (CDC, 1995; Kupek et al., 2000; Oliveria et al., 2001; M&H articles, 2010; Lau et al., 2010).

3.3 Livestock Species Kept in the Study Area

The study reveals that all respondents keep livestock: 87.9% (n=400) keep cattle, 8.2% (n=400) keep sheep and 2.3% (n=400) keep other livestock, which includes pigs. Evidence for carriage of leptospirosis has been demonstrated in all mammalian species, including domestic animals (Adler & Mactezuma, 2010). Livestock rearing is considered to be a risk factor for leptospirosis as this increases chances of contamination with urine during routine animal husbandry practices such as cleaning pens, milking, and assisting the animals during delivery (Ramachandra et al., 2014; Sakundarno, 2014). The livestock species kept were subjected to a Pearson Chi-Square test and gave (X^2 =8.22, $p<0.05$ at df=3) as shown in Table 4 below.

Table 4:
Pearson Chi-Square Test for the Livestock Kept In Kimilili and Mt Elgon Sub-Counties, Bungoma County, Kenya

Chi-Square Test			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square Test	8.22	3	P<0.05

This shows a high variation in the livestock kept in the region, meaning that all the livestock species kept have a role to play in the transmission of leptospirosis in the study area.

3.4 Other Domestic Animals Kept

To determine the role of other domestic animals, the study showed that 59.8% (n=400) of the respondents reported having kept dogs, 27.8% (n=400) kept cats, 4.6% (n=400) keep other domestic animals such as donkeys, while the remaining 7.7% (n=400) do not own any other domestic animals.

A Chi-square test on other domestic animals gave a result of, X^2 =2.998, $p<0.05$ at df=3, as shown on Table 5 below.

Table 5
Pearson Chi-Square Test for other livestock species kept in Kimilili and Mt Elgon Sub-Counties, Bungoma County, Kenya

Chi-Square Test			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square Test	2.998	3	P<0.05

These finding suggest that other domestic animals are likely to contribute to the increased risk for leptospirosis infection in the study area. Ananyima (2012) has shown that dogs and cats are important reservoirs of leptospirosis and act as a source of infection in humans. Another study conducted in Indonesia demonstrated that although dogs and cats are important reservoirs of leptospirosis, they played a marginal role in disease transmission because only a few people kept the pets (Silviana, 2013).

3.5 Grazing Systems in the Study Area

The study identified the common grazing systems in the study area, and the results are presented in Figure 7.

