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Retrospective Study of *Cysticercus Bovis* and the Associated Zoonotic Risk Factors in Kajiado County, Kenya

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Abstract:
Bovine cysticercosis is a common zoonosis whose epidemiology is estimated at 50 million cases of infestation worldwide with economic losses from condemned and downgraded carcasses in Kenya amounting to £1.0 million by 2003. A retrospective study was conducted in Kajiado County, Kenya from January 2013 to December 2015 to determine the prevalence of Cysticercus bovis in the County and the associated zoonotic factors. Data on cases of bovine cysticercosis was extracted from monthly meat inspection reports of the County Director Ministry of Agriculture, Livestock and Fisheries from January 2013 to December 2015 and entered in excel spreadsheets. One sub-location was picked per a sub-county and a total of 91 households were sampled for a questionnaire interview according to Bebe et al., 2000. Prevalence rates were analyzed using descriptive statistics, while the Chi-square was used to analyze the association of the zoonotic factors with the cases of bovine cysticercosis. The mean of bovine cysticercosis obtained from the retrospective study was 150.9 with a P-value of 0.000 which is less than the 0.05 significant levels. Zoonotic factors investigated showed a positive association with the prevalence of bovine cysticercosis e.g. availability of toilets, source of water and its treatment, backyard slaughters and meat inspection had a P value of 0.000. The study showed that bovine cysticercosis is prevalent in Kajiado County and there were factors exposing the residents to this zoonotic infection. Public awareness on spread and implication of this zoonosis is important and also emphasis on hygiene is of necessity.

Keywords: *Bovine cysticercosis, Cysticercus bovis, Kajiado, Zoonotic*

1. Introduction

Zoonoses have important impacts on public health and livestock economies representing 61% of all infections known to be pathogenic to humans, (Desta, 2016). These diseases are massively misdiagnosed and underreported but impose a dual burden on human and animals. They affect poor and marginalized people in developing countries who live in close contact with animals, often in unsanitary conditions, where health services coverage is inadequate, (Schelling *et al.,* 2007). Transmission as a result of contact with an infected animal/ host represents a direct mode of transmission, whereas infection as a result of contact with a vector or vehicle is an indirect mode, (Kahn, 2006). Transmission of pathogens from livestock to pastoralists may occur through consumption of raw milk and meat or through contact, (Taylor *et al*., 2001). Proximity to animals, food consumption behavior, problems related to milk and meat contamination, inadequate supply of treatment drugs, harsh environment, and socioeconomic and cultural practices contribute to the morbidity of zoonoses, (Megersa *et al*., 2010). Bovine cysticercosis, caused by the metacestodes of *T. saginata*, is one such zoonosis, a cosmopolitan disease occurring in industrialized as well as developing countries, (Dorny *et al.,* 2009).

Globally, there are 77 million human carriers of which 40% live in Africa. In developed countries, even if the disease has very low prevalence, the problem with the removal and treatment facilities in their sewages system plays a great role in the distribution of eggs which can survive longer in sewages, (Gracy *et al.,*1999). In France, however, it was estimated that one undetected carcass could potentially infect between eight and 20 humans, (Dupuy *et al.,* 2014). It's one of the major food borne pathogens that should be monitored to protect human health and affects the muscles and some viscera organs of cattle, (Abuseir *et al.,* 2006). It has a worldwide distribution and the prevalence is low in developed countries, being less than 1% in inspected carcasses and very common in Africa reaching a level of 30-36% in Kenya, 20% in Guinea, 18% in Sierra Leone and 20% in Cameroon, (Gebreab, 1995). The available data on the presence of *C. bovis* in cattle determined by traditional meat inspection indicate a diversity in prevalence (from 0.43 % to

22.4 %), which largely depends on the number of examined animals, their age, origin and the breeding manner, (Zdolec *et al.,* 2012). Official meat inspection reports are considered to be an underestimation of the real prevalence as meat inspection has a low sensitivity for the detection of cysts in muscles, (E.U., 2006). The prevalence is considered to be higher in developing countries because of poor sanitation, traditional cattle husbandry systems e.g. nomadic pastoralism and inadequate meat inspection facilities, (Coker *et al.,* 2011). The prevalence rates further confirm that in spite of the time and effort taken by meat inspectors in looking for cysticerci at predilection sites, this method limited due to the number of incisions made. It was therefore recommended that more parts of the carcass not currently inspected according to the Kenya Meat Control Act CAP 356– 1973, (2012) for bovine cysticercosis such as hind legs, ribs, lungs and liver, need to be considered as possible and equally important predilection sites and larger areas of these predilection sites should be examined, (Wanzala *et al.,* 2003). Humans are the only definitive hosts for this tapeworm, while cattle serve as the main intermediate hosts and the source of infection to humans, (Teklemariam and Debash, 2015). Cysts are prevalently found in predilection sites such as the masseter muscles, heart, tongue, and the muscles of the shoulder and diaphragm, although they could also be found in other sites and organs, (Chiesa *et al*., 2010). In cattle, natural infections are normally asymptomatic but they cause financial losses to the cattle industry due to down grading, condemnation, extra handling and refrigeration of the infected carcasses. The main intervention to control bovine cysticercosis is education on hygiene, meat inspection, followed by condemnation or freezing treatment when necessary as prescribed by European legislation, (Laranjo-González, 2000).

Taeniasis, which is the infestation in humans, is food-borne caused by the consumption of meat containing viable cysticercus. This develops to a tapeworm and patients are frequently asymptomatic. However, they may present mild symptoms of nausea, abdominal discomfort, flatulence, epigastric pain, diarrhea, vitamin deficiency, excessive loss of appetite, weakness and loss of weight, digestive disturbances, and intestinal blockage may occur. Variably adult tapeworms release motile distal segments containing eggs and their independent motility is the reason for various disorders such as appendicitis, biliary tract obstruction and anal pruritis, (Asaava, 2009). A case of peritonitis secondary to proximal jejunal perforation due to *Taenia saginata* has been presented during preoperative evaluation which suggested acute duodenal ulcer perforation, (Bekraki and Hanna, 2016). Different improved postmortem diagnostic methods have been proposed, such as Ag-ELISA methods detecting antigens in meat juice, immunohistochemical techniques, using the avidin–biotin complex and biomolecular assays, (Chiesa et al., 2010). The epidemiology of bovine cysticercosis/human taeniasis varies from one area to another so control measures appropriate in one area are not necessarily of value in another. Hence, it is essential to have adequate knowledge of the epidemiology of the disease before contemplating control programs, (Teklemariam and Debash, 2015). It is therefore, important that due attention be given to this disease to improve the quality and quantity of beef so as to satisfy the domestic consumption and to increase the foreign export earnings. The objectives of this study were to determine the prevalence of *C. bovis* in Kajiado County and also the associated zoonotic factors.

2. Materials and Methods

2.1. Study Site

Kajiado County is located in the southern rangelands of Kenya at an altitude ranging from 600m at the floor of Rift Valley, to 1,100m above sea level around Lake Magadi; enclosed within longitude 36.0^0E – 37.8^0E and latitude 1.25^0S – 3.12^0S. Kajiado County is divided into five constituencies namely Kajiado Central, Kajiado North, Kajiado South, Kajiado East and Kajiado West which are further divided in to five (5) Wards each. Kajiado County has a total population of 687,312 and a surface area of 21,901km^2 with a population density of about 31 persons per km^2. The cattle population by 2009 was 246,829 heads, (Kenya Open Data, 2013). Most of Kajiado County lies in the semi-arid and arid zones characterized by warm and hot climate with temperature mean of 25ºC. The rainfall pattern is bimodal, with high average of 1,250mm and a low average of about 500mm per annum, (Bobadoye, 2014).