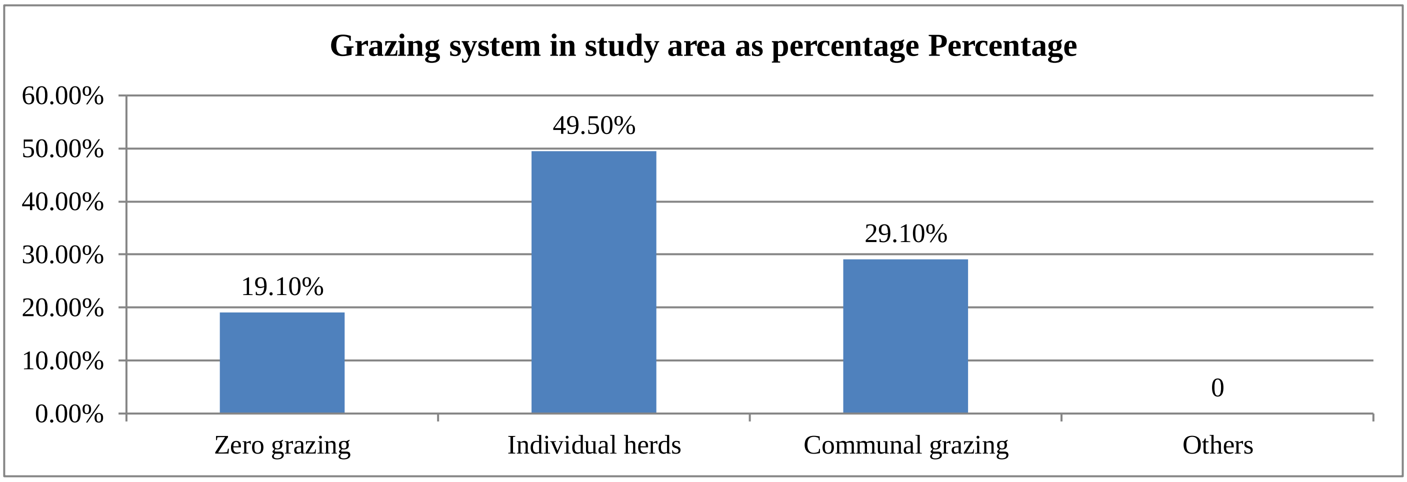

Figure 7
Grazing System in the Study Area

Most of the respondents practice individual herding at 49.5% (n=400), where the cattle graze in the open fields, but are not allowed to mix with herds from other households (Figure 7). Another 19.1% (n=400) reported using zero-grazing, 29.1% (n=400) reported communal grazing, while the remaining 2.3% (n=400) reported other forms of grazing systems which include semi-zero grazing. This study reveals that communal grazing is a common practice among the residents whereby animals from different farms converge and mix freely in the grazing field. A Chi-square test was subjected to the grazing system giving results were, X^2 =1.810, p<0.05 at df=3, and presented in Table 6 below.

Table 6
Pearson Chi-Square Test for Grazing Systems in Kimilili and Mt Elgon Sub-Counties, Bungoma County, Kenya

Chi-Square Test			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.810	3	P<0.05

This result indicates that there is a high variation in the grazing system in the region. Communal grazing is risky because it is easy to introduce and spread disease in a clean herd. Nanyende (2010), in a study on brucellosis, demonstrated that cattle grazed communally are nine times more likely to contract infectious diseases than herds grazed individually.

3.6 Livestock Watering System in the Study Area

The results for livestock watering system used in the study area are shown in Figure 8 below.

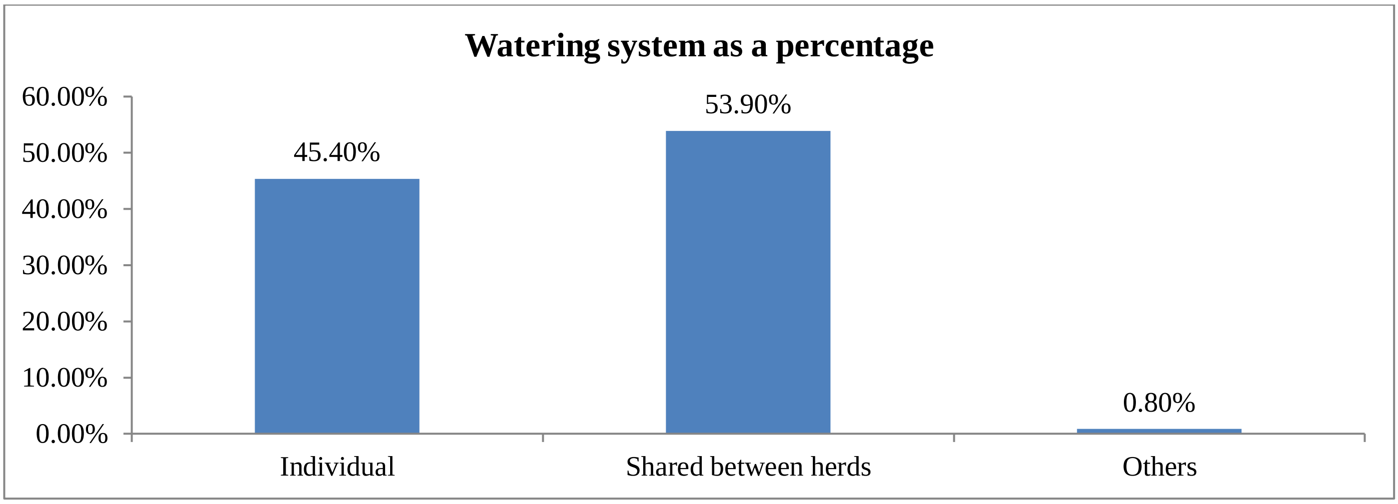

Figure 8
Watering Systems in the Study Area

Figure 8 shows that the majority of the respondents (53.9% where n=400) reported the use of shared watering points for their animals, 45.4% (n=400) said having individual herd watering points and the remaining 0.8% (n=400) of the respondents reported other forms of watering such as fetching water from the rivers and taking to their herds. It was also noted that many respondents using individual herding systems were using watering systems which involve sharing between different herds, a practice which still increases the risk of disease spread across herds. A Chi-square test of the watering system is as shown in Table 7 below.