2.2. Ministry of Livestock Data

Retrospective data of cases of bovine cysticercosis in the entire County was extracted from monthly meat inspection reports from the County Director of Veterinary services Ministry of Agriculture, Livestock and Fisheries for a period of 3 years (2013-2015) detailing the total cattle slaughtered and the positive cases recorded, (Thuo *et al*., 2014; Dzoma *et al.,* 2011). This data was entered in Microsoft Excel 2007 program as per the Sub-County, (Schmidt *et al.,* 2015).

2.3. Zoonotic Risk Factors Exposing Human and Cattle to taeniasis and Cysticercus bovis, *Respectively, in Kajiado County*

Questionnaire based interview to pastoralists in Kajiado County was conducted in the five (5) Sub-Counties. From each Sub-county, the ward with the highest population of the locals was selected and one sub-location from each ward was selected (see Table 1).

Constituency	Ward	Sub-location
Kajiado North	Ongata Rongai	Ole Kasasi
Kajiado East	Kaputiei	Olturotu
Kajiado South	Entonet/ Lenkism	Entonet,
Kajiado West	Keekonyokie	Oltepesi
Kajiado Central	Matapato North	Bissil

Table 1: Sub-locations for questionnaire administration in Kajiado County (Source: https://kajiado.go.ke/kajiado_map.pdf)

Two pairs of major landmarks/permanent features e.g. trading center, school, or river were identified and an imaginary transecting line was drawn across the sub-location using the landmarks. Volunteer pastoral households along the line transects were interviewed to establish the risk factors of human exposure to *Cysticercus bovis* in Kajiado County, (Bebe *et al*., 2000). The risk factors being investigated included availability and use of toilets, sources of water for family and animals, home/backyard slaughters and emphasize on meat inspection.

3. Results

Year	No. of Slaughters	Positive	Negative
2013	19,330	61	19,269
2014	21,895	114	21,781
2015	31,624	198	31,426
Total	**72,849**	**373**	**72,476**

Table 2: Bovine cysticercosis cases for Kajiado County

The prevalence rate of the entire county was 0.50% while the Sub-county prevalence were calculated according to Sub-counties for the three different years i.e. 2013 t0 2015.

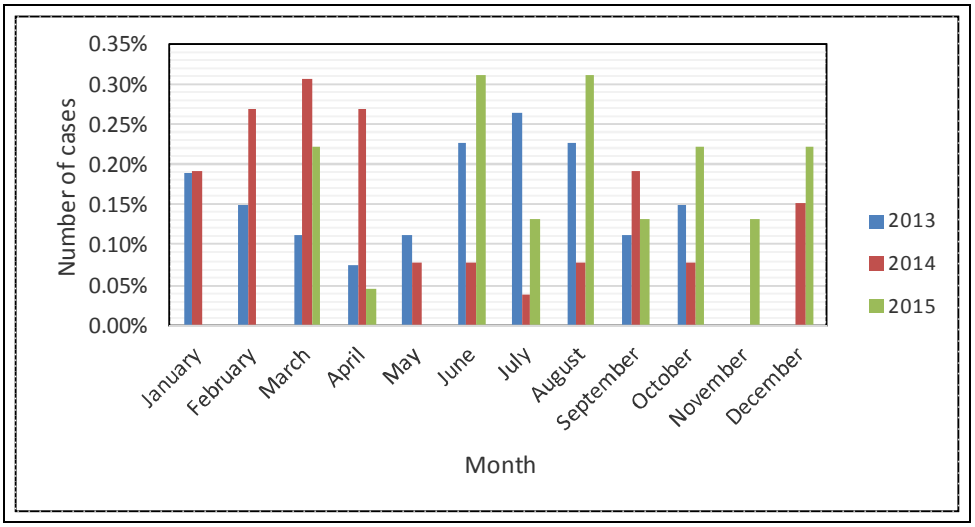

Figure 1: Prevalence rate of bovine cysticercosis between 2013-2015, Kajiado Central, Kenya

From Fig 1, it was observed that in Kajiado Central, cases of the cysticercosis in 2013 were present throughout the year except in November and December where reports were missing. In the year 2014 the occurrence of cysticercosis was reported throughout the year except in the month of November. The highest prevalence was recorded March 2014 and June and August 2015. In January and February 2015 there was no data but all the other months had cases of cysticercosis. July 2014 and April 2015 recorded the lowest prevalence rates in the County.

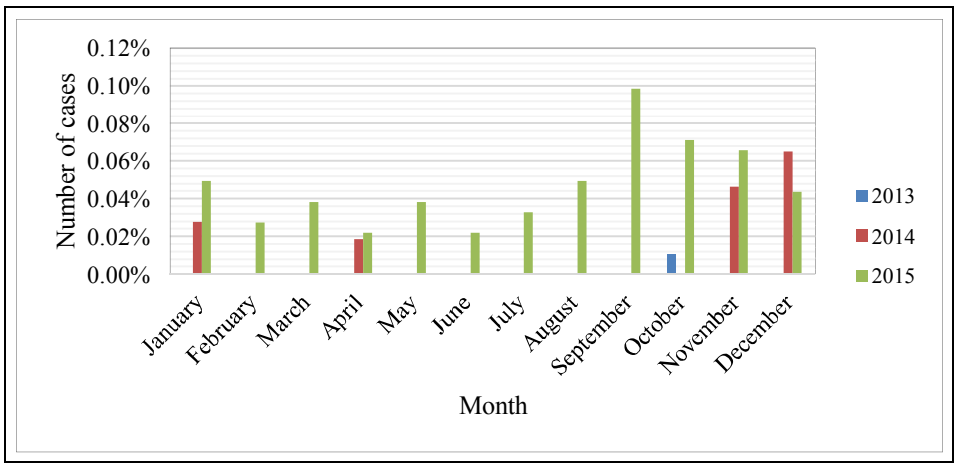

Figure 2: Prevalence rate of bovine cysticercosis between 2013-2015, Kajiado West

Results from Fig 2 showed that bovine cysticercosis was present across the year from January to December for the year 2015. The presence of cysticercosis in 2013 and 2014 was scarce across the year from January to December. The highest prevalence was at 0.09% in the month of September 2015 with the lowest being October 2013. This was associated to poor capture of data at the slaughter house or there were improved hygiene standards in the Sub-county.

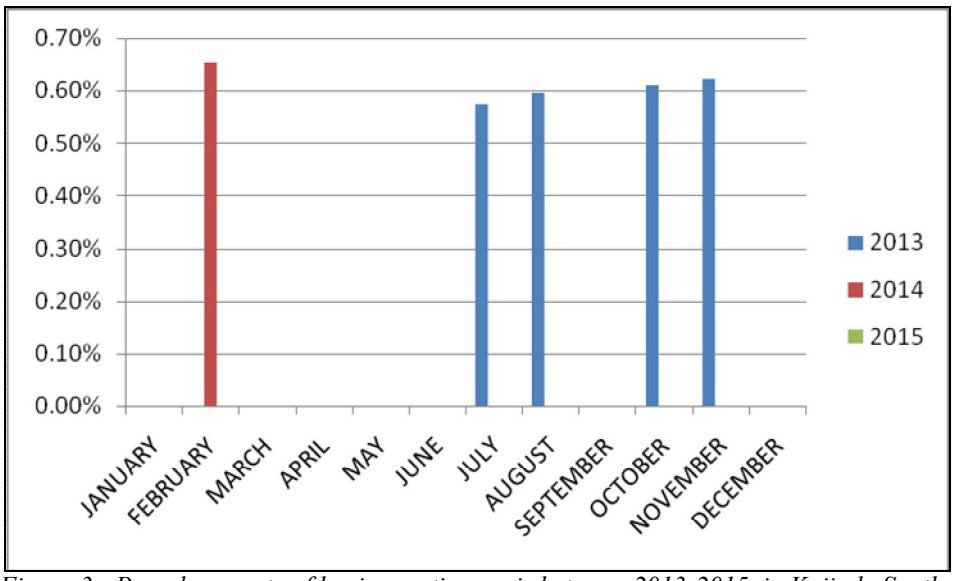

Figure 3: Prevalence rate of bovine cysticercosis between 2013-2015, in Kajiado South