Table 7
Pearson Chi-Square Test for watering systems in Kimilili and Mt Elgon Sub-Counties, Bungoma County, Kenya

Chi-Square Test			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.893	2	P<0.05

The Chi-square test shows that the watering systems are significantly different. Rivers have been shown to present a risk for leptospirosis where the river water acts as a medium of leptospirosis transmission (Silviana, 2013). The vegetation on the river banks and its outskirts can be prone to flooding and are likely to be habitats for rodents, thereby increasing the chances of leptospirosis transmission (Rejeki et al., 2013; Silviana, 2013).

3.7 Rodent Infestation

The study showed that 92.3% (n=400) of the respondents reported having rodent infestation in their houses, while 7.7% (n=400) did not have the menace (Figure 9). According to Halliday (2013), rodents are considered the most significant reservoirs for a wide range of Leptospira serovars. In fact, according to Himsworth et al. (2013), rats are thought to be the main rodent reservoirs for leptospirosis. Various studies conducted in different parts of the world, such as Brazil, France, and Indonesia, have demonstrated a strong link between leptospirosis in humans and rodents (Sarkah et al., 2002; Dh & Ristiyanto, (2008); Febrian & Solikhah, 2013; Dupouey et al., (2014). Figure 9 shows the frequency of rodent infestation amongst households in the study area.

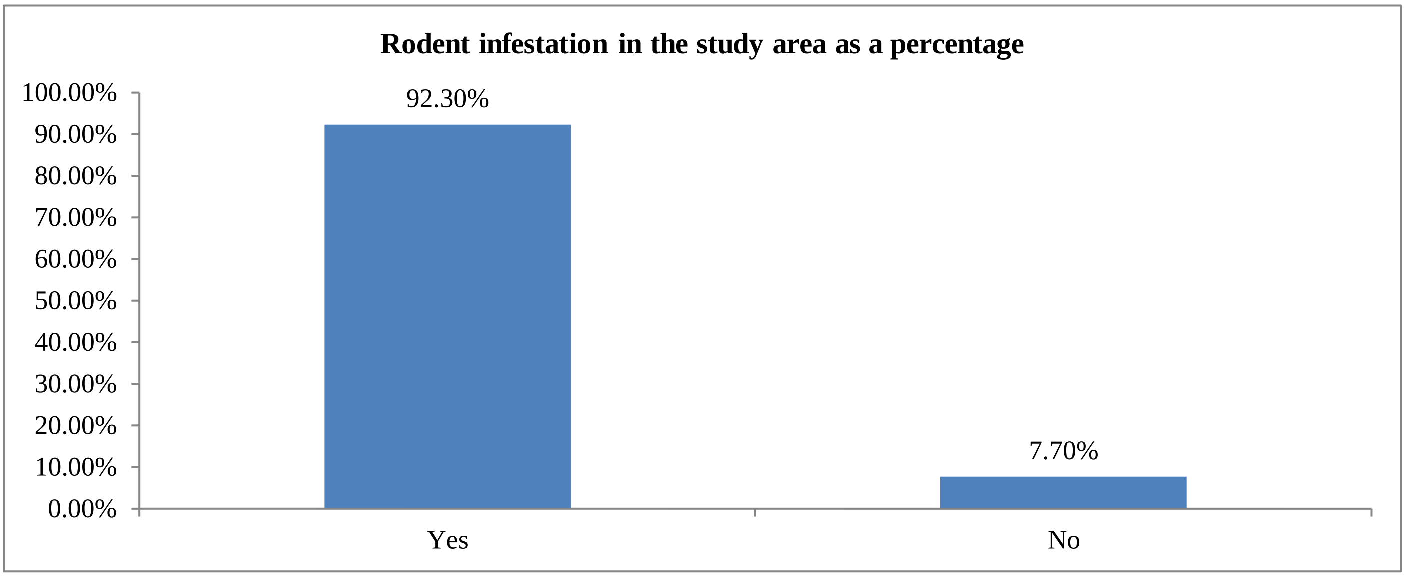

Figure 9
Rodent Infestation among Respondents in the Study Area

Ramachandra et al. (2014) have shown that contact with rodents through using food materials eaten by rats and contact with soil, water, and food especially that which is contaminated with the urine of rats, is an important risk factor for leptospirosis. Key informant Interviews however reveal that most respondents cannot tell any relationship between rodent infestation and leptospirosis disease.

3.8 Slaughter of Livestock At Home

Slaughter of livestock at home is a common practice in the study area. Figure 10 shows that 83.8% (n=400) of the respondents slaughter their livestock at home for consumption. Key Informant Interviews revealed that slaughter of livestock at home is rampant during traditional ceremonies such as circumcision, weddings, funerals and when very weak animals that are on the verge of death are slaughtered to salvage them.

Table 8
Pearson Chi-Square Test for slaughter of livestock in designated facilities in Kimilili and Mt Elgon Sub-Counties, Bungoma County, Kenya

Chi-Square Test			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	176.918	1	P<0.05

A Chi-square test revealed that the number of those practicing home slaughter of their livestock significantly differ from those slaughtering at the designated slaughter facilities.

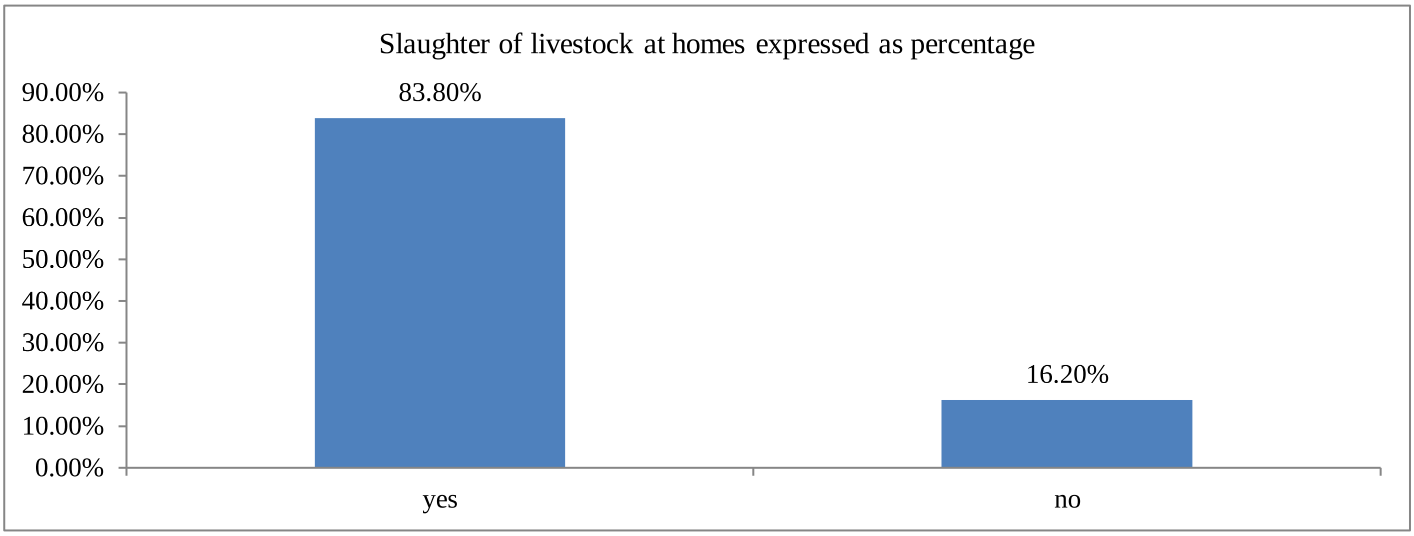

Figure 10
Slaughter of Livestock at Homes

Slaughter of livestock in non-designated areas provides an avenue for the spread of zoonotic diseases such as leptospirosis (Cook et al., 2016). Of all the respondents who slaughtered their livestock at home, only 1.5% had the meat inspected, while the remaining 83% did not make any effort to inspect the beef (Figure 11).