In 2013 there were only 4 positive cases of bovine cysticercosis in the months of June, July, September and October which translates to 0.01 prevalence rate. The other months were marked zero which means no cases were reported. In 2014 there was only one case for a whole year while no case was reported in 2015.

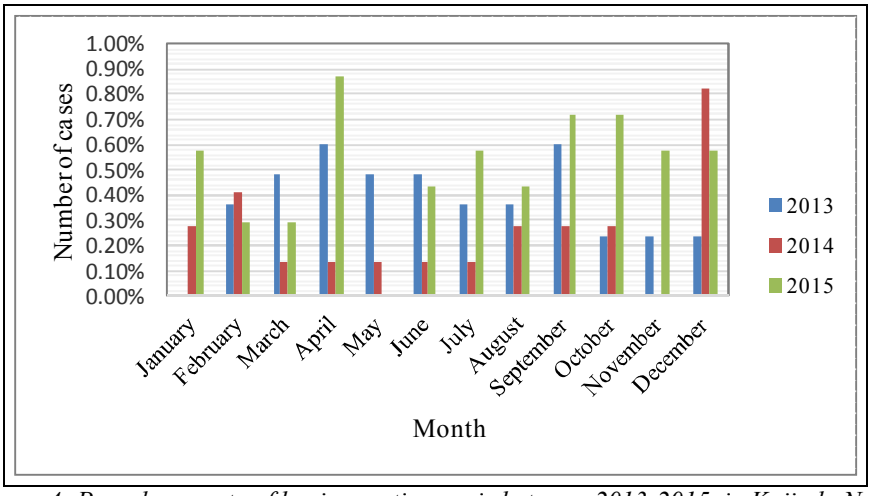

Figure 4: Prevalence rate of bovine cysticercosis between 2013-2015, in Kajiado North

Kajiado north recorded prevalence rate of bovine cysticercosis throughout the years and in all months of the year except January 2013, November 2014 and May 2015. The highest prevalence rate was recorded in April, 2015 and December, 2014. The lowest prevalence rate was during the months of March, April, May, June and July 2014.

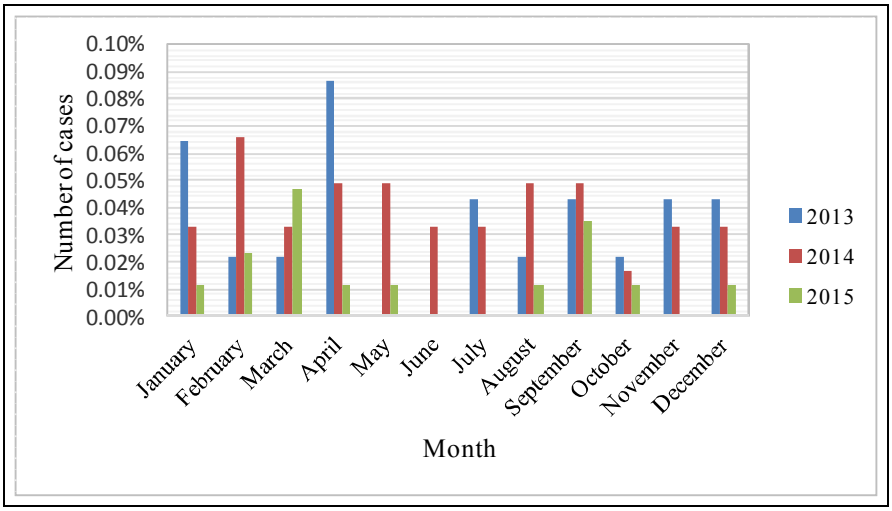

Figure 5: Prevalence rate of bovine cysticercosis between 2013-2015, in Kajiado East

This Sub-county had cases of bovine cysticercosis reported throughout the 3 years except the month of May 2013, June 2013, June and November 2015. The highest prevalence rate was recorded in April, 2013 and the lowest prevalence rate was during the months of January, April, May, August, October and December 2014.
Various zoonotic factors were investigated and the following results were got.