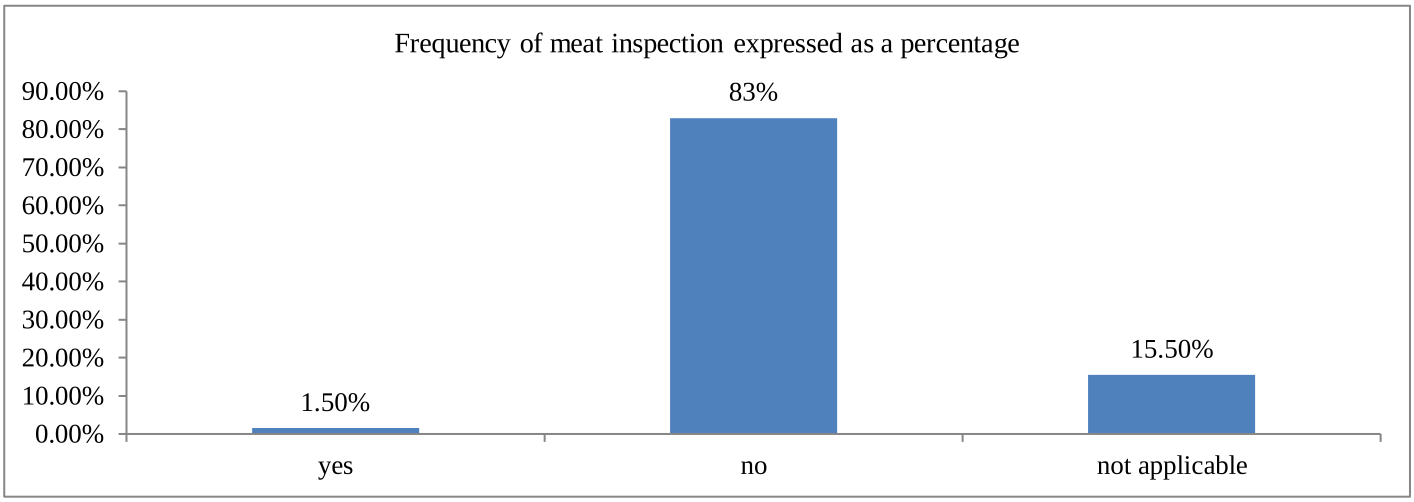

Figure 11
Frequency of Meat Inspection on Animals Slaughtered at Home

Table 9
Pearson Chi Square Test for the Frequency of Meat Inspection for Animals Slaughtered at Home in Kimilili and Mt Elgon Sub-Counties, Bungoma County, Kenya

Chi-Square Test			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	176.918	1	P<0.05

A Chi-square test showed a significant difference between those consuming inspected meat compared to those consuming non-inspected meat. Studies have demonstrated that people who slaughter animals have a high risk for leptospirosis. They have contact with the viscera through cleaning of offals. The risk for leptospirosis is most likely due to contact with infected organs, poor personal hygiene, having wounds, eating and smoking while slaughtering, and lack of protective clothing such as gumboots, aprons, and gloves (Cook et al., 2016).

3.9 Level of Contact between Farmers and Veterinary Extension Staff

The respondents' contact level with extension staff is shown in Figure 12. It was shown that 63.7% (n=400) of the respondents reported none or rare, which denotes less than two visits in the last one year.

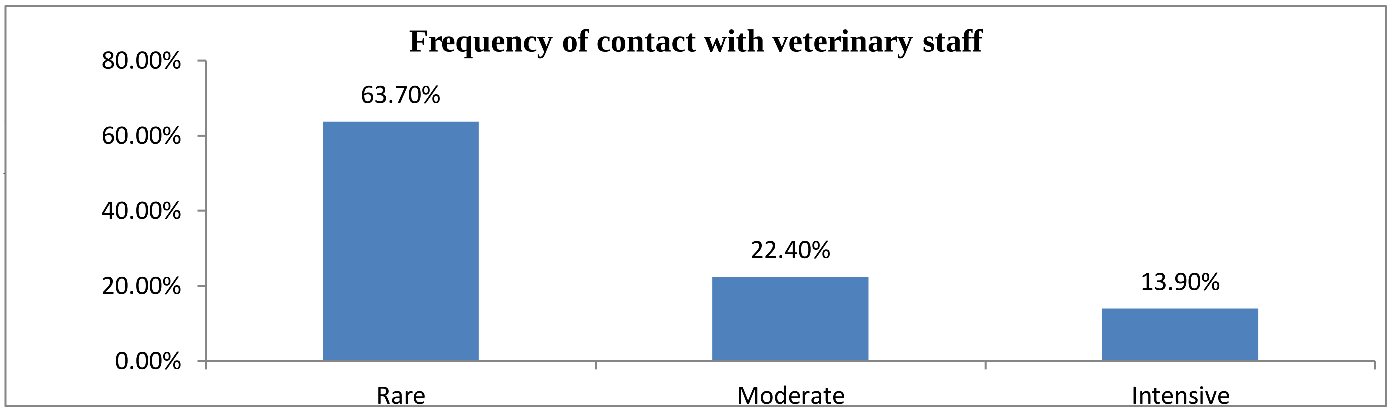

Table 10

Pearson Chi-Square Test for the Level of Contact Between Respondents and Veterinary Extension Staff in Kimilili and Mt Elgon Sub-Counties, Bungoma County, Kenya

Chi-Square Test			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	164.789	2	P<0.05

A Chi-square test on the level of contact between respondents and veterinary extension staff is significantly different. Veterinary extension staff provide an avenue of reaching out to the farmers and informing them about common diseases and their management. Only 13.9% (n=400) of the respondents reported intensive contact with extension staff, corresponding to more than four contacts in the last one year. The remaining 22.4% (n=400) of the respondents recorded moderate contact with extension staff, which corresponds to three to four contacts in the previous year. The limited contact between veterinary extension staff and farmers explains the poor knowledge and understanding of leptospirosis and other livestock diseases in the study area

IV. CONCLUSIONS & RECOMMENDATIONS

4.1 Conclusion

The study has demonstrated that the exposure to the risk factors of leptospirosis is very high in the study area. The study has shown that a high proportion of the population in the study area has a close association with livestock and shares watering points with their livestock. They also have high rodent infestation and carry out livestock slaughter from non-designated slaughter facilities, even so, meat inspection is not done. These factors contribute to the increased risk of leptospirosis in Bungoma County.

4.2 Recommendation

This study recommends that improving knowledge on leptospirosis and its risk factors among communities in Bungoma County is critical in implementing any control and prevention program.

ACKNOWLEDGEMENT

The support accorded to this study through field data collection, laboratory testing, and processing is acknowledged.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest in this study.

AUTHOR CONTRIBUTION

David Wanyonyi Nanyende: Conceptualization of the study, data collection, analysis, and writing of the original draft.
Siamba Donald Namasaka: Investigation, writing review, editing, and supervision.
Ferdinand Nabiswa: Conceptualization, investigation, writing review, editing, and supervision
Jacob Wanambacha Wakhungu: Methodology, data collection, software analysis, writing review, editing, and supervision.
All the authors have made a significant contribution and agree with the manuscript's content.

DATA AVAILABILITY STATEMENT

The data used in this study is available from the corresponding author upon reasonable request.

FUNDING STATEMENT

This is not applicable.

DISCLAIMER

All the views expressed in this article are the author's own and not an official position of the institution.

ETHICS STATEMENT

The protocol of this study was approved by the Institutional Ethics Review Committee of the Masinde Muliro University of Science and Technology (MMU/COR:403009(1), and all study methods were carried out according to relevant guidelines and regulations. In addition, the research was undertaken with authorization from Kenya's National Commission for Science, Technology and Innovation-Nacosti/P/16/44515/13304. The purpose and methods of this study were explained to all participants in detail, and their consent was secured through a written Informed Consent Form.

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