Variable (households with toilets)	**Sub-county**						**Total**	**P-value**
	Kajiado East	Kajiado West	Kajiado South	Kajiado North	Kajiado central	Percentages (%)		
Yes	24	1	2	31	4	33.9	**62**	**0.000**
No	1	14	10	0	4	66.1	**29**	
Total	25	15	12	31	8	100	**91**	

Table 3: Households with toilets

Out of 91 households only 29 (33.9%) had toilets. Kajiado East and Kajiado North had the highest number of respondents who had access to toilets while Kajiado West and Kajiado South had the lowest access of the toilets. The P- value was 0.000 which was < 0.05 significant level meaning there was an association between availability of toilets and prevalence rate of bovine cysticercosis.

Variable (No. of people/toilet)	**Sub-County**						**Total**	**P-value**
	Kajiado East	Kajiado West	Kajiado South	Kajiado North	Kajiado Central	Percentage (%)		
0-5 people	6	0	2	10	0	19.7	**18**	**0.000**
6 -10 people	18	0	5	17	2	46.2	**42**	
11- 20people	1	9	5	4	4	25.3	**23**	
above 20	0	6	0	0	2	8.8	**8**	
Total	25	15	12	31	8	100	**91**	

Table 4: Number of people using a single toilet per household

The largest number of households (65.9%) had one toilet shared between 1-10persons while the other households (34.1%) had 11 or more persons share a single toilet. This means during peak hours e.g. morning a given fraction would use the bush/thickets as an alternative especially the children.

Variable (source of water)	**Sub-County**						**Total**	**P-value**
	Kajiado East	Kajiado West	Kajiado South	Kajiado North	Kajiado Central	Percentage (%)		
Dam	0	15	0	0	1	17.6	**16**	**0.000**
Borehole	19	0	12	30	5	72.5	**66**	
River	2	0	0	1	0	3.3	**3**	
Wells	0	0	0	0	2	4.4	**4**	
Others	4	0	0	0	0	2.2	**2**	
Total households	25	15	12	31	8	100	**91**	

Table 5: Source of water

Dams and boreholes were the two major sources of water in Kajiado County. In Kajiado east, south, north and central boreholes were the major sources of water, while in Kajiado west dams/water pans were the major water sources. 17.6% households used dam water, 72.5% used boreholes, 3.3% rivers, 4.4% wells and 2.2% used other sources. A P-value of 0.000 was calculated which was < 0.05 significant level.

Variable (Water treatment)	**Sub-County**						**Total**	**P-value**
	Kajiado East	Kajiado West	Kajiado South	Kajiado North	Kajiado Central	Percentage (%)		
Yes	6	0	8	30	3	51.6	**47**	**0.000**
No	19	15	4	1	4	47.3	**43**	
Sometimes	0	0	0	0	1	1.1	**1**	
Total households	25	15	12	31	8	100	**91**	

Table 6: Households that do water treatment

51.6% households regularly treated their water or used water from the county government which was treated at the source, while 47.3% used untreated water, 1.1% were erratic in water treatment. Kajiado east, Kajiado west, and Kajiado central had a large number of respondents who used untreated water. The P- value of 0.000 is <0.05 level of significance which showed there was sufficient evidence to conclude that the use of untreated water within the county is a contributing factor to the risk of taeniasis and cysticercosis as indicated by Murrell *et al.*, 2005.

Variable (people who buy beef)	**Sub-County**						**Total**	**P-value**
	Kajiado East	Kajiado West	Kajiado South	Kajiado North	Kajiado Central	Percentage (%)		
Always	2	0	0	9	1	13.1	**12**	**0.000**
Monthly	0	0	0	0	1	1.1	**1**	
Regularly	14	0	9	14	4	45.1	**41**	
Rarely	5	12	1	1	1	22.0	**20**	
Never	4	3	2	7	1	18.7	**17**	
Total	25	15	12	31	8	100	**91**	

Table 7: People who buy beef from butchery

The percentage of households who buy beef regularly (45%) and always (13.1%) form the bulk of the population i.e. 58.2%. It was also observed that in Kajiado east, Kajiado south, Kajiado north and Kajiado central respondents bought beef more regularly other Sub-counties. Only 17 households didn't use beef either due to low income levels or religious beliefs while the remaining 74 bought beef. The P-value of 0.000 was obtained which is <0.05 level of significance. This implies that there is a strong association between consumption of beef and exposure to taeniasis and cysticercosis.

Variable (backyard slaughters)	**Sub-County**						**Total**	**P-value**
	Kajiado East	Kajiado West	Kajiado South	Kajiado North	Kajiado Central	Percentage (%)		
Yes	19	3	10	2	8	46.2	**42**	**0.000**
No	6	11	2	29	0	52.7	**48**	
Rarely	0	1	0	0	0	1.1	**1**	
Total	25	15	12	31	8	100	**91**	

Table 8: Households that do home/backyard slaughters

In table 11 out of the total households sampled 48 (52.7%) said they don't do backyard slaughter while 42(46.2%) don't either due to poverty or the size of the families where small families rarely slaughtered cattle. The respondents of Kajiado East, Kajiado South and Kajiado Central had home slaughters while in Kajiado West and Kajiado North had minimal home slaughters. A P-value of 0.000 which is <0.05 significant level was obtained meaning that there is a strong association between backyard/home slaughter and exposure to bovine cysticercosis and taeniasis.

Variable (home meat inspection)	Sub-County						Total	P-value
	Kajiado East	Kajiado West	Kajiado South	Kajiado North	Kajiado Central	Percentage (%)		
Yes	0	0	2	18	0	22	**20**	**0.000**
No	25	15	10	13	8	78	**71**	
Total	25	15	12	31	8	100	**91**	

Table 9: Households that do home meat inspection upon slaughter

From table 12 above 78% of the households didn't involve the meat inspector in their backyard slaughters. In Kajiado East, Kajiado West, Kajiado South and Kajiado Central meat inspectors were seldomly or totally not involved in home slaughters while in Kajiado North meat inspectors were regularly involved. It was observed that the chi-square value was 37.261 with a P-value of 0.000 which is less than 0.05 level of significance. This was a strong association between meat inspection in the County and the risk of infection of both human and cattle with taeniasis and *Cysticercus bovis* respectively This implies that there was sufficient evidence to conclude that the low numbers of meat inspectors in many areas in the county exposes the residents to consumption of uninspected beef.

4. Discussion

This study shows an increase in the number of slaughter animals over the years and also an increase in positive cases. The trend can be associated to changing market dynamics where beef trade is gaining economic popularity and also regional trade has become daily norm. This means importation of animals from one country to another is now common thus opening avenues for zoonosis. The prevalence of the entire county was 0.51% which is within range compared with other research works; for instance, according to European data on meat inspection, prevalence ranges from 0.007% to 6.8% were recorded, (Chiesa *et al.,* 2010). The prevalence of *Cysticercus bovis* reported is closer to that found in developed countries such as Spain, Denmark, Belgium and Australia which ranged from 0.06% to 0.21%, (Meiry *et al.,* 2012). After devolution, increased number of cases was reported meaning importation of animals from other counties and countries could have an association with the bovine cysticercosis cases. This concurred with results observed earlier by Cabaret *et al.,* 2002 who associated the increase in bovine cysticercosis prevalence to the importation of live infected cattle. Real differences among counties might exist due to heterogeneity in the exposure to risk factors among and within counties, the level of compliance with the officially established meat inspection protocols and also the characteristics of the facilities where meat inspection is carried out e.g. speed of slaughter line and lighting, (E.C. 2004).

The distribution of the cases across the year and in all the sub-counties is in agreement with the findings of Sungirai *et al*., (2014) and Dzoma *et al*., (2011) who did not observe seasonal differences in the occurrence of bovine cysticercosis cases in Zimbabwe and North West Province of South Africa respectively. Moreover, other authors have reported that the accuracy of meat inspection data is dependent not only on the number of cysts present in a carcass but also on the skill, rigor and number of meat inspectors employed in the abattoir, (Garedaghi *et al.,*2011). The reason for the relatively high identification rates of bovine cysticercus cases in some sub-counties is unclear. However, it could be attributed to differences in data capturing practices across abattoirs (some abattoirs might be doing a better job of recording than others) as well as differences in the rigor of meat inspection procedures, (Opara *et al.,* 2006). This suggests lack of uniformity in meat inspection and documentation even among inspectors. This finding is in line with other results shown in reports conducted around the world including Europe, Africa, Australia and America where the prevalence ranged greatly even in the same country, (Pearse *et al.,* 2010; Terefe *et al.,* 2014). Another reason for differences in prevalence rates across sub-counties could be due to form of settlement whereby sub-counties with urban form of settlement could be less exposed than sub-counties with suburban and rural settlements. Also, the nomadic lifestyle encourages backyard slaughters in the bush where there are no meat inspectors and also hygiene is below standards, (Birhanu and Abda, 2014*)*. On the

other hand, the reason for the variation may be related to the level of environmental contamination and degree of awareness of different societies about bovine cysticercosis transmission. Reports have indicated that the prevalence of *T. saginata* may also vary in relation to educational status and income of individual, (Endris and Negussie 2011; Regassa *et al.,* 2010).

Due to the low sensitivity of meat inspection, as has been reported in other studies it is possible that results reported here are an underestimation of the true proportion of the cysticercosis positive carcasses. Therefore, additional studies are needed to further investigate this issue, (Eichenberger *et al.,* 2013; Dupuy *et al.,* 2012; Allepuz *et al.,* 2009).

Zoonotic diseases among pastoralists are a common occurrence due to the fact that their livelihood is mainly dependant on livestock production, (Aweke *et al*., 2013); this makes the pastoralists to have an intimate relationship with their animals, (Zinsstag *et al*., 2006). This study showed significant association (P<0.000) food consumption behavior e.g. consumption of raw or improperly cooked meat, problems related to environmental pollution e.g. defecation in the open and the morbidity of bovine cysticercosis, (Abunna *et al.,* 2008). Other factors such as harsh environment (hot, dry weather) cause the pastoralists to move with their animals in search of water and pastures which put nomadic pastoralists at periodical risk of infection because there are no basic amenities such as toilets around water points as observed by Schelling *et al*., 2007. Socioeconomic and cultural practices such as backyard slaughters, consumption of beef from dead animals or killed by wildlife are among the factors that were found to expose the pastoralists to bovine cysticercosis as reported by Swift *et al*., 1990; Rahmann, 1996.

5. Conclusion and Recommendation

From the results of this study it can be concluded that the occurrence of bovine cysticercosis cuts across the entire Kajiado County and its distribution is not seasonal dependent. The disparity in prevalence rates depends on record keeping, integrity of the meat inspector, social economic factors e.g. awareness and availability of basic amenities. The results shown could be highly underestimated. Many zoonotic factors investigated contributed to the prevalence rates and had an association with the morbidity rate of this infection.

More detailed studies need to be done to further investigate the true prevalence rates and the role of inspection service providers in the identification and reporting of bovine cysticercosis.

More sensitive investigation methods need to be employed to get the true image of this zoonosis.

